EXPERT EVIDENCE IN CRIMINAL TRIALS IN AUSTRALIA: DOES THE ADVERSARIAL SYSTEM PROVIDE AN EFFECTIVE WAY OF TESTING THE RELIABILITY OF EXPERT EVIDENCE?

Katrin Robinson (Bachelor of Laws, Postgraduate Diploma in Forensic Science (Courtroom Practice))

THE UNIVERSITY OF WESTERN AUSTRALIA

Centre for Forensic Science
University of Western Australia

This thesis is presented in fulfilment of the requirements for the Master of Forensic Science by Research.

2011

Abstract

Expert evidence on forensic techniques is regularly presented in criminal trials. Forensic results can potentially decide the outcome of a criminal trial. In order to achieve a just result, it is essential that the results are reliable, and that the evidence is presented in a manner which allows the decision-maker to properly assess its significance.

The US decision of *Daubert* v *Merrell Dow Pharmaceuticals Inc.* outlines a number of scientific principles which should be considered when assessing the reliability of expert evidence. Australian case law has no equivalent set of criteria, but expert evidence must be reliable to be admitted.

This study examines whether the reliability of two commonly used forensic techniques, namely fingerprints and DNA, is adequately tested within the adversarial system. I reviewed 20 transcripts of fingerprint evidence and 20 transcripts of DNA evidence in criminal trials in Western Australia in order to investigate how lawyers approach these two areas of expert evidence, i.e. what areas they tend to canvass during examination-in-chief and cross-examination.

Part A outlines the case law in Australia and the US in relation to expert evidence, and the main scientific principles. Part B discusses the techniques of fingerprint analysis and DNA analysis, including potential difficulties associated with the two techniques, as well as the results of the analysis of the trial transcripts.

The result of the analysis shows that lawyers focus on the result of the analysis, whereas the reliability of the method which the findings are based on is subject to little scrutiny. This is particularly so in the area of fingerprint evidence.

Contents

Acknowledgements

My sincere thanks to my supervisors Dr Mark Reynolds, Associate Professor Judith Fordham and Winthrop Professor Dr Ian Dadour for their guidance and advice throughout my work on this thesis. I thank Alexandra Knight from the Centre for Forensic Science for her assistance with practical matters; the Director for Public Prosecutions of Western Australia, Joe McGrath SC, and Deputy Director of Public Prosecutions for WA, Bruno Fiannaca SC, for granting me permission to access the relevant files; my colleagues at the DPP for assisting me in identifying relevant cases; and Valter Guarino and his staff from the DPP Records Department for their assistance in the location and retrieval of the files. Special thanks to Craig Robinson with Leo and Amber for their moral support and their patience.

Declaration

I declare that the research presented in this thesis, for the Master of Forensic Science at the University of Western Australia, is my own work. The results of the work have not been submitted for assessment, in full or part, within any other tertiary institute, except where due acknowledgement has been made in the text.

……

Katrin Robinson

Introduction

1. Background

The fair resolution of legal conflicts often relies on an accurate determination of facts or questions which require scientific knowledge. [1] In criminal trials expert evidence from a range of disciplines has become so common that in the experience of the writer[2] the absence of any forensic evidence often results in an explanation by the prosecutor and sometimes the judge as to why no forensic evidence was adduced. There appears to be an assumption on part of the advocates and the judiciary that the jury expect to hear forensic evidence of some kind in a criminal trial, and that its absence warrants an explanation.

The admissibility of expert evidence in court is governed by the laws of evidence. The questions asked by counsel during a trial are rarely the subject of a review, unless a matter is appealed, in which case the Court of Appeal will review the trial transcript (or relevant parts thereof).[3] Consequently, unless the expert evidence becomes a point of appeal upon a conviction, the manner in which expert evidence is adduced is rarely subject to scrutiny.

Instances in which unreliable forensic science has led to unjust results in criminal trials have been the subject of comment in the mainstream media. [4] Concerns about the manner in which expert evidence is dealt with courts have been raised by stakeholders within the judicial system. Freckleton, Reddy & Selby conducted studies on the views of the judiciary on expert evidence. In response to the question of whether the courtroom is adequate for the evaluation of expert evidence, several magistrates observed that this depended on the calibre of the advocate, presumably meaning an advocate's ability to highlight methodological flaws and inconsistencies in a manner which allows the decision maker to evaluate the probative value of the opinion. [5] Judges

[1] D. Faust et al "The Admissibility of Behavioural Science Evidence in the Courtroom: The Translation of Legal to Scientific Concepts and back" Ann Rev Clin Psych 2010:6:49-77 p 49-50
[2] This observation is based on the writer's own experience in the prosecution of jury trials.
[3] In some circumstances the judge might provide feedback to counsel, but this occurs only rarely.
[4] For example C. Merritt "Forensic science in the dock" The Australian 3 April 2010
[5] I. Freckleton et al "Australian Magistrates' Perspectives on Expert Evidence: A Comparative Study" 2001 Australian Institute of Judicial Administration Inc., Carlton, Victoria p 64

who participated in a similar survey raised concerns about poor advocacy – both in examination-in-chief and cross-examination - in relation to expert evidence.[6]

The Australian Law Reform Commission has noted serious concerns among judicial officers and legal practitioner about lenient approaches to expert evidence, including concerns that the relevant specialised knowledge of experts might not be adequately demonstrated, and that the facts or assumptions relied upon by the expert are not adequately identified. [7]

Deficiencies in the presentation of expert evidence in court may result in a number of undesirable consequences: The jury may not understand the evidence, or may be unable to attribute the appropriate significance to an opinion. They may overrate or underrate the relevance of the opinion, which may affect the outcome of a trial. An innocent person might be convicted or a guilty person might be acquitted, both of which undermine the public confidence in the criminal justice system.

The forensic community is also affected by a failure of the judicial system to adequately deal with forensic expert evidence because it may unfairly be tainted by unjust trial outcomes or because the results of its work are not presented in the best possible manner. Faulty forensic science practices have come under scrutiny and have been blamed for wrongful convictions. According to the Innocence Project in the US, forensic science contributed to the wrongful conviction in 50 % of its cases in which a convicted person was later exonerated on the basis of DNA evidence. [8] However, there has also been criticism of studies which attribute wrongful convictions to faulty forensic science as opposed to the performance of the advocates.[9] It is also noted that according to the Innocence Project the biggest contributor to wrongful convictions are not faulty forensics but eyewitness misidentifications, which played a role in 75% of the cases in which a conviction was later on overturned on the basis of DNA evidence.[10]

Failure by the expert and the party calling the expert to adhere to certain standards may lessen the impact of the evidence. A 2008 study by Wheate investigates how forensic scientists perceive the legal system and its use of forensic science, based on their

[6] I. Freckleton et al "Australian Judicial Perspectives on Expert Evidence: An Empirical Study" 1999 Australian Institute of Judicial Administration Inc., Carlton, Victoria p 38
[7] Australian Law Reform Commission, ALRC Report 102 "Uniform Evidence Law-9.The opinion rule and its exception" at http://www.austlii.edu.au/au/other/alrc/publications/reports/102/14.html#Heading106
[8] Innocence Project at http://www.innocenceproject.org/understand/Unreliable-Limited-Science.php
[9] J. Collin & J. Jarvis "The wrongful conviction of forensic science" 2008 Crime Lab Report
[10] Innocence Project at http://www.innocenceproject.org/understand/Eyewitness-Misidentification.php

experience as expert witnesses. The study concludes that expert witnesses are to some degree dissatisfied with the manner in which their evidence is adduced in court.[11] Areas of concern which were raised include that lawyers did not seem to understand the forensic results and a tendency not to explore a witness' qualification, thus denying the jury to opportunity to hear what qualifies the witness as an expert [12] and possibly resulting in a jury undervaluing the expert's evidence.[13] Further, the impact of an expert's evidence might be weakened if counsel fails to facilitate the communication of the reliability of the method or results.[14]

2. Aims of this research

This study aims to add to the body of knowledge about expert evidence in criminal trials in Western Australia by exploring whether the adversarial system and the law pertaining to expert evidence provide an adequate safeguard to ensure that expert evidence is reliable. In this thesis, the term "reliability" is used in the in the same sense as in the US decision of *Daubert v Merrell Dow Pharmaceuticals*[15] *("Daubert"),* i.e. it refers to **evidentiary reliability**, meaning essentially the trustworthiness of the evidence.[16] *Daubert* has been described as "landmark ruling"[17] on expert testimony and is discussed below. Whilst it is not the law in Australia, it has been referred to by Australian courts in the context of the admissibility of expert evidence. There is no equivalent decision in Australia which discusses the scientific merits of expert evidence in as much detail as *Daubert*, but the concepts discussed in *Daubert* provide useful guidance for assessing the merit of expert testimony.

3. Objectives

The study focuses on two areas of forensic techniques which are regularly adduced in criminal trials: fingerprint evidence [18] and DNA evidence. Its objectives are to:

•Investigate whether the manner in which this evidence is presented in court adequately establishes the reliability of the evidence, in particular to review if :

---

[11] R. Wheate "Australian forensics scientists: a view from the witness box" Australian Journal of Forensic Sciences Vol 40 No 2 Dec 2008
[12] Ibid p 126
[13] Ibid p 127
[14] Ibid p 131
[15] 509 U.S. 579, 1993
[16] See below under for a discussion of the term "reliability" in the scientific sense.
[17] K.R. Foster & P.W. Huber "Judging Science: Scientific Knowledge and the Federal Courts" 1999 The MIT Press Cambridge Massachusetts, London – England p 1
[18] The writer has chosen the expression "fingerprint analysis" over the technically more correct "friction ridge analysis" because in court the evidence is commonly referred to as "fingerprint evidence".

- An expert's qualifications are adequately established;
- The basis for the expert's conclusion is sufficiently canvassed, or whether there is a tendency to accept an expert's option without exploring these issues – do lawyers ask the right questions: do they understand the answers?
- The current legal rules provide sufficient guidance for testing the reliability of expert evidence.

- Inform both criminal lawyers and forensic scientists of their obligations to ensure that expert evidence is adequately adduced and presented it court;
- Highlight potential areas for improvement;
- Improve communication between lawyers and experts in the lead-up to a trial.

4. Structure of the thesis

The thesis comprises two parts: Part A discusses relevant case law on expert evidence in the US, in particular the decision of *Daubert*, and compares this to the existing legislation in Australia, and specifically Western Australia. The thesis does not propose to discuss whether *Daubert* offers the best approach to dealing with expert evidence. Rather, *Daubert* is discussed for the purpose of demonstrating the different approaches in Australia and the US, and because it provides detailed consideration of the factors which may assist in assessing the merits of expert evidence. Part A also includes a discussion of the main principles of science with the objective of providing a summary of the main scientific concepts in order to clarify the principles discussed in *Daubert*, and to explain why science is a useful benchmark for testing the reliability of expert evidence. This is the theoretical component of the thesis, and forms the basis for part B as it establishes what rules and recommended standards the evidence should be measured against.

Part B comprises the practical research component and includes the analysis of the fingerprint and DNA evidence in the cases which have been identified. It is subdivided into Part I (fingerprint evidence) and Part II (DNA evidence). Both parts include a discussion of the basic principles of the relevant technique and any potential difficulties. The case analysis will focus on whether during the course of an expert's evidence in court the expert's qualifications are sufficiently explored and if the reliability of the opinion is tested in a meaningful way (i.e. explanation of the underlying facts and assumptions, and the reasoning process). It will also discuss any other issues which -

based on the potential problems associated with the respective forensic technique - might impact on the fact-finder's ability to assess the expert's evidence.

5. Methodology

The analysis comprised twenty District Court and/or Supreme Court trials which involved the presentation of fingerprint evidence and twenty trials which involved the presentation of DNA evidence. [19] A number of cases were identified with the assistance of state prosecutors at the Office of the Director of Public Prosecutions for Western Australia ("ODPP"), who were asked via email to identify any recent trials they conducted which involved DNA and/or fingerprint evidence. Due to limited feedback the target figure of twenty cases could not be achieved by this method. The remaining cases were identified by way of a keyword search [20] of the transcript database at the ODPP. With the assistance of the ODPP the trial transcripts of the identified cases were accessed either via the relevant file held by the ODPP, or – where available – via the ODPP transcript database. The Director of Public Prosecutions had given permission to access the relevant files. None of the analysed cases were prosecuted by the writer. [21] A list of the analysed cases is annexed to this study. For reasons of confidentiality the cases are only referred to by their indictment number, and none of the parties involved are identified in this study. Direct quotations from the transcript are limited to isolated expressions.

The transcripts of the relevant evidence were analysed and for each case the writer compiled a short summary of the main points of examination-in-chief, and – where applicable – cross-examination and re-examination. The results were reviewed under consideration of whether the basis for the conclusion and the reliability of the technique had been explored, and if the main issues commonly associated with the technique had been addressed.

PART A

1. Reliability in a legal sense

1.1 Leading US decisions

In the USA a number of decisions provide guidelines for the admissibility of expert evidence. The general starting point for the discussion of the admissibility of scientific

[19] Trials in the Magistrates Court are not routinely transcribed and were therefore not targeted.
[20] "fingerprint expert" and "DNA expert"
[21] The writer was the file manager of three of the analysed DNA cases but had no involvement in the presentation of the evidence in court.

expert testimony is the decision of *Frye v U.S.* (1923).[22] In *Frye*, which dealt with the admissibility of a polygraph examination, the test for admissibility of an expert's opinion was considered to be whether the principles had gained "general acceptance in the particular field in which it belongs".[23] This test has been criticised because it requires the courts to adopt the standards of the field which is the subject of the scrutiny.[24] Saks & Faigman note that this may result in situations where products of the most rigorous fields with the healthiest scientific discourse might fail the general acceptance test, whilst the work of more "shoddy" fields with less critical standards might pass. [25]

1.1.1. The Daubert test

In 1993 the decision in *Daubert v Merrell Dow Pharmaceuticals, Inc*[26] the Supreme Court rejected the Frye test [27] and ruled that the criterion for the admissibility of scientific testimony was whether the evidence "is not only relevant, but reliable". [28]

Daubert concerned a toxic tort action.[29] The plaintiffs had been born with serious birth defects. They alleged that the birth defects had been caused by Bendectin, a prescription anti-nausea drug marketed by the respondent company. The plaintiffs' mothers had taken Bendectin during pregnancy.[30]

The court in *Daubert* held that expert testimony was governed by the Federal Rules of Evidence, and quoted Rule 702: "If scientific, technical or specialised knowledge will assist the trier of the facts to understand the evidence or determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training or education, may testify thereto in the form of an opinion or otherwise."[31]

The Federal Rule did not provide any guidance how to determine whether a scientific methodology is relevant or reliable. Therefore, prior to the decision in *Daubert,* the

---

[22] M.J. Saks & D.L. Faigman "Expert Evidence After Daubert" Annual Review Law Soc.Sci.2005.1:105:30 p106
[23] *Frye v U.S.* 293 F. 1013 (D C Cir 1923)
[24] M.J Saks & D.L.Faigman (2005) p 107
[25] Ibid p 108
[26] *Daubert v Merrell Dow Pharmaceuticals, Inc* 509 U.S. 579 (1993)
[27] National Research Council "Strengthening Forensic Science in the US: A Path Forward" 2009 The National Academies Press Washington D.C. 2009 p 90
[28] *Daubert v Merrell Dow Pharmaceuticals, Inc* 509 U.S. 579 (1993) at 589. The decision pertained to the interpretation of the relevant Federal Rules of Evidence, it did not set down a new rule– see M.J. Saks & D.L. Faigman (2005) p 108
[29] M.A. Berger "The Supreme Court's Trilogy on the Admissibility of Expert Evidence" Reference Manual on Scientific Evidence, 2nd edition Federal Judicial Center 2000 p 10
[30] *Daubert* as quoted by K.R. Foster & P.W. Huber (1998) p 277
[31] *Daubert* at 588

courts continued to apply the Frye standard to assess the admissibility of expert evidence.[32]

The court noted that the term "scientific" implies a grounding in the methods and procedures of science, and that "knowledge" connotes more than subjective belief or unsupported speculation. In order to qualify as "scientific" knowledge, an inference or assertion must be derived by the scientific method. The requirement that an expert's testimony relates to scientific knowledge establishes a standard for evidentiary reliability.[33] The court noted the scientific distinction between reliability and validity and stated that in a case involving scientific evidence, evidentiary reliability will be based on scientific validity.[34]

The court examined the characteristics of scientific methodology and set out a nonexclusive list of factors to be considered when determining if a theory or technique has been derived by the scientific method. [35] The factors to be considered are whether a theory or technique can and has been tested, whether the theory or technique has been subjected to peer review and publication, the known or potential error rate of a particular scientific technique, and the existence and maintenance of standards controlling the technique's operation. [36] Whilst general acceptance of the methodology within the scientific community is not a requirement, it remains a factor to be considered.[37] However, the Court also emphasized that the inquiry pertaining to the interpretation of Rule 702 is essentially flexible and expressed confidence that the adversarial system, through vigorous cross-examination, presentation of contrary evidence and careful instructions on the burden of proof, was adequately equipped to attack "shaky but admissible evidence". [38]

The "*Daubert* factors" in a scientific sense are discussed in more detail below. The court made the following observations: Whether or not a theory or technique can be tested is a key question in determining whether the technique or theory is scientific

[32] C.R. Grivas & D.A. Komar "Kumho, Daubert, and the Nature of Scientific Inquiry: Implications for Forensic Anthropology" Journal of Forensic Sciences July 2005, Vol 53, No 4, 1-6, p 2
[33] *Daubert* at 590
[34] At footnote 9. See below for discussion of scientific meaning of validity and reliability.
[35] M.A. Berger (2000) (referring to *Daubert at* 594) p 13
[36] National Research Council (2009) p 91 (referring to *Daubert* 592 to 594)
[37] M.A. Berger(2000) p 13 (referring to *Daubert* at 594)
[38] National Research Council (2009) p 91 (referring to *Daubert* at p 596)

knowledge. The court cited various sources, all of which considered the testability of a hypothesis as an essential criterion for its scientific status.[39]

As to peer review, the court noted that submission to the scrutiny of the scientific community is a component of "good science", as it makes it more likely that flaws in the methodology will be detected. Hence the publication or lack thereof in a peer reviewed journal will be a relevant consideration in the assessment of the scientific validity of a particular methodology or technique on which an opinion is expressed. [40]

The court did not elaborate on the meaning of potential error rate and the existence and maintenance of standards controlling the technique's operation.[41] As to "general acceptance", the court noted that "a known technique that has been able to attract only minimal support within the community" may be properly viewed with scepticism, hence "general acceptance" could still have a bearing on the inquiry.[42]

Referring to the flexibility of the inquiry under Rule 702, the court noted that "its overarching subject is the ***scientific validity – and thus the evidentiary relevance and reliability*** [emphasis added] – of the principles that underlie a proposed submission. The focus ....must be solely on principles and methodology, not the conclusions that they generate".[43]

In 2000 Rule 702 was amended and now provides:"If scientific, technical or other specialised knowledge will assist the trier of fact to understand the evidence or determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case."[44]

1.1.2. Joiner

General Electric & Co v Joiner [45] concerned a case in which the plaintiff claimed that exposure to polychlorinated biphenyls (PCB) had promoted his lung cancer. The plaintiff had been a long time smoker and had a family history of lung cancer. The trial

[39] See *Daubert a*t 583
[40] See *Daubert* at 953-594
[41] *Daubert* at 594
[42] *Daubert* at 594, quoting from United States v Downing, 753 F.2d, at 1238
[43] *Daubert* at 594 and 595
[44] Fed R Evid 702 as quoted by National Research Council p 93
[45] 522 U.S. 136 (1997)

court excluded evidence by the plaintiff's expert, and this decision was later overturned on appeal. The Supreme Court examined the record and found that the evidence of the plaintiff's expert had properly been excluded. [46] The Supreme Court concluded that it was within the District Court's discretion to find that the evidence by the plaintiff's expert as to the causation amounted to no more than speculation. The Supreme Court noted a failure on part of the plaintiff to explain "how and why the experts could have extrapolated their opinions" from animal studies far removed from the circumstances of the plaintiff's exposure. [47] The Supreme Court held that "conclusions and methodology are not entirely distinct from one another. Trained experts commonly extrapolate from existing data. But nothing in either *Daubert* or the Federal Rules of Evidence requires a district court to admit opinion evidence which is connected to existing data only by the ipse dixit[48] of the expert. A court may conclude that there is simply too great an analytical gap between the data and the opinion proffered."[49]

1.1.3. Kumho Tire Co v Carmichael

In the case of *Kumho* the plaintiffs had sued the manufacturer and distributor of a tyre which had blown out on a minivan, resulting in a serious accident. The plaintiffs argued that the tyre was defective, and relied on the evidence of an expert in tyre-failure analysis, who concluded on the basis of a visual inspection of the tyre that a defect in the tyre's manufacture of design had caused the blowout.[50]

The Supreme Court ruled that the trial judge's gate keeping function as established in *Daubert* applied not only to testimony based on "scientific" knowledge, but also testimony based on "technical" and "other specialised knowledge". The court also said that "no clear line" can be drawn between the different kinds of knowledge, and confirmed that an expert "might draw a conclusion from a set of observations based on extensive and specialised experience."[51] Essentially the court adopted a flexible approach that stresses the importance of particular circumstances of each particular case, and ensures that the expert observes the same standard of "intellectual rigour" in testifying as they would employ with dealing with similar matters outside the courtroom.[52] The court clarified that the four *Daubert* factors "may or may not be

[46] M.A. Berger (2000) p 14
[47] M.A. Berger (2000) p 14(referring *to Joiner* at 144 and 145)
[48] Ipse dixit (Latin) literally means "he himself said it" and is used to describe "an arbitrary and unsupported assertion" – see Collins English Dictionary (3rd ed) p 814
[49] *Joiner* at 146 as quoted by M.A. Berger (2000) p 15
[50] M.A. Berger (2000) p15 -16
[51] As quoted by M.A. Berger (2000) p 18
[52] M.A. Berger (2000) p 18

pertinent" and that it will all depend "on the nature of the issue, the expert's particular expertise, and the subject of his testimony".[53] The court's subsequent analysis of the proposed expert evidence illustrated its previous comment in *Joiner* that an expert must account for "how and why" they arrived at their opinion.[54]

1.1.4. How Daubert and scientific reliability correlate

Faigman et al note that despite concerns that *Daubert* requires a level of scientific sophistication among judges that would make them "amateur scientists", only two *Daubert* factors – namely falsifiability and error rate – focus on the scientific merit directly. General acceptance depends to a significant degree on the field from which the evidence comes, and peer review and publication somewhat defer to the opinion of the field, although it should assist the courts in evaluating the methodology employed by the experts.[55] As far as scientific validity is concerned, Faigman at el point out that no list of factors can capture the various considerations which go into determining the validity of research results, as validity is not a categorical conclusion. Scientists tend to speak of validity in terms of the strengths of the evidence and reasoning supporting a conclusion, rather than in terms of its "truth". Although *Daubert* requires judges to make a categorical decision, i.e. admitting or excluding an expert's evidence, they are not required to have a categorical view on the science in question. Rather, they are required to use the *Daubert* factors and other factors to determine if it is more likely than not that the methods and reasoning validly supports the expert's evidence. [56]

Gold sees the explicit significance of the *Daubert-Joiner-Kumho* trilogy as the mandating of science as the threshold for the admissibility of expert evidence.[57] Faigman et al comment that *Daubert* stands for the concept that the legal culture must assimilate the scientific culture[58], and Goodstein describes *Daubert* as an attempt to regulate the encounter between the two disciplines of science and law.[59]

Haack criticises *Daubert's* equation of "scientific" with "reliable". She notes that these days words such as "science" and "scientific" are commonly used as synonyms for

---

[53] As quoted by M.A. Berger (2000) p 19
[54] M.A. Berger (2000) p 19
[55] D.L. Faigman et al "Science in the law: Standards, statistics and research issues" American Casebook Series, West Group, St Paul Minnesota 2002 p 24
[56] Ibid p 25
[57] A.D. Gold "Expert evidence in criminal law: The scientific approach" 2nd ed Irwin Law Inc. Toronto 2009 p 31
[58] D.L. Faigman et al (2002) at vii
[59] D. Goodstein "How Science Works" Reference Manual on Scientific Evidence 2nd ed, Federal Judicial Center 2000, p 81

"good" or "reliable" and are often used as words of praise. [60] She argues that the use of the word "science" in this "honorific" sense, as in *Daubert*, overlooks the fact that some representatives from recognised scientific areas such as biology or physics might be incompetent or mistaken, whilst some historians, detectives or plumbers are good investigators. She suggests that rather than dismissing certain work as "pseudoscientific", it would be better to specify what exactly is wrong with it, for example if it was conducted carelessly, or if it is based on unsubstantiated assumptions.[61]

Faigman et al point out that the factors established in *Daubert* do not equal the application of the scientific method. For example, the criterion of falsifiability is widely considered to be the hallmark of scientific statements, whereas *Daubert* selected this factor as one of four possible indicators of validity. In practice, however, it would be difficult to apply the other *Daubert* factors if falsifiability is treated as an optional factor, as the remaining factors all presuppose that a method can be tested. A proposition which cannot be tested cannot have an error rate and is unlikely to be published in a peer-reviewed journal and achieve general acceptance [62]. Faigman et al further note that not all empirical tests of a theory are equally valuable. Hence it is necessary that judges and lawyers acquire sufficient scientific literacy to be able to distinguish research which is designed to truly test a hypothesis from research which is merely designed to look impressive and simply imitates science.[63]

Faigman et al comment that the criterion of falsifiability contains an added complexity because it is not entirely clear which aspects of the science must have been tested to cross the threshold of admissibility and which aspects are a matter of weight for the trier of fact to determine. *Daubert* stated that the focus must be on principles and methodology and not on the conclusions. This does not provide as clear a demarcation line between the issues for judges and those for the triers of the facts because whilst scientists clearly differentiate between the methods employed and the conclusions reached, they also understand that the two are mutually dependent. [64]

---

[60] Haack provides the example of television advertisements marketing household products as "scientific".
[61] S. Haack "Trial and Error: The Supreme Court's Philosophy of Science" American Journal of Public Health, 2005,95,S1, 66-73, p 68-69
[62] D.L. Faigman et al (2002) p 27
[63] Ibid p 28
[64] Ibid

As far as the criterion of error rate is concerned, Faigman et al note that errors occur in a multitude of ways and not all of them are quantifiable. Few scientists would be confident in stating conclusions from one or even a few studies, due to the limitations inherent in scientific studies. It is only through replications using various designs and methods that scientists become confident that a hypothesis has been sufficiently corroborated. This is a gradual process rather than a specific number or moment determining this point. [65]

As to peer review and publication, Faigman et al acknowledge that it facilitates the detection of flaws in the design of studies. However, they point out that not all peer-reviewed journals are of the same quality, and even high quality journals sometimes publish work which is later found to be wrong. Mainstream journals are more likely to publish conventional scholarships and might be slow to accept revolutionary findings or methods; hence the criteria of peer review and publication should not be viewed in isolation, but are simply part of the larger process of critical evaluation.[66]

1.1.5. Difficulties with the criteria in Daubert and Kumho

It has been noted that not every methodology fits squarely within the standards laid down in *Daubert* and *Kumho*.[67] Edmond & Mercer point out the large diversity of activities which fall into the realm of modern science and which rely to varying degrees on observational practices, experimental tests and mathematical proof. Notions such as acceptable error rates or the role of observation will vary between the different branches of science.[68] Grivas & Komar mention the example of various techniques of forensic anthropology. Whilst some techniques employed in this field can be empirically tested, other techniques such as the use of "unique" identifiers such as fractures or other anatomical anomalies which are used to establish identity do not have an error rate. This is due to the fact that there is almost an infinite number of potential skeletal or soft tissue alterations, and no way of quantifying them, which distinguishes them from techniques such as DNA identifications, where a probability can be calculated due to a finite number of possibilities.[69] Some of the difficulties with the notions of science as expressed in *Daubert* are further discussed below under "Reliability in a scientific sense".

[65] Ibid p 35
[66] Ibid p 36- 37
[67] C.R. Grivas & D.A. Komar (2008) p 4
[68] G. Edmond & D. Mercer (1997) p 72
[69] C.R. Grivas & D.A. Komar (2008) p 4

1.2 Australia

1.2.1 Admissibility

Australian courts are not bound by US decisions and the rules set out in *Frye* and *Daubert* are not the law in Australia, but US decisions are often influential in the development of Australian law.[70] The "area of expertise rule" has found expression in Australia in a variety of novel scientific areas and has functioned as a mechanism to protect triers of fact from having to judge the reliability and validity of areas which are still the subject of disputation within their disciplines.[71] Evidence has been rejected when it was not established to be "expert evidence in a recognised field of expertise". [72]

Freckleton & Selby suggest that leading decisions in Australia have focussed on whether the field of expertise which the expert evidence belongs to is reliable, and that therefore the impact of *Daubert* can be seen in Australia.[73] Mercer comments that the *Daubert* criteria still "frequently warrant favourable mention, often in the context of a judicially sanctioned reliable model of science."[74] High Court decisions addressing the need for the reliability of the expert evidence include *Osland v R* [75] in relation to the "battered woman syndrome" ("BWS"), in which Kirby J[76] noted that critics of BWS claim that it is not universally accepted and empirically established, and cited a critic who claimed that BWS fails to meet the *Daubert* test for scientific reliability.[77] Gummow and Gaudron JJ noted the evidence about a "reliable body of knowledge" about BWS.[78] However, unlike in *Daubert* no specific criteria have been developed by Australian decisions to ascertain the reliability of scientific evidence.[79]

In Australia "[e]xpert evidence is admissible with respect to a relevant matter about which ordinary persons are [not] able to form a sound judgment …..without the assistance of [those] possessing special knowledge or experience in that area and which

---

[70] G. Edmond & D. Mercer "Keeping 'Junk' History, Philosophy and Sociology of Science out of the Courtroom: Problems with the Reception of Daubert v Merrell Dow Pharmaceuticals Inc" 1997 UNSW Law Journal Vol 20(1) 48-100, p 57

[71] I. Freckleton & H. Selby "Expert Evidence" Loose-Leaf Series: LBC Practical Law Library, 2001 The Law Book Company Sydney, Vol 1 at [6.50]

[72] Ibid, referring to *R V Jamieson* (1992) 60 A Crim R 68 at 77. See also *Mallard v The Queen* [2003] WASCA 296 in relation to the results of polygraph testing at [288] and [355].

[73] I. Freckleton & H. Selby Vol 1 at [6.50].

[74] D. Mercer "Science, Legitimacy and 'Folk Epistemology' in Medicine and Law: Parallels between Legal Reforms to the Admissibility of Expert Evidence and Evidence-based Medicine" 2008 Social Epistemology 22:4, 405-423, p 415

[75] *Osland v R* [1998] HCA 75; 197 CLR 316

[76] At [165]

[77] At footnote 202

[78] At [54]

[79] I. Freckleton et al (2001) p 62

is the subject of a body of knowledge or experience which is sufficiently organised or recognised as a reliable body of knowledge or evidence". [80] It has been suggested that the Australian approach of assessing the existence of a "field of expertise" and the qualifications of an expert bears structural similarities to the *Frye* test, and that "[l]egal categories such as 'field of expertise', 'general acceptance' and 'expert qualifications' are inextricably interdependent".[81]

In the leading decision of *Makita (Australia) Pty Ltd v Sprowles*[82], which concerned the evidence of a physicist who specialized in the investigation of slipping accidents, Heydon JA held that for expert evidence to be admissible, the following criteria need to be fulfilled:

"[T]here must be a field of 'specialised knowledge'; there must be an identified aspect of that field in which the witness demonstrates that by reason of specified training, study or experience the witness has become an expert; the opinion proffered must be 'wholly or substantially based on the witness's expert knowledge' so far as the opinion is based on facts "observed" by the expert, they must be identified and admissibly proved by the expert, and so far as the opinion is based on 'assumed' or 'accepted' facts the facts must be identified and proved in some other way; it must be established that the facts on which the opinion is based form a proper foundation for it; and the opinion of an expert requires demonstration or examination of the scientific or other intellectual basis of the conclusions reached: that is the expert's evidence must explain how the field of 'specialised knowledge' in which the witness is expert by reason of 'training, study or experience' and on which the opinion is 'wholly or substantially based', applies to the facts assumed or observed so as to produce the opinion propounded. If all these matters are not made explicit, it is not possible to be sure whether the opinion is based wholly or substantially on the expert's specialised knowledge. If the court cannot be sure of that, the evidence is strictly speaking not admissible, and, so far as it is admissible, of diminished weight. And an attempt to make the basis of the opinion explicit may reveal that it is not based on specialised or expert knowledge, but, to use Gleeson CJ's characterization of the evidence in *HG v R* (1999) 197 CLR 414, on 'a combination of speculation, inference, personal and second-hand views as to the

[80] *Osland v The Queen* [1988] HCA 75 at [53] per Gaudron and Gummow JJ, see also *Clark v Ryan* [1960] HCA 42; *HG v R* [1999] HCA; *Farrell v R* [1998] HCA 50
[81] G. Edmond & D. Mercer (1997) p 59
[82] *Makita (Australia) Pty Ltd v Sprowles* [2001] NSWCA 305

credibility of the complainant, and a process of reasoning which went well beyond the field of expertise' (at [41])."[83]

Unlike in some other jurisdictions[84], the *Evidence Act 1906* (WA) does not provide any specific rules as to the admissibility of expert evidence. [85] Hence the rules of expert evidence in Western Australia are those developed by the common law.[86]

During a voir dire in the case of *State of Western Australia v Martinez & Ors* [87] Heenan J considered the admissibility of the evidence of a defence expert who was a qualified engineer and specialised in research on injuries on the human body as a result of accident and falls. The expert concluded that somebody of the height and strength of the accused could not have pushed the victim over the railing of the bridge as alleged by the prosecution.

Heenan J noted that as far as the expert's hypothesis of the direction, trajectory and rate of the fall of the body from the bridge was concerned, the expert had applied classical Newton mechanics to determine the velocity of the falling body and the duration of the fall hence had applied well established scientific principles.[88] However, he expressed concerns about a number of experiments conducted by the expert which simulated a number of scenarios in which a body was thrown over the bridge. He criticised that there was conjecture on part of the expert as to what had happened, for example the lack of resistance from the victim, and the manner of throwing. [89] He further criticised the failure to attempt to standardise results, and that there was no error analysis, and described the experiments as "not particularly scientific".[90] Heenan J noted that the features of the expert's methods and assumptions might render the expert's conclusions questionable and the results tendentious[91], and the experiments speculative.[92] However, despite these reservations he held the evidence to be admissible and noted that the

[83] at [85]
[84] See Evidence Act 1995 (Cth) and Evidence Act 1995 (NSW) sections 79 and 80
[85] with the exception of section 36BE regarding expert evidence on child behaviour
[86] see *Hillstead v The Queen* [2005] WASCA 116 which refers to and relies upon the requirements established in *Makita*
[87] WASC [2006] 98
[88] at [17]
[89] at [21] to [25]
[90] at [25]
[91] at [34]
[92] at [43]

reservations about the experiments went to the weight of the evidence, and it was matter for the jury to evaluate the expert's experiments.[93]

On the basis of appeal decisions, it appears that in Australia the gate keeping function of the court seems to have a lower threshold than in the US under *Daubert*, and is limited to questions of whether there is a body of recognised skill, science or research and whether the expert has the necessary expertise. Any weaknesses in the method are left to the fact-finder to evaluate rather than the court excluding this evidence, which means it is left to counsel to highlight any weaknesses in the reliability of the evidence.

1.2.2. Qualifications

The failure by the prosecution to adequately qualify their expert was considered a ground of appeal in the decision of *The Queen v Broughton.* [94] The appellant had been convicted of grievous bodily harm. The prosecution case at trial was based on circumstantial evidence. The most important circumstances relied upon by the prosecution were marks of blood found on the clothing worn by the appellant on the evening in question, and the inferences which the jury were asked to draw from them.[95] Two forensic scientists gave evidence for the prosecution on the blood stains found on the appellant's clothing. The appellant's evidence was that he had found the complainant injured on the ground, and that the complainant's blood stained his clothing when the appellant squatted down and lifted the complainant's body and held him and took his pulse.[96]

The two prosecution experts gave evidence that some of the stains on the appellant's clothing were medium to high velocity stains of blood. It was suggested on behalf of the appellant that the high or medium velocity stains might have been deposited on the appellant's clothing from a damaged artery close to the wounds on the complainant's face, when the appellant was assisting the complainant. One of the experts gave evidence that the patterns of blood splashes were not in the pattern he would expect to find from arterial blood spurts, which contradicted the appellant's explanation.[97] The expert also suggested that the pattern of blood stains on the appellant's trousers were typical of a kick pattern, and referred to a scenario of the blood stains on the trousers

[93] at [48]
[94] Unreported, Court of Criminal Appeal Queensland C.A. No 55 of 1988, 22 September 1988
[95] at p 9
[96] at p 12
[97] at p 13

resulting from blood splashes caused by the appellant kicking the face and head of the complainant. [98]

It became apparent during the trial that the expert to a significant extent based his opinion on his own experiments of having shot a projectile into a sponge and noting the shape of the spots of liquid splashing onto objects close to the sponge, as well as on various books about blood pattern analysis. The Court of Appeal noted that "...in the absence of evidence led from Mr Freney to qualify him to be an expert in such matters [one can only speculate] as to the source of his expert knowledge which would make such an expression of opinion admissible".[99]

In relation to the other expert the court noted that was "nothing in the evidence to suggest that Miss Bentley had ever observed force applied to a source of blood which caused splashing or that any of her work involving the examination of clothing brought to her for the testing of blood and seminal stains involved making such an observation or indeed that any part of her professional qualifications involved her making a study of such things."[100]

The Court of Appeal held that the evidence had not established that there was a specialised field of learning and training in blood pattern analysis. The court acknowledged that the laws of physics might determine how far blood splashes of a certain size would travel from their source but validity of such a determination would depend on the wealth of factual data. The evidence had not disclosed that either of the two prosecution experts had such specialised knowledge or the necessary factual bases for an opinion.[101]

The Court further held that even if it had been shown that the forensic biologists had the necessary specialised knowledge to draw inferences from the examination of blood stained clothing, the evidence given by Mr Freney as to various possible scenarios and hypotheses amounted to speculation as to the acts of violence which the appellant might have committed against the complainant, and went far beyond the permissible limits of expert evidence.[102]

---

[98] at p 17
[99] at p 17
[100] at p 15
[101] at p 18
[102] at p 23

2. Reliability in the scientific sense

2.1. Logical relevance as a requirement for the admissibility of expert evidence

For evidence to be admitted at a criminal trial, it has to be relevant to the issues. Evidence is relevant if it affects the probability of whether a fact in issue is true or not.[103] Gold notes that in cases of non-expert evidence, which is limited to a witness' observations, the assessment of relevance simply depends on the rules of logic to the content of the witness' evidence. Evidence is relevant if it is so related to a fact in issue that it tends to establish or disestablish it. Gold describes this as logical relevance. [104]

Gold proposes that unlike the evidence of non-experts, relevance of an expert's opinion is not just relevance of the content of an expert's opinion, but that the method or procedure by which the opinion was formed must also be examined. He notes that an improperly founded opinion is not logically relevant, as it does not provide valid information to help decide the probabilities of the contentious fact in issues. [105]

2.2 The scientific method

Science has been described as "a process, a way of examining the natural world and discovering important truths about it."[106] This was noted by the court in *Daubert:* "Science....represents a *process* for proposing and refining theoretical explanations about the world that are subject to further testing and refinement".[107] The court further noted that an inference or assertion could only qualify as "scientific knowledge" if it had been derived by the scientific method.[108] Indeed, the scientific method is considered the "essence of science".[109] A scientific claim is evaluated by applying the scientific method, which involves experimentation and/or observation. [110]

Daubert does not include an express definition of the scientific method. Haack notes that there is no " 'scientific method' in the sense the Court [in *Daubert*] assumed" and points out that there is "no uniquely rational mode of inference or procedure of inquiry used by all scientists and only by scientists". [111] Others have commented that *Daubert* "involves the Supreme Court appropriating a questionable and highly contentious

[103] A.G. Gold (2009) p 53
[104] Ibid
[105] Ibid p 53 to 55
[106] D. Goodstein (2000) p 69
[107] *Daubert* at 590, quoting from Brief for American Association for the Advancement of Science et al as Amicus Curiae 7-8
[108] *Daubert* at 590
[109] D. Goodstein (2000) p 69
[110] J.A. Ives & J. Giordano "Unusual Claims, Normative Process: On the Use and Stringency of the Scientific Method" Forschende Komplementärmedizin 2007, 14; 138-139, p 138
[111] S. Haack (2005) p 68

philosophy of science".[112] A number of theories of science and the scientific method have been proposed[113], and Goodstein comments that "[w]e don't really know what the scientific method is".[114] Chalmers points out that there is no general account of science and the scientific method which applies to all sciences in all historical stages in their development. [115] Welsh comments that the scientific method is too generic and unspecific and hence unsuitable for establishing a framework for scientific explanations in an area such as chemistry.[116] Haack quotes Einstein as describing scientific inquiry as "nothing but a refinement of our everyday thinking".[117]

However, it seems to be accepted that the most fundamental aspect of the scientific method is the formulation and testing of hypotheses.[118] A scientific activity commences with the observation of phenomena and the categorisation of observations, in order to explore certain patterns among the phenomena. The observations lead to the formulation of a hypothesis which is then tested by comparing predictions to actual data.[119] The scientific method is based on the application of logic to the problem of how to observe an empirical phenomenon in a way which will allow drawing valid inferences about that phenomenon.[120] It is essentially a set of logically and demonstrably effective procedures for testing the validity of empirical claims - a process, not a product, that makes phenomena recognisable and predicts outcomes. [121] The subject of scientific method is a necessary foundation of every discipline which attempts to gain knowledge of the world

[112] G. Edmond & D. Mercer (1997) p 49
[113] Various theories as to the scientific method are discussed and reviewed by Chalmers (1999).
[114] D. Goodstein (2000) p 70
[115] A.F. Chalmers "What is this thing called science?" 3rd ed University of Qld Press 1999, p 247. See also G. Edmond & D. Mercer (1997) p 70, pointing out that there is no clearly defined operational universal scientific method.
[116] S.M. Welsh "Advice to a New Science Teacher: The Importance of Establishing a Theme in Teaching Scientific Explanations" J of Science, Education and Technology, Vol 11, No 1, March 2002, p 93. Welsh argues that students need a framework in order to assess which scientific explanations are sensible and which ones are not, and suggests a theme which provides such a framework.
[117] S. Haack (2005) p 68
[118] See D.L. Faigman et al "Modern Scientific Evidence" 2006 Student Edition Thomson West, p 13; K. Knisely "A Student Handbook for Writing in Biology" 2nd ed 2005 Sinauer Associates, Sunderland, Massachusetts, p1
[119] see B.K. Williams "Logic and Science in Wildlife Biology" The Journal of Wildlife Management Vol 61, No 4, Oct 1997, 1007-1015, p 1009-1010
[120] D.L. Faigman et al (2002) p 116
[121] A.D. Gold (2009) p 85- 86. See also D.L. Faigman et al (2002) p 117 suggesting that science be thought of as a verb and not a noun.

through systematic empirical inquiry, including behavioural and social sciences.[122] "Empirical" means based on direct experience or observation of the world.[123]

The scientific method involves the following number of steps:

• Asking questions

• Looking for sources which might help answer the questions

• Developing hypotheses, i.e. possible explanations

• Designing an experiment to test a hypothesis

• Predicting the outcome of an experiment if the hypothesis is correct

• Data collection

• Organising data to help interpret the results

• Developing possible explanations for the results of the experiments

• Revising the original hypothesis to take into account new findings

• Designing new experiments to test the revised hypothesis, or other experiments to provide further support for the original hypothesis

• Sharing the findings with other scientists.[124]

Faigman et al point out that to a real scientist a finding of fact is only as good as the methods used to find it, and describes scientific method as the logic by which the observations are made. It is the logic of the research design, measures and procedures which generates knowledge that is scientific. Just as lawyers and judges focus on credibility to determine which witnesses are telling the truth and which ones are not, the way for scientists to discover which one of several contradictory studies is most likely correct is to scrutinise the methodology.[125]

Scientific reasoning has been described as "controlled thinking", seeking to eliminate false beliefs and reasoning errors. By using standard procedures and criteria that are

[122] D.L. Faigman et al (2002) p 116. Faigman comments that although the scientific method has been described innumerable times, most lawyers and judges remain illiterate in that area.
[123] K.F. Punch "Introduction to Social Research" 2nd ed 2005 Sage Publications Ltd London, Thousand Oaks, New Delhi, Singapore, p 290
[124] K. Knisely (2005) p 1
[125] D.L. Faigman et al (2002) p 117

demonstrably effective, scientists seek to minimise potential errors in the investigation of the external world. The essence of the experimental method is the manipulation and control of the events the subject of the study, so that findings are generated which allow valid, logical conclusions to be drawn. The recording of the process allows for examination and repetition. The validity of and reliability of opinions lie in their underlying methodology. [126]

Faigman et al point out that a hypothesis or theory is never proven to be true, and that testing is only capable of disconfirming. The theories which withstand such attempts at falsification better and longer become accepted, at least until something better comes along. Essentially a theory is put to the test by diligent attempts at falsification. This distinguishes science from non-scientific activities, where investigators engage in search for evidence which confirms their suspicion.[127]

Similarly, Ives and Giordano comment that "[t]he process of discarding and/or accepting scientific claims is one of convergence upon 'a truth' that is subject to change as a consequence of scientific knowledge itself", and that scientific claims are always subject to scrutiny, challenge and revision, which is "based upon both ongoing evaluation of the claim, and intellectual understanding of science and nature".[128]

2.3. Defining features of science

2.3.1. Data recording

Gold notes that the most basic requirement of science is the documentation of objective evidence. All concepts under discussion must be meaningful and capable of measurement, which requires objective standards, a counting or measurement of something capable of being counted or measured. Subjective measurements are meaningless as support for any conclusions.[129] Gold uses the following example to illustrate this point: Declaring that sexual abuse destroys a victim's self-esteem would require a clear standard for the measurement of self-esteem, otherwise this statement would only be a subjective impression. He states that if there is no quantification but only reliance on personal experience and observations, the analysis is more personal speculation than science.[130]

[126] A.D. Gold (2009) p 92
[127] D.L. Faigman et al (2002)p 121
[128] J.A. Ives & J. Giordano (2007) p 138
[129] A.D. Gold (2009)p 95
[130] Ibid p 95

The accurate recording of data is a fundamental requirement for scientists to maintain a permanent record of what they have done, with sufficient detail to enable others to check their work, and replicate it.[131] Faigman et al comment that that forensic science cannot be viewed solely in terms of their products, but that they are also to be judged by the legitimacy of their processes. Any conclusion must be documented in such a manner as to allow another competent examiner to evaluate the original examiner's work, and interpret the data.[132]

2.3.2. Falsifiability

As outlined above, the court in *Daubert* noted that falsifiability is a key factor in determining whether a technique qualifies as science. The court noted that "[s]cientific methodology today is based on generating hypotheses and testing them to see if they can be falsified..."[133] A hypothesis is falsifiable if there exists a logically possible observation statement which is inconsistent with it, i.e. which would falsify the hypothesis if the observations statement were to be established as true.[134]

However, despite the importance which *Daubert* placed on falsifiability as a distinctive feature of scientific methodology, the concept of "falsifiability" has been widely discussed in the area of philosophy of science, and has not necessarily been fully resolved.[135] Edmond & Mercer point out that whilst the concept of falsification has been used to defend "orthodox science" against the perceived threat from "fringe science", "falsificationism" has been criticised on philosophical, historical and practical reasons. Amongst a number of criticisms discussed by Edmond & Mercer are the following: Falsification itself relies on observations which may be fallible and open to revision; some propositions accepted by scientists would not pass a strict test of being falsifiable and in fact every area of scientific knowledge has its own basic set of assumption which is not open to falsification; the financial and political context in which modern science exists does not allow for every hypothesis and conjecture being subject to test; and that it is not clear how falsification would work in practice and which of its different versions should be applied. [136]

---

[131] Ibid p 97
[132] D.L. Faigman et al (2006) p 22
[133] At 593 (citing Green 645)
[134] A.F. Chalmers (1999) p 62
[135] D. Faust et al (2010) p 57
[136] G. Edmond & D. Mercer ((1997) p 81-97

Whilst some comment that scientists try to disprove the desired hypothesis and accept the desired result only when there is no other possible explanation[137], other point out that the actual practice of science is often more concerned with the confirmation of a theory rather than falsifying it.[138]

Foster & Huber note that despite the fact that the concept of falsification is controversial, falsifiability is still useful - if only "as a rule of thumb" - to identify assertions which are so nebulously or imprecisely expressed that they cannot be subjected to serious scientific scrutiny or refutation by other scientists.[139]

2.3.3. Error rate, reliability and validity

Scientists distinguish between reliability and validity: Reliability in the scientific sense refers to consistency, i.e. the ability of a measure to reproduce a result each time it is applied to the same thing. Validity refers to the accuracy of a result. For a result to be accurate, a reliable method is required, but a reliable method will not necessarily produce a valid result. [140] Foster and Huber mention the example of a 30-inch "yardstick" which can reliably (i.e. repeatedly) ascertain that a room is twelve yards wide, even though the true figure is only ten yards.[141] In *Daubert* the concepts of reliability and validity were combined into the concept of the "reliability of evidence".[142]

Errors can affect either the reliability of a measurement by introducing non-reproducible results, or its validity by leading to incorrect interpretation of results. One of the fundamental problems in science is how to draw valid inferences from data, given that inevitably there will be random errors present due to the sampling process, or systematic errors based on inadequate experimental designs or other factors. [143]

Foster & Huber point out that asking judges to examine the known or potential error rate in a scientific study is a "tall order", as science has many tools for estimating and controlling errors, many of which are specific to a particular discipline. Most scientists provide some kind of error analysis with their results, and standard methods do allow

---

[137] A.D. Gold (2009) p 127
[138] K.R. Foster & P. W. Huber (1998)p 48; D. Goodstein (200) p 71 comments that credit in science is most given for demonstrating the correctness of unexpected predictions, not falsifying them.
[139] K.R. Foster & P.W. Huber (1998) p 63
[140] D.L. Faigman et al (2002) p 125
[141] K.R. Foster& P.W. Huber (1998)p 69
[142] D.L. Faigman et al (2002) p 125
[143] K.R. Foster & P.W. Huber (1998) p 69- 70

scientists to estimate and report potential errors. However these standards are seldom applied consistently and scientists often overestimate the accuracy or their results.[144]

Foster & Huber suggest that assessing an expert's testimony might begin by considering how carefully an expert has documented potential errors in methods or data. They suggest that failure or unwillingness on part of a scientist to confront potential errors is almost conclusive proof in itself that the work is flawed.[145]

Specifically in relation to court proceedings the significance of the error rate needs to be explained to the fact-finder, namely a) what the error rate is, b) what the accepted norm is within the relevant scientific or technical community, c) whether steps can be (and were) taken during the test to reduce the error rate, and d) how the error rate may have affected the results in the case which is being decided.[146]

2.3.4. Peer review

Peer review plays a central role in scientific debate in separating valid science from nonsense, and has been described as "one of the sacred pillars of the scientific edifice".[147] The idea behind peer review is that flawed tests or methods will be exposed by neutral, unbiased and learned analysis in scientific journals or literature. [148] Whilst in theory peer review is essential to screen out flawed methods, commentators warn that the reality is somewhat different: "[P]eer review is not and cannot be an objective scientific process, nor can it be relied on to guarantee the validity or honesty or scientific research, despite much uninformed opinion to the contrary. Its functions are more modest but nonetheless valuable...Although peer review can screen out work that is clearly invalid and greatly improve the chances that published work is valid, it cannot guarantee scientific validity....If peer review cannot guarantee validity of the research, still less can it be relied on to detect fraud."[149] Goodstein expresses the view that scientists are socialised to believe that other scientists are honest in the reporting of scientific results, hence peer review is not a useful tool for detecting fraud.[150]

---

[144] Ibid
[145] Ibid p 82-83
[146] D. Faust et al (2010) p 58
[147] D. Goodstein (2000) p 74-75
[148] D. Faust et al (2010) p 58
[149] Ibid citing Relman and Angel (1989)
[150] D. Goodstein (2000) p 75

2.4. Should forensic evidence be evaluated against scientific principles to save the justice system from misleading expertise?

Faigman et al note that the classical description of how science develops theories, tests hypotheses and revises its ideas and understanding can rarely be seen in forensic science. This is partly because forensic science is an applied science, whereas the scientific method is a description of basic science or knowledge building.[151]

As stated above, there is no universal scientific method. The decision in *Daubert* has been criticised for adopting a specific view of science. [152] Edmond and Mercer point out that one of the problems with identifying a universal scientific method is the vast diversity of activities which fall under the scope of modern day science. Various branches of science rely on observation, experiments or mathematical proof to varying degree, and it might be preferable to talk about "scientific methods" rather than just the one "scientific method" which might apply to the various branches of science. Notions such as standards of proof, the role of models, acceptable error rates and the role of observation, will vary between the various branches of science. [153] The adequacy of *Daubert* has been described as "problematic" in the light of a more nuanced image of the institutional mechanisms of science and scientific method.[154]

In response to critics of *Daubert*, Saks & Faigman comment that the court was merely trying to provide a flexible solution to the problem of how to distinguish reliable expert evidence from unreliable expert evidence. *Daubert* involved a particular type of expertise, empirical claims, which lends itself to evaluation by scientific methods. Essentially, *Daubert* proposes that expert evidence should be excluded if it cannot provide appropriate validation, i.e. if it cannot supply good grounds for concluding that the expert evidence is sufficiently trustworthy.[155]

Saks and Faigman comment that rather than subscribing to a particular philosophy about science, the court in *Daubert* intended to illustrate that good science follows certain methodological conventions, whereas bad science does not. The *Daubert* factors – testing, peer review and publication, error rate and general acceptance – are simply

[151] D.L. Faigman et al (2006) p 13
[152] M.J. Saks & D.L. Faigman (2005) p 110; see also G. Edmond & D. Mercer (1997)
[153] G. Edmond & D. Mercer (1997) p 72
[154] Ibid p 70
[155] M.J. Saks & D.L. Faigman (2005) p 110

aspects of the ordinary conduct of scientific investigation, and immediately recognisable as central to the scientific enterprise.[156]

Saks & Faigman point out that no set of criteria would be useful to assess the validity of every kind of science or every kind of expertise, and the *Daubert* factors were never more than a set of suggested criteria by which to evaluate scientific evidence. Essentially the opinion in *Daubert* provides that trial courts are required to determine whether the basis for proffered evidence is reliable and valid. The *Daubert* factors will often assist in making that determination, but sometimes they will not.[157]

Why scientific principles assist in the evaluation of expert evidence

Given the potential significant impact of expert evidence on the fact-finder, it is necessary that such evidence be subjected to scrutiny. Evidence which claims to be scientific should comply with the methodological conventions of good science, hence scientific principles are an appropriate tool to assess this kind of evidence. The fact-finder needs to know whether or not evidence which purports to be scientific really meets the criteria for good science, in order to attribute the correct weight to this kind of evidence.

As outlined above it would be naive to assume that a set of fixed criteria would be appropriate given the vast range of areas of expertise which are used in court. Not all areas of expertise can necessarily be tested against the scientific method. However, some factors used for assessing the validity of scientific claims are still useful for assessing the validity of technical "non-scientific" evidence. For example, accurate recording of data and the manner of conducting experiments or tests are important to assess how an expert arrived at a particular conclusion. The concept of testability is also important to assess the validity of a statement. As pointed out by Chalmers[158], conclusions or theories that cannot be tested are potentially too vague to provide any valuable insight. This does not mean that the evidence is irrelevant, and frequently there might be a legitimate basis for adducing, for example, psychological evidence which may be hard or impossible to falsify.[159] However, awareness on part of the fact-finder that a claim cannot be tested will assist in attributing the appropriate weight to a claim and acknowledging its limitations, hence the scientific concept of testability or

[156] Ibid p 111-112
[157] Ibid(2005) p 113
[158] See above
[159] For example in the context of an accused's or complainant's reaction to a particular situation.

falsifiability can provide a useful tool in the evaluation of such evidence. The concept will also assist in addressing the issue of potential bias - has the expert thought of any alternative explanations?

Similarly, a technique may not have a know error rate, but awareness of this criterion will still be useful if assessing the trustworthiness of a technique.

PART B

I. Fingerprint Evidence

1. Background

The question of whether fingerprint analysis counts as a science is the subject of debate. Most fingerprint experts believe that the determination of sufficiency of details represents the individualisation of a human to an acceptable forensic science standard, whereas critics argue that the question of sufficiency is an unscientific outcome which requires a "leap of faith".[160]

Those who consider the technique to be science argue that there is a systematic approach to each fingerprint analysis, which begins with an analysis of the detail observed within the pattern area. [161] Bush explains that in a typical latent fingerprint he would normally expect to find at least five features before forming a hypothesis about the probability of a common source, and generally a further five features are then used to test the hypothesis before reaching a deductive conclusion of individualisation. Sufficiency is established by the combination of the physical similarity, sequential arrangement and spatial relationship of the fingerprint details. [162] As to the theory of the uniqueness of fingerprints, Bush argues that under scientific conditions the theory can be reasonably tested by using a sufficiently large and diverse population to represent the human race (as opposed to checking a set of fingerprints against the prints of all other humans in the world). He notes that Australian National fingerprint database currently holds millions of records, and that to date no two persons have been shown to have the same fingerprints, hence the proposition that all known Australian human fingerprints are unique has not been falsified. [163]

This thesis does not endeavour to discuss the discipline of fingerprint analysis under the aspect of whether or not it is a science. Rather, this thesis focuses on the practical aspect of whether not the reliability of the discipline is adequately tested in court.

---

[160] L. Bush "The Authority of Fingerprint Experts: Is it Based on Belief or Science?" J of Forensic Identification 59(6)2009, 599-608, p 599

[161] Ibid p 603

[162] Ibid; See also H. Tuthill "Individualization: Principles and Procedures in Criminalistics" Lightning Powder Co Inc., Salem Oregon USA, p 28-30 arguing that the scientific process in criminalistics is a three-step process: analysis-comparison-evaluation, hence the ACE-V method used in fingerprint analysis is in accordance with the scientific method.

[163] L. Bush (2009) p 605

In the context of the "science debate" Champod et al comment that the crux of the matter would appear to be the transparency of the process rather than its scientific merit.[164] As will become apparent in the section of this thesis which discusses the findings of the transcript analysis, the transparency of the process is an issue which is not routinely canvassed in court.

2. History of forensic fingerprinting

The importance of fingerprints and latent fingerprints in the identification of individuals has continued to receive increasing acceptance ever since the first report of its potential in the second part of the 19th century. [165] A person's fingerprint on an object can confirm that the corresponding finger contacted the object, i.e. the fingerprint itself documents the contact and is therefore a powerful investigative tool.[166]

Early fingerprint experts did not consider fingerprinting as a technique for linking criminals to evidence left at a crime scene, but rather as a record keeping technology, a way of linking persons to their criminal records. Fingerprinting as a forensic technique developed later and was only considered a "fringe benefit" of the fingerprint system of criminal identification.[167] The possibility of the use of fingerprints for the identification of criminals was raised in late 19th century.[168] Shortly thereafter the International Medical Congress in London was told by J S Billings, a US army physician, that "....even the minute ridges and furrows at the end of his forefingers differ from that of all other forefingers and is sufficient to identify."[169] Cole comments that whilst Western scientific community had accepted that each fingerprint is unique, this did not address the question of whether it is possible to mistake two fingerprints impressions – especially if smudged, indistinct or incomplete – for one another.[170]

Cole reports a 1897 case in which the Indian police had the opportunity to use finger printing for a criminal investigation into the murder of a manager of a tea garden who had been stabbed to death in his bungalow. A wooden box which was the property of the victim had been opened and money had been removed from it. A bloody fingerprint

---

[164] C. Champod et al "Fingerprints and Other Ridge Skin Impressions" 2004 CRC Press LLC Boca Raton, London, New York, Washington DC, p 32
[165] I. Freckleton & H. Selby Volume 4 at [96.90]
[166] R.K. Noon "Scientific Method. Applications in Failure Investigation and Forensic Science" 2009 CRC Press p 31
[167] S.A. Cole "Suspect Identities. A history of fingerprinting and criminal identification" 2001 Harvard University Press Cambridge, London, p 168
[168] Ibid p 65 and 73
[169] As quoted by S.A. Cole (2001) p 73-74
[170] S.A. Cole (2001) p 74

had been found on the almanac, which matched a fingerprint on the police record. This led to the arrest of a former servant of the victim and a subsequent trial.[171]

In this case there were 18 matching ridge characteristics which convinced the investigators that the bloody print had come from the accused. Interestingly, there was no expert witness for fingerprints in this case. Instead, the judge and the assessors performed their own examination of the evidence. Although they found that the bloody print was that of the accused, they declined to convict him of murder. The court held that whilst the bloody fingerprint found at the crime scene was strong presumptive evidence that the accused had been in the room and stained his fingers with the blood, this was not enough to connect him with the actual murder, and it would be unsafe and unfair to presume that it was the accused who had murdered the victim. The evidence could only prove that the accused had handled the wooden box and its content, and consequently the court convicted the accused of burglary only.[172]

Despite this result, it had been established that an accused could be convicted on the basis of fingerprint evidence and in 1899 the Indian Evidence Act was passed, which was the world's earliest endorsement of fingerprints as legal evidence.[173]

In the US, fingerprint evidence was first adduced in two trials in 1910 (People v Jennings) and 1911 (People v Crispin), one a murder trial, the other one a burglary case. The murder trial resulted in a conviction, and the burglary trial in a confession. [174] Fingerprinting was a new forensic technique at the time, hence its validity as a forensic technique was debated extensively, and during the Jennings trial five experts gave evidence. Defence objected on the basis that it was a matter for the jury to compare the fingerprints, but the court allowed the expert testimony. The Supreme Court of Illinois agreed that "the classification of finger print impressions and their method of identification is a science requiring study" and consequently expert evidence was admissible.[175]

Cole reports that in People v Crispin, a case which rested entirely on the fingerprint evidence, the defence also objected to expert evidence interpreting the evidence, arguing that the prints were "in evidence and speak for themselves".[176] The objection

[171] Ibid p 88-89
[172] Ibid p 89 - 90
[173] Ibid p 90
[174] Ibid p 159-160
[175] Ibid p 179
[176] Quoted by S.A. Cole (2001) p 181

was overruled. The prosecution was also allowed – against objection from the defence – to introduce evidence of how the fingerprints of identical twins were different. Further, the prosecution expert conducted an experiment during which the fingerprints of all jurors were taken, and one of the jurors was subsequently instructed to touch one of the exhibits (the windowpane from the loft). The expert correctly matched the fingerprint on the exhibit to the print of the juror who had deposited it there. The prosecution expert distributed enlargements of the evidence to jurors so that they could share in the process of fingerprint matching. The accused changed his plea to guilty after hearing the expert's evidence. Interestingly, when polled by the judge as to whether they would have convicted on the basis of the fingerprint evidence alone, several jurors indicated that they would not have convicted.[177]

Cole notes that by the end of the 1920s the moment for challenging for forensic fingerprint identification had been lost, and that in the absence of any organised, credible scientific challenge, the fundamental premises of latent fingerprint identification had been largely established. [178] Over the period roughly between the two world wars fingerprint examiners would gradually "blackbox" latent fingerprint identification, i.e. taking the process for granted and declining to inquire further into its inner workings. Rather than demonstrating their credentials to the jury, examiners would rely on their credentials and membership in professional communities. The public's faith in the reliability of fingerprint identification shifted from the reliability of the individual expert to the reliability of the technique itself, and fingerprint identification essentially became routine.[179] Jurors became increasingly more willing to accept fingerprint evidence on faith, without having seen a courtroom demonstration.[180] In 1928 the Supreme Court of Vermont, in response to the appellant's demand as to evidence as to the state of the "so-called science" of fingerprinting, held that such evidence was not required.[181]

By the beginning of the second World War fingerprinting had been transformed from a new technique into the most credible and unassailable form of identification evidence around - a result of fingerprint examiners portraying fingerprint identification as a

[177] S.A. Cole (2001) p 184
[178] Ibid p 188-189
[179] Ibid p 199
[180] Ibid p 206
[181] Ibid p 207

routine process, during which the individual skills and judgments of the examiners were essentially interchangeable.[182]

Disagreement about standards

Cole comments that although fingerprinting had become "the most trusted form of forensic evidence", latent fingerprint identification was based on anecdote, experience and nineteenth century statistics, as opposed to scientific research.[183] In particular, it did not address the question which is fundamental for forensic identification, namely how great is the likelihood of a latent fingerprint impression being mistakenly matched to the wrong finger?[184]

Cole explains that in the period following the Second World War, two different strategies were developed to minimise the chances of a mismatch. Britain sought to address this problem by mandating an overly conservative number of 16 matching ridge characteristics, "points of similarity", which had to be found before a match could be declared. If the required number of points was not found, the finding was inconclusive, even though an examiner might think there was a match. The point system was rejected as unscientific in the US, as the minimum standards were not based on empirical evidence but were merely estimates designed to provide a margin of safety against error. American examiners argued that the number of matching points was not always an indication of how similar two prints were, and depending on the nature of the prints two prints with only four points might be declared a match, whereas another set of prints might require more points in order to declare a match. Essentially American examiners relied on a flexible standard which was based on the judgment of the examiner. They saw themselves as scientists who used expert judgement and knowledge, whereas in Britain fingerprint examiners were thought of as technicians who followed proven protocol. [185]

In 1988 the sixteen point standard was scientifically reviewed and the authors of the review found that the standard had no logical or statistical justification, i.e. the standard was found to be unscientific.[186] However, even though this finding seemed to support the American view of the point standard as being unscientific, American examiners

[182] Ibid p 215
[183] Ibid p 259
[184] Ibid p 260
[185] Ibid p 259 - 264
[186] Ibid p 270

effectively used numbers of points to support their finding, whereas at the same time claiming that there was no minimum number because the identification essentially relied on the expert judgement of the examiner. [187]

Cole refers to an American robbery trial in 1991, in which a critical judge scrutinised the evidence given by the fingerprint expert who was called by the prosecution. When the expert explained that there was no minimum standard prescribing a specific number of points which needed to match, and that uniqueness could be found in just a few very uncommon points, the judge criticised the lack of standards, the lack of study and statistical basis and commented that the expert's opinion was just an "ipse dixit".[188] Cole comments that the judge seems to have been genuinely surprised by the lack of standards and scientific studies of the individuality of human fingerprints.[189]

3. Basics of fingerprint analysis

3.1. Types of fingerprints

There are two kinds of fingerprint evidence which may be located at a crime scene or on an item related to a crime – visible fingerprints and latent fingerprints. Visible fingerprints can be seen without any particular treatment. They can be positive (when the print is formed by fingerprint ridges covered in blood, paint or other substances), negative (where the fingerprint ridges remove surface material such as dust or soot), or indented (where the finger comes into contact with a malleable substance such as candle wax or wet paint which retains the three-dimensional image of the print).[190] Latent fingerprints lie hidden and need to be visualised, for example by physical, alternate light and / or chemical treatment. They are the most common form of fingerprint evidence.[191]

Langenburg explains that usually the friction ridges in a fingerprint reflect the colour of the development medium, e.g. the ridges appear black when black fingerprint powder is used, or the colour of the matrix which compose the fingerprint, e.g. red when deposited with blood, black when deposited with fingerprint ink. On occasions, however, the colour of the friction ridges in a print are the opposite of what is expected – e.g. the ridges are white where black powder was used. This is known as "tonal reversal". In a

[187] Ibid p 271
[188] Ibid p 272-273
[189] Ibid p 274
[190] C. Champod et al (2004) p 105
[191] Ibid p 106

tonal reversal the furrows, not the ridges, reflect the colour of the development medium, or fingerprint ink or blood. [192]

Whilst it was previously thought that tonal reversal is a result of high deposition pressure, a study by Langenburg found that two other mechanisms might lead to tonal reversals: If a fingerprint is deposited at a time when the blood on the ridges has dried, but the blood in the furrows is still wet, a tonally reversed print can be produced even with light pressure. A tonal reversal can also be produced where blood from the ridges is removed (for example by touching surfaces), and subsequently a print is produced with excessive pressure.[193]

Langenburg notes a lack of data for quantitatively or qualitatively assessing the effects of various factors which might impact on the appearance of a bloody fingerprint. He emphasises the importance of thoroughly understanding the distortions that can be present in a bloody fingerprint given that this type of evidence is potentially quite powerful in a criminal trial, and advocates further research in this area.[194]

3.2. Methodology of fingerprint evidence – "*ACE-V*"

The generic methodology for the analysis of fingerprints is known as "ACE-V" (analysis, comparison, evaluation and verification) and was first adopted by the Royal Canadian Mounted Police. [195] Its steps are outlined below.

3.2.1.Analysis

In this first step the unknown print is examined in order to assess its ridge formations and their clarity. This must be done before the examiner has access to the known print. [196] If this procedure is not followed and the examiner sees the known print before analysing the unknown print, they may be deceived into seeing what they expect to see, as the human brain tends to take an abstract pattern and organise it into an object we recognise from previous experience. [197] This may result in an examiner believing that a known print and an unknown print have features in common when in fact the feature is only present in the known print but not the unknown one.[198] In particular, if the unknown print is smudged and of poor quality, the brain will try to analyse what the

[192] G. Langenburg "Deposition of Bloody Friction Ridge Impressions" Journal of Forensic Identification 58(3) 2008, 355-389, p 377
[193] Ibid p 385
[194] Ibid p 356 and p 386
[195] C. Champod et al (2004) p 15
[196] H. Tuthill p 30; C. Champod et al (2004) at p 15-16
[197] H. Tuthill p 30-32
[198] C. Champod et al (2004) p 21

smudge signifies and the examiner might "recognise" ridge characteristics if they have previously seen the known print and had an expectation of seeing a particular characteristic also in the unknown print. [199]

There are three levels of information which can be recorded: Level 1 refers to the overall pattern of the ridges, such as whorls, arches and loops. Level 2 refers to the minutiae, i.e. the major ridge path deviations such as ridge endings, bifurcations or dots. Features such as scars, wrinkles and similar also count as level 2 characteristics. Level 3 refers to innate ridge formations such as the alignment and shape of each ridge unit, pore shapes and pore positions.[200]

In order to avoid any suggestions that – during the comparison stage – the examiner only sees certain ridge characteristics in the unknown print because they have previously studied the known print, an examiner should record the features they observe in the unknown print during the analysis stage.[201]

Champod et al note that when skin structure – a three-dimensional organ – leaves a two-dimensional print, some information will be lost in the transfer process. The fingerprint examiner will not only have to assess the clarity and visibility of the print, but also the tolerances which need to be taken into account, i.e. tolerances which allow for the mechanisms and constraints of the deposition process. In order to tackle these issues, the examiner needs to know the circumstances under which the unknown print has been obtained. Factors to consider are the medium which deposited the print (latent print, or bloody print, or other), the surface on which the print was found (rough, smooth), the contact pressure, distortion and the fingerprint development technique employed (what substances were used to enhance the print).[202]

The examiner needs to consider a number of factors which impact on the quality and the quantity of detail in the latent print, and might lead to variations in the resulting impressions[203]:

1. The condition of the skin: Natural ridge structure and its robustness, consequences of aging, superficial damage to the skin, permanent scars, skin diseases and masking attempts.

[199] H. Tuthill p 32-33
[200] C. Champod et al (2004) p 17
[201] H. Tuthill p 37-39
[202] C. Champod et al (2004) p 20
[203] National Research Council (2009) p 137

2. Type of residue: natural residue such as sweat or oily residue, other types of residue such as blood or paint, the amount of the residue and where it accumulates (top of the ridge, one edge of the ridge, both edges of the ridge).
3. Mechanics of touch – underlying structure of the hands and feet, flexibility of the ridges, furrows and creases; the distance adjacent ridges can be pushed together or pulled apart during lateral movement; the distance the length of the ridge might be compressed or stretched; the rotation of the ridge systems during torsion; and the effect of ridge flow on these factors.
4. Nature of the surface touched: rough or smooth texture, flexibility (rigid or pliable), flat or curved shape, clean or dirty, background colours or patterns.
5. Development of the technique: Chemical signature of the technique and consistency of the chemical signature across the impression.
6. Capture of the technique : digital photograph or film, lifting material (e.g. tape or gelatine lifter).
7. Size of the latent print or percentage of the surface that is available for comparison.[204]

3.2.2. Comparison

During this phase the characteristics that have been observed on the unknown print are compared to the characteristics of the known print, and the similarities and dissimilarities recorded.[205] The examiner should focus successively on level 1, level 2 and level 3 features and take into account the tolerances dictated by the quality of the unknown print. In order to avoid "expectation-led observations" – i.e. the examiner erroneously observing features in the unknown print which are in fact only present in the known print – the comparison process should focus on features which have previously been identified during the analysis of the mark. The comparison should begin with a previously observed feature in the unknown print, which serves as a control measure to be compared against the known print.[206]

3.2.3. Evaluation

This step requires the examiner to draw an inference - based on his prior observations – as to the source of the unknown print. Where the examiner finds discrepancies between the known and unknown print which cannot be explained, it will lead to exclusion. The examiner needs to distinguish between discrepancies on the basis of distortion, and real

[204] Ibid
[205] H. Tuthill p 50
[206] C. Champod et al (2004) p 21

dissimilarities. [207] Essentially the question is whether the examiner has found characteristics "of such number and significance as to preclude the possibility or probability of their having occurred by mere coincidence."[208]

When the examiner has not observed any significant differences between the known and unknown print, the value of the match needs to be assessed (identification process). Where the known and unknown prints only agree in class characteristics - i.e. level 1 features – without any significant differences, the result will be inconclusive. A positive identification can only be made when the examiner observes sufficient agreement of individual characteristics – i.e. Level 2 and 3 features. [209]

Champod et al point out that the distinction between class characteristics and individual characteristics oversimplifies the concept of selectivity, and that the term "individual characteristics" is somewhat misleading, as a concordance of one minutia only would not be considered sufficient to express uniqueness. [210]

Champod et al explain that there are two different positions as to the required standard to declare an identification: The empirical criterion is based on an quantitative approach, whereby a fixed minimum number of minutiae is required to establish an identification. This approach is mainly favoured in European countries. The holistic approach, on the other hand, rejects a predetermined numerical standard as unscientific because there no valid basis for a predetermined number. Some types of minutiae are much more selective than others. Also, the absence of minutiae might be as significant as their presence. Rather than simply relying on the number of corresponding minutiae, the holistic approach requires the balancing of quantitative aspects (number of minutiae) and qualitative aspects (such as the overall pattern or the types of minutiae). [211]

In 1995 the International Association for Identification (IAI) approved the resolution that "no scientific basis exists for requiring that a pre-determined minimum number of friction ridge features must be present in two impressions in order to establish a positive identification".[212] The IAI resolution has been adopted by a number of countries. In Australia, the previous "12 point rule" was abandoned in 1996 in favour of the IAI

[207] Ibid p 22-23
[208] H Tuthill at p 59
[209] C. Champod et al (2004) p 23-24
[210] Ibid p 24
[211] Ibid p 29-30
[212] As quoted by C Champod et al (2004) p 29. In 1973, the IAI had already adopted the resolution that there was no valid basis for the quantitative approach – C. Champod et al (2004) p 29

resolution. In 2000, the National Fingerprint Accreditation Board adopted a resolution excluding any numerical standard, resulting in a uniform policy across Australia.[213]

In the UK, the adoption of the IAI resolution which resulted in the abandonment of the 16 point standard was significantly influenced by a study of 130 fingerprint examiners in England and Wales. The participants were provided with 10 unknown/known print comparisons and were asked to mark the number of corresponding minutiae. Whilst no misidentifications were reported, there were significant variations in the number of points of comparison found by the participants. In relation to one print, the number varied from 11 to 40 corresponding minutiae observed. A comparable study in Switzerland in 1997 led to disconcerting results specifically in relation to false exclusions. Among other things the UK study concluded that the determination of minutiae is highly subjective. [214]

Champod et al suggest that both the quantitative approach and the qualitative approach are essentially based on a subjective conclusion by the expert.[215] Unlike DNA evidence, fingerprint evidence is not probability based. Rather, the expert effectively assigns the probability of the identification to 100% by declaring a match.[216]

3.2.5. Verification

The verification process provides the principal safeguard against error. Each comparison should be verified by experienced examiners, in a clearly documented process. In order to avoid confirmation bias, the verification should be done blindly.[217]

Champod et al also suggest that the subjective judgments by examiners should be monitored by the setting of training standards, competency assessment and proficiency testing. This would allow an examiner to convince a court of their expertise by presenting a detailed portfolio recording their proficiency in a number of independent proficiency tests.[218]

---

[213] See C. Champod et al (2004) p 31, Table 2.5
[214] C. Champod et al (2004) p 30
[215] Ibid p 31
[216] Ibid p 33
[217] Ibid p 40
[218] Ibid p 39

3.3. Reliability of fingerprint comparison –potential for error

3.3.1. Examples of misidentifications and disputed findings

Although fingerprints are often considered to be the classic example of incontrovertible expert evidence[219], concerns have been expressed about the validity of fingerprint identification. [220] Fingerprint identification mistakes have occurred in the past, and as a result the reliability of fingerprint evidence has been called into question.[221]

Perhaps the most prominent recent example is the Brandon Mayfield case. FBI experts erroneously identified partial latent fingerprints on an exhibit in the Madrid terrorist attacks to the prints of Brandon Mayfield, after a search of the Automated Fingerprint Identification System had produced a short list of potential matches. Upon review it was determined that the identification by the FBI experts was based on an image of substandard quality.[222] Dror & Cole note that the erroneous identification was not only made by one FBI examiner, but also at least two additional FBI examiners who verified the initial examiner's work. An independent examiner appointed by the court also identified Mayfield as the source of the print. It was only when the Spanish National Police subsequently identified the unknown print to an Algerian national that Mayfield was released.[223]

One possible reason for the erroneous identification in the Mayfield case was that the prints were extremely similar, which makes it easier for cognitive biases to affect the examiner's conclusion. The subsequent examiners might have been influenced by the knowledge that previous examiners had already concluded that the prints were from the same source, i.e. they might have been biased by the initial finding. However, the initial examination may also have been biased by the conviction that Mayfield was the source of the print, which caused the examiner to dismiss discrepancies which would otherwise not have allowed an identification.[224] The issue of bias is discussed below.

Another prominent case in which the declaration of a match by the prosecution experts came under scrutiny was the 1999 Scottish case of Shirley McKie. McKie was a police officer involved in a murder investigation. At the murder trial she testified that she had

---

[219] The FBI homepage states that "[f]ingerprints offer an infallible means of personal identification" see http://www.fbi.gov/about-us/cjis/fingerprints_biometrics/fingerprint-overview

[220] A.D. Gold (2009) p 135

[221] R.K.Noon (2009) p 32

[222] FBI press release (2004) as quoted by National Research Council (2009) p 46

[223] I.E. Dror & S.A. Cole "The vision in 'blind' justice: Expert perception, judgment, and visual cognition in forensic pattern recognition" Psychonomic Bulletin & Review 17(2) 2010, 161-167, p 162

[224] Ibid p 163

never been to the murder victim's house. A few months later she was charged with perjury. The only evidence against her was a thumbprint found at the murder victim's house. Four experts from the Scottish Criminal Records Office had identified the thumbprint as having originated from McKie. All experts from abroad who gave evidence at the perjury trial, and other later invited by the Scottish authorities to analyse the print, found that McKie was definitely not the source of the thumbprint from the murder scene. Shirley McKie was acquitted of perjury. The evidence of two leading US experts, who found that there was no match, played a vital part in this result. A subsequent investigation concluded that the thumbprint was not made by Shirley McKie.[225]

Cole suggests that despite media reports, judges, juries and the general public continued to have "infinite faith" in fingerprint evidence.[226]

3.3.2. Fingerprint comparison versus eye- witness identification

Gold suggests that a fingerprint comparison, being a test of comparison and recognition, is not in substance much different to eye witness identification, which involves a comparison and recognition test between a subject and an internal mental image. The claim that "no two fingerprints are alike" fails to address the question of whether two fingerprints can be so similar as to be mistaken for the other. He points out that whilst no two persons are exactly alike, it happens on a daily basis that two different persons are perceived to be similarly alike so as to be mistaken for the other. Gold distinguishes the assumption that no two of something are alike from the logically quite distinct proposition no two of something are sufficiently similar as to be mistaken for one another, and suggests that fingerprint examiners seem to assume the latter proposition.[227]

Whether the comparison with eye witness identification is valid is debatable, given that the circumstances of identification tend to be very different. An eye witness is asked to identify a person whom they have seen during a crime, often only for a brief moment and under traumatic circumstances, from a photo board or an identity parade – i.e. the comparison is based on his/her memory of a particular person. A fingerprint examiner, however, has the latent print and the prints on record in front of them. They do not compare a print from memory to a print in record. However, whilst the comparison with

[225] Shirley McKie website at http://www.shirleymckie.com/facts.htm
[226] S.A. Cole (2001) p 283
[227] A.D. Gold (2009) p 136

eye witness identification seems tenuous, the question of whether a mismatch can occur is live issue which may not receive much attention in the context of a criminal trial.

3.3.3. Proficiency testing

A fingerprint proficiency test was conducted in the US by the Collaborative Testing service in 1995 to determine how well fingerprint examiners match fingerprints to the correct persons. During the test, four fingerprint cards with all ten fingerprints were given to the participants, together with seven latent prints. Of the 156 fingerprint examiners who participated in the test, only 44 % correctly classified all seven of the latent prints.[228] Six examiners failed to indentify matching prints, and 22 % of the examiners reported false positives.[229] This result has been described as "startlingly high for a forensic technique that claimed 'practical infallibility'".[230]

Subsequent proficiency tests resulted in fewer false positives[231] but these numbers were still too high to support the claim that errors in fingerprint identification could not occur.[232]

3.3.4. Fingerprints and bias

Dror & Cole describe fingerprint identification as "cognitively challenging" because even two fingerprint impressions from the same person are not completely identical. Due to factors such as elasticity of the skin, pressure applied, the surface on which the prints are deposited and the method of lifting, even in the best and most ideal cases visual differences are introduced. Hence the role of the analyst is not to determine whether two prints are identical, but rather whether they are sufficiently similar to allow the conclusion that they are from the same source. The possibility of bias and other cognitive influences affecting fingerprint comparison is yet to be fully understood, but a number of studies have been undertaken in this area.[233]

Dror et al note that the human cognitive system can only process a fraction of the available information. What information is processed is determined by our expectations,

---

[228] R.K. Noon (2009) p 32; S.A. Cole (2001) p 281
[229] S.A. Cole (2001) p 281
[230] Ibid
[231] 1996: 3 %, 1998: approximately 15 %, see Cole (2009) p 281
[232] S.A. Cole (2001) p 283
[233] I.E. Dror & S.A. Cole (2010) p 161-162

which are derived from experience, motivation and context. Consequently the presence of any contextual information may affect cognitive information processing.[234]

Dror et al conducted a number of experiments to test the consistency of findings between different fingerprint experts and within the same examiner on different occasions, and the effect of a "target comparison". In the experiment regarding the "target comparison" examiners were provided with five latent prints by themselves (solo condition) and five latent prints with the matching target prints (pair condition). The experts were instructed to record all the minutiae present in the latent print. The experts tended to record fewer minutiae when analysing the prints which were accompanied with a match comparison, so the presence of a target comparison print affected the perception and judgement of the latent print. Dror et al conclude that this finding emphasises the importance of examining the latent print in isolation before the expert looks at the known print.[235]

Following the "target comparison experiment", Dror et al investigated the consistency in the perception and judgement of minutiae in a latent print between different experts as reflected by the results of the solo data. The number of minutiae recorded for the latent prints varied significantly between the examiners. Dror et al note that the apparent lack of consistency in determining how many minutiae are present in a latent print might reflect a lack of objective and quantifiable measures as to what constitutes a minutia, but might also be a result of individual differences between the examiners such as variations in eyesight, training or cognitive style.[236]

Dror et al then conducted an "intra-observer" (i.e. within expert subjects) experiment designed to examine "intra-observer" effects by comparing an examiner's responses at one time to their responses at another time. The examiners used in this experiment were asked to report all the minutiae present on ten latent prints. A few months later the same exercise was repeated. Not only did the examiners differ significantly from each other in the number of minutiae which they reported, there were also varying levels of inconsistencies in how experts analysed the prints the first time and the second time. Dror et al note that the inconsistencies did not only vary between examiners, but also on the latent mark itself, which means that some latent marks are more susceptible to

[234] I.E. Dror et al "Cognitive Issues in fingerprint analysis: Inter and intra-expert consistency and the effect of a 'target' comparison" Forensic Science International 208 (2011) 10-17, p 11
[235] Ibid p 11-13
[236] Ibid p 13

inconsistent analysis than others. Dror et al recommend further research into which latent marks are likely to cause consistency problems in order to recommend procedures to address this problem.[237]

Dror et al pose the question of whether the described variations in minutiae selection are merely an academic issue, or if they impact on the decision-making outcome and thus present a practical concern. They note that on the basis of other research it would appear that the reduction of available minutiae in a fingermark can lead to different decisions, especially where the numbers are close to decision thresholds. [238]

Langenburg et al note that cognitive biases can come in many forms: Context bias is a result of exposure to extraneous information, for example knowledge that a suspect has admitted being at a crime scene, knowledge that a suspect has a criminal history or knowledge that another expert has already declared a match. Confirmation bias relates to the expectations of the observer and means that an observer tends to notice what they want to notice or what they except, rather than evaluate what is present. In the context of fingerprint analysis, confirmation bias might occur when an analyst who is told that a particular print is a match disregards discrepancies in favour of similarities which support the proposition that the prints are a match. [239]

Langenburg et al note that often the second examiner is aware of the first examiner's conclusion, i.e. the verification process is not performed as a blind testing procedure. There is disagreement as to whether blind testing should be mandated for all verifications - which would put a significant demand on the relevant agency's resources - or whether blind testing should be conducted only in limited circumstances, as has been recommended by SWGFST[240], for example in circumstances where there has been a single conclusion in relation to an individual, or a complex latent print comparison.[241]

Langenburg et al conducted a study to assess if fingerprint experts could be influenced by extraneous contextual information during the verification phase. A group of experts was divided in three groups – on control group, one low bias group and one high bias group. Each group was instructed to conduct the same six side-by-side comparisons.

---

[237] Ibid p 14-16
[238] Ibid p 16
[239] G. Langenburg et al "Testing for Potential Contextual Bias Effects During the Verification Stage of the ACE-V Methodology when Conducting Fingerprint Comparisons" J Forensic Sci, May 2009, Vol 54(3)571-582, p 571
[240] Scientific Working Group on Friction Ridge Analysis, Study and Technology
[241] G Langenburg et al (2009) p 571-572

The control group were provided with no contextual information. The low bias group were provided with conclusions which they were told had been reached by a latent print examiner trained to competency, and were instructed to state whether or not they agreed with those conclusions. The high bias group were provided with similar conclusions, but were told by an internationally acclaimed fingerprint expert that these were his opinions from an actual case. The same experiment was repeated with laypersons who had no training in fingerprint comparison. The aim of the study was to test whether there was a measurable effect in the bias groups. On the basis of the outcome of the experiments, Langenburg et al observed a contextual bias effect both for the experts and the laypersons, with a stronger effect on the laypersons. Experts were more resistant to bias suggestions towards individualisation – in fact none of the experts from the bias groups made an erroneous individualisation.[242] The bias effect in the expert groups was towards inconclusive responses rather than definitive individualisation or exclusion, and the effect was equivalent in the low and high bias groups (i.e. the prominent expert was no more influential on the experts than the anonymous expert). It must be noted though that experts from the bias groups revealed after the experiment that they had become suspicious during the experiment and therefore were in an "alert state" which may have impacted on their performance.[243]

Langenburg et al conclude that their study in conjunction with previous studies [244] suggests that fingerprint experts can be influenced by contextual bias, and hence note the importance of reducing extraneous context information. They express the view that a blind testing regime may not be required in all circumstances, but would best be used in complex cases. Based on the outcome of the study they note that blind testing might also be employed when the first expert's finding is an exclusion or inconclusive, in order to avoid false negatives.[245]

Schiffer & Champod conducted a study to find out if the availability of a known comparison print and differing background scenarios – one high profile (terrorism), one

[242] But note that an erroneous individualisation was made by a participant in the expert control group – see G. Langenburg et al (2009) p 578
[243] G. Langenburg et al (2009) p 576-581
[244] G. Langenburg et al at p 577 refer to a 2006 study by Dror et al in which experts were presented with identifications which the experts had made themselves in previous years, but this time the identifications were presented as the FBI's erroneous individualisation to Brandon Mayfield in the Madrid bombing case. In 10 out of 53 trials the expert reached a different conclusion than initially reported. In nine cases the second finding was exclusion or inconclusive finding, whereas the initial finding was an individualisation. Only one case was an individualisation from a previous exclusion, and in this case no contextual information was presented.
[245] G. Langenburg et al (2009) p 581

low-profile (attempted petty burglary) - impacted upon the performance of the participants in identifying minutiae in an unknown print. Contrary to what they expected, they did not observe any effect of the availability of the known prints or context information on the participants' performance. Schiffer & Champod conclude that not all stages of the ACE-V process are similarly vulnerable to observational bias, but note that further research is required for a better understanding of how the ACE-V process could be influenced by potential observational biases, especially in the phases following analysis.[246]

In a review of studies conducted in the area of factors affecting cognitive processes, Dror & Cole conclude that the studies which have been conducted so far show that extraneous information such as emotional context, expectation and motivation affects decision-making and may lead to contradictory decisions. Some examiners are more susceptible than others, and extraneous information affects findings more in cases where patterns are more difficult to compare, and when examiners are unaware that they are taking part in an experimental study. Dror & Cole identify the need for further research in this area to increase the understanding of expert performance. [247]

3.3.5. Subjectivity of conclusion

The National Research Council notes that the ACE-V method does not specify any particular measurement or a standard test protocol, which requires the examiners to make subjective assessments. The subjectiveness/subjectivity is deliberate and allows the examiner to take into account both the quantity and the quality of comparable details. However, this means that the outcome of the analysis is not always repeatable from examiner to examiner.[248]

The National Research Council reports that the criteria for an identification depend on an examiner's ability to observe possibly complex patterns among a large number of features, and on the examiner's experience judging the discriminatory value in those patterns. Particularly when dealing with a latent print which may be incomplete or smudged, the interpretation relies more on the examiner's subjective judgment.

[246] B. Schiffer & C. Champod "The potential (negative) influence of observational biases at the analysis stage of fingermark individualisation" Forensic Science International 167 (2007) 116-120
[247] I.E. Dror & S.A. Cole (2010) p 165-166
[248] National Research Council (2009) p 139

According to the National Research Council, the development of specific measurement criteria would be desirable in order to enhance the reliability of the ACE-V process.[249]

The National Research Council further notes that the subjectivity is intrinsic to fingerprint analysis, which is apparent when compared to DNA analysis. In DNA analysis, studies are available which determine the range of variation in the sequence of base pairs at each of the loci which are generally compared for each of the samples, and also the variations between different populations. The resulting data allow scientists to calculate the probability that two DNA samples from different people have the same variations at each locus. In fingerprint analysis, on the other hand, the features which are compared are not known from the beginning, but are selected during the comparison phase, when an examiner decides which features are common to both the known and the unknown impression and are clear enough to be evaluated. Moreover, a feature which may have been useful in previous comparisons may not have been captured in a latent print. Therefore, unlike in DNA analysis, there are no population statistics for fingerprints and the analysis relies on subjective judgement by the examiner.[250]

The lack of statistical models prevents the examiners from reporting in terms of the probability of a match, hence they testify in terms of absolute certainly.[251] Critics argue that in the light of the lack of validity testing for fingerprinting and the lack of validated standards for declaring a match, this kind of confidence in identification is not justified, and urge examiners to replace claims of "absolute" and positive" identifications by claims about the meaning and significance of a match.[252]

3.3.6. Conclusions by National Research Council

The National Research Council acknowledges that fingerprint analysis is a valuable forensic tool, but criticises claims of a zero error rate as scientifically implausible. [253] Whilst the ACE-V method provides a framework for friction ridge analysis, it does not guard against bias, fails to ensure repeatability and transparency and does not guarantee that different analysts will arrive at the same results.[254]

---

[249] Ibid p 140 - 141
[250] Ibid p 139
[251] Ibid p 143
[252] J.L. Mnookin "The validity of latent fingerprint identification: Confessions of a fingerprinting moderate" 2008 Law Probability and Risk 7:127 as quoted by National Research Council (2009) p 142
[253] National Research Council (2009) p 142. (Note that SWGFAST acknowledges that errors do occur and that claims of a zero error rate are scientifically not plausible. See "Position Summary" at p 4.)
[254] Ibid p 142

The National Research Council notes the need to document the individual steps in the ACE-V process, to allow for the reconstruction of the analysis. Proper documentation of the information gathered during each step and the basis for the conclusion will result in a transparent record of the method, thus providing the courts with additional information on which to assess the reliability of the method for a specific case. [255]

The National Research Council further calls for more research into ridge flow and crease pattern distributions in hands and feet, which would provide examiners with a better understanding of the prevalence of ridge flows and patterns. It notes that uniqueness - whilst a necessary condition for friction ridge analysis – does not guarantee that prints from two different people are always sufficiently different so as not to be confused, or that two impressions made by the same finger are always so similar that they are judged to be from the same source. [256]

In a response to the report by the National Research Council, SWGFAST acknowledges that errors do occur and that claims of a zero error rate are scientifically not plausible. It also acknowledges that subjectivity is inherent in the friction ridge examination process, but notes that subjectivity is present in any scientific activity involving humans as the instrument. It proposes that subjectivity is a necessary aspect of complex reasoning and that the real issue is not subjectivity, but transparency. [257] The president of the International Association for Identification suggested in a memorandum to members (in response to the NAS report) that members should not suggest a zero error rate or "100% infallibility" when addressing the reliability of fingerprint analysis in court.[258]

3.3.7. Problems other than misidentification

Apart from errors regarding the analysis of a fingerprint, incorrect results can also occur on the basis of mislabelled fingerprint evidence.[259] This occurs when fingerprint lifts are submitted as having come from the crime scene, when in fact they were taken from another source, for example, the suspect's residence or a surface touched by the suspect. Unexpected "background noise", i.e. background noise inconsistent with the surface purportedly fingerprinted, may be an indicator that a print has been mislabelled.[260]

---

[255] Ibid p 143
[256] Ibid 145
[257] SWGFAST (2009) p 4
[258] R.J. Garrett "Memo to IAI Members" 19 February 2009 at http://www.theiai.org/current_affairs/nas_memo_20090219.pdf
[259] See I. Freckleton & H. Selby Volume 4 at [96.1100] to [96.1140]. Intentional fabrication of fingerprint evidence by investigators is also a possibility; however, this has not been addressed here because it falls outside the scope of this thesis.
[260] I. Freckleton & H. Selby, Volume 4 at [96.1110]

Careful documentation by the examiner is required to authenticate the evidence, such as:

• photograph latent fingerprints prior to dusting if possible;

• photograph prints in place after being dusted and prior to lifting;

• lift prints in the presence of another person who can testify to the authenticity of the lift. [261]

3.4. Automated fingerprint identification systems (AFIS) and potential problems

Three kinds of AFIS searches are possible:

1. Ten-print to ten-print searches, in order to compare the prints from a suspect in custody against the database in order to determine whether a person is using an alias or has a criminal record.
2. Latent print to ten-print searches, when a latent print is retrieved from a crime scene and cannot be linked to anyone. If the AFIS search does not report a match, the latent print is entered as an unsolved latent print, and is compared against new ten-prints which are subsequently entered into the system.
3. Ten-print to latent print search, to determine if a suspect is responsible for a previously unsolved crime.[262]

For the purpose of criminal prosecutions, 2 and 3 are the most relevant.

Most AFIS systems use minutiae, i.e. ridge characteristics, to match prints, and unlike human examiners they use minutiae in their initial search for matches. When a new print is entered, the AFIS retrieves the images of the possible matches and displays them on a split screen next to the new print. In the final stage a human examiner compares the prints to see if there is a match. It is the human examiner, not the computer, who declares a match, and therefore false positives on the basis of a computer glitch are not possible. [263]

Concerns have been raised that the use of automated fingerprint identification systems such as the US AFIS and the Australian NAFIS present new risks and challenges for fingerprint identification which have not been researched or considered. Dror & Mnookin refer to technologies such as automated fingerprint identification systems

[261] Ibid at [96.1140]
[262] S.A. Cole (2001) p 254
[263] Ibid p 255

which carry out cognitive operations and computations similar to the human cognitive information processing as "cognitive technologies".[264] They argue that in systems such as automated fingerprint recognition a mode of distributed cognition occurs between technology and human experts, with them working side by side as partners. In this scenario the cognitive tasks are divided between the human expert and the technological apparatus. [265] Dror & Mnookin suggest that the use of automated fingerprint recognition systems changes the cognitive tasks of latent fingerprint experts and that the effects of automated fingerprint identification systems warrant significant further inquiry. The use of such systems has changed the cognitive task of making identifications, and it should change the way comparisons are conducted, and what is required to declare a match.[266] Dror & Mnookin express the view that a failure to think through the consequences of the use of automated fingerprint identification systems increases the chances of incorrect identifications.[267]

Dror & Mnookin argue that prior to the use of AFIS, experts would compare the latent print to a fairly small number of known prints, compared to the large quantity of prints available on AFIS. Given the small number of prints and the high degree of variability of prints across individuals, the likelihood that any of the comparison prints would be very similar to the latent print from the crime scene was very low. However, via AFIS the latent print can now be compared to a very large number of prints stored in a huge database, hence the likelihood of finding a print on the database which is from another person but yet extremely similar to the latent print is much higher.[268] The likelihood of an erroneous identification is much higher when comparing two very similar prints than when comparing less similar prints. [269] Dror & Mnookin suggest that decision-making thresholds and criteria for declaring a match should be increased because of database size, and express concerns that this has not been reflected in any formal guidelines from the relevant professional bodies.[270]

Doro & Mnookin also discuss the potential for bias introduced by AFIS. This may occur because AFIS provides the expert with a ranked list of most likely candidates for a

[264] I.E. Dror & J.L. Mnookin "The use of technology in human expert domains: challenges and risks arising from the use of automated fingerprint identification systems in forensic science" Law, Probability and Risk Advance Access published 22 January 2010, 1-21
[265]Ibid p 2
[266] Ibid p 4 - 5
[267] Ibid p 8
[268] Ibid p 9
[269] Ibid p 10
[270] Ibid p 11

match, which may influence the expert's assessment of the prints. Dror & Mnookin argue that experts usually start their comparison with the top AFIS matches, and point out that according to the FBI, when a match is found using IAFIS, the source of the latent print is the top-scoring IAFIS candidate 80% of the time. They query if any modification of the AFIS scores and order would have an impact on the conclusion reached by the expert.[271]

They further raise the possible contamination of the ACE-V methodology as another source of bias introduced by AFIS. This may occur because an examiner would quickly reject a number of the AFIS candidates because AFIS systems rely on the distance between minutiae for selecting similar prints and do not consider overall ridge pattern, hence the examiner will see that a suggested print has a different overall pattern from the latent print and cannot come from the same source, regardless of whether the prints have similar minutiae.[272] Only after this preliminary selection process does the examiner begin the ACE-V process, but at this time he has already engaged in an initial evaluation and deemed the print in question a possible potential match. It is possible that this early scrutiny could have a biasing effect by leading to an examiner's "gut feeling" that he or she is dealing with an actual identification.[273]

3.5. Presentation of fingerprint evidence in court

In the context of the introduction of the non-numerical system for fingerprint identification in the UK, Lord Rooker stated to the House of Lords: "Although there is no set numerical standard to be satisfied before experts make a decision that a mark or impression left at a crime scene and a fingerprint were made by the same person, there are objective criteria which must be satisfied and which must be ***capable of demonstration*** (emphasis added), e.g. in a court, before any decision is made ….".[274]

Freckleton & Selby note that in order for defence to evaluate fingerprint evidence adduced by the prosecution, it is essential for defence to obtain fingerprint examiner documentation of the prints which have been examined from the crime scene and those taken from an accused person. This should then be submitted to an independent

[271] Ibid p 14
[272] Ibid p 15 and fn 17
[273] Ibid p 15
[274] As quoted in I. Freckleton & H. Selby Vol 2 at [12.15.40]

fingerprint examiner, but Freckleton & Selby note that in many jurisdictions there are limited options in this regard.[275]

They recommend that defence counsel focus on the following topics when cross-examining experts on fingerprints and related areas:

• The potential for crime scene prints to have been left at the scene before or after the commission of the offence.

• The possibility that the crime scene prints are of insufficient quality to enable definite identification with those of the accused.

• The potential for doubt as to whether there are sufficient points of identification between the crime scene prints and those of the accused.

• The potential for dissimilarities between the crime scene prints and those of the accused.

• Whether the null hypothesis has been applied in the expert's methodology.

• Whether crime scene examiners have complied with standard protocols.

• Whether the fingerprint examiner has had sufficient training to qualify as an expert in respect of the particular testing or examination that he or she undertook.

• Whether the crime scene prints could have been "planted".[276]

4. Case law on fingerprints

4.1. Australia

Since the early fingerprint cases in 1911 [277] fingerprint evidence has become an orthodox form of identification which is rarely questioned in court.[278] It is accepted that fingerprint evidence can be a legitimate basis for a conviction.[279]

As to the role of the fingerprint expert, in the case of *R v Parker* [280] Cussen J expressed the view that when a fingerprint expert attempts to point out similarities, they are not

[275] I. Freckleton & H. Selby Volume 2 at [12.15.440]
[276] Ibid
[277] See above
[278] I. Freckleton & H. Selby Vol 2 at [12.15.40]
[279] For example in *Moreshead v Police* [1999] SASC 162 (16.4.1999); *R v SMR* [2002] NSWCCA 258 (1.7.2002)

speaking as experts at all but are simply pointing out matters to the jury which the jury could not determine themselves. However, in the case of *R v Lawless* [281] the court held that jurors were not permitted to conduct an examination of fingerprints to form their own opinion as to whether the pints originated from the same source, i.e. they were not allowed to act as experts themselves. However, they are permitted to examine the fingerprint exhibits to determine if they are satisfied to the necessary degree by the evidence of the experts. In this context Freckleton & Selby refer to the prohibition stated by Mason J in *Kozul v The Queen* [282] of an inexpert jury substituting its views for the evidence of an expert.[283]

In Australia there is relatively little case law which considers the reliability of fingerprint evidence. Freckleton & Selby refer to the unreported decision of *R v Darren Walsh,*[284] in which an expert gave evidence that certain identification could be made from the latent print on the basis of eight characteristics which it shared with the accused's print. After a review of the standards adopted in other Australian jurisdictions as well as in Canada and the US, the evidence was admitted. It was held that the question of whether such a contention was correct was a matter for the jury. [285] The High Court case of *Mickelberg v The Queen* [286] addresses the theoretical potential fabrication of fingerprint evidence but does not deal with any principles as to the admissibility of fingerprint evidence in general.

In the case of *Bennett v Police*[287] the court considered whether the evidence of a fingerprint expert should have been excluded on the basis that the expert had not produced the image or copy of the image of the accused's fingerprint and had not demonstrated the features which he observed in the unknown print and the accused's print which caused him to conclude that they were identical. The fingerprint evidence was the basis of, and hence crucial to, the prosecution's case. During the examination-in-chief the expert described in general terms how a comparison is made, and that he compared the unknown print and the accused's print and found them to be identical.[288]

---

[280] [1912] VLR 152 at 160
[281] [1974] VR 398 at 423
[282] (1981) 147 CLR 221 at 227
[283] As quoted by I. Freckleton & H. Selby Vol 2 at [12.15.80]
[284] Victorian Supreme Court 29 March 1993
[285] I. Freckleton & H. Selby Vol 2 at [12.15.160]
[286] (1989) 167 CLR 259; 86 ALR 321; [1989] HCA 35
[287] [2005] SASC 167 (4 May 2005)
[288] at [6]

In cross-examination the expert was unable to produce a blow-up in order to point to the features on which he based his opinion. He also stated that at the time of the comparison he had not recorded the features on which he based his opinion that the prints were identical. The expert was not asked in cross-examination to repeat the process of comparison in court. [289] On appeal it was held that the evidence was admissible. The fact that had to be proved was the presence of features which the expert regarded as significant for the purpose of concluding that the prints were identical. This could be proved without the expert providing a picture of the prints. The failure of the expert to describe in detail what he observed goes to the weight but not the admissibility of his evidence.[290] The court acknowledged that the witness' failure to record any details at the time of the comparison meant that if the witness had been asked to repeat the comparison in court, he might have found similarities which he had not observed during the original comparison. However, it was held that this went to the weight of the evidence only, and that the witness did not have to demonstrate or reproduce what he observed. [291] The court held that the expert had fully informed the magistrate of the facts on which his opinion was based by stating that he compared the unknown print located at the crime scene to the accused's print, and that he had observed features in each print which were considered sufficiently similar and significant to conclude that the prints were identical. It was not necessary to set out the facts in full detail but it was sufficient for the expert to assert that they were present. It was open to defence to cross-examine on the failure to produce the full details.[292]

It is somewhat difficult see how a mere assertion that there were enough features present to declare a match, without being able provide at least some examples of matching features, or a record of how the comparison was done, could constitute more than an "ipse dixit". It raises the question of whether the low threshold as to its admissibility was a result of the court's faith in the technique, and if the result would have been different if a lesser established forensic technique had been the subject of a review.

[289] at [9] to [13]
[290] at [42] to [47]
[291] at [48]to[49]
[292] at [51] to [55]

4.2. New Zealand

Fingerprint evidence was challenged on appeal in the case of *Wallace v The Queen.*[293] One of the grounds of appeal was that the appellant should be allowed to lead "fresh" evidence, i.e. evidence by an expert who had been involved in the Brandon Mayfield case.[294] The expert had analysed the fingerprint relied upon by the prosecution, and, contrary to the prosecution expert who had been called at trial, concluded that there were insufficient points of identification.[295] This ground of appeal was dismissed as insufficiently cogent for a new trial in the context of the case. The Court noted that whilst the defence expert arrived at a different result, he nevertheless concurred that there were some points of identification. [296]

In the context of this appeal ground, the appellant submitted that his trial counsel had not adequately challenged the fingerprint evidence. He contended that challenges could have included cross-examination on the Mayfield case, confirmation bias, the subjectivity of the analyst's judgement call in the context of a poor quality partial print.[297] The cross-examination by defence counsel at trial had focussed on the impossibility of "aging" fingerprints. [298] The Court of Appeal noted:"As we apprehend it, the present situation in the United Kingdom and New Zealand is that courts still largely accept a non-numerical standard, and challenges are not routinely made to the identification. This may be because of an ongoing perception that in general fingerprint evidence is irrefutable and safe. And it may be that, in general, there is something of a lack of adequate defence expertise. On the occasions when challenges are made, they tend to be directed toward discrediting the examiner, raising questions going to the lack of a demonstrably transparent process, or attacking scant recordkeeping. In relation to the latter, examiners are sometimes inclined to document factually what has been done without documenting why a given conclusion has been drawn." [299]

[293] *Wallace and The Queen* [2010] NZCA 46
[294] See below.
[295] at [73] and [74]
[296] at [76]
[297] at [66]
[298] at [71]
[299] at [69]

4.3. UK

In *R v Buckley* [300] the Court of Appeal, in considering the admissibility of fingerprint evidence, held that if there were eight or more similar ridge characteristics, the court had a discretion to admit the evidence. Factors to be considered were the experience and expertise of witness, the number of similar ridge characteristics, whether there are dissimilarities, the size of the print relied upon (fragment or entire print) and the quality and clarity of the print. The court emphasised that it will generally be necessary for the judge to warn the jury that the evidence by the expert is opinion evidence only and not conclusive, and that it is for the jury to determine whether guilt is proved beyond reasonable doubt in the light of all the evidence. [301]

4.4. US

The reliability of fingerprint evidence came under scrutiny in 2002 in the conflicting decisions by Pollak J in the cases of *Plaza 1* and *Plaza 2*.[302] In *Plaza 1* the admissibility of fingerprint evidence was challenged on the basis of the criteria in *Daubert* and *Kumho*. In applying the *Daubert* criteria, Pollak J concluded that fingerprint examination techniques had not been tested in a manner which could be characterised as "scientific". He found that even the leading experts in the fingerprint field had no advanced academic training, and hence rejected the notion that they could be called a "scientific community". He also did not accept that fingerprint identification is controlled by a clear set of standards. He found since fingerprint evidence failed to meet the first three *Daubert* factors, heavy reliance on the "general acceptance" factor was not warranted. He concluded that the ACE-V method did not meet the *Daubert* criteria on the basis that they did not meet the criteria of testing, peer review, rate of error or uniform standards. He did, however, not rule the evidence inadmissible, but - taking judicial notice of the uniqueness and permanence of fingerprints- permitted expert evidence as to how the fingerprints were obtained, place before the jury the fingerprints and such magnifications as were required to show minute detail, and point out similarities and differences between the prints. The experts, however, were precluded from providing their opinion on whether or not a particular print was in fact the print of a particular person.[303]

---

[300] [1999] EWCA Crim 1191
[301] As referred to in I. Freckleton & H. Selby Vol 2at [12.15.200].
[302] United States v Plaza 179 F Supp 2d 492 (2002) and United States v Pollack 188 F Supp 2d 549 (2002). See I. Freckleton & H. Selby Vol 2 at [12.15.280].
[303] As summarised in I. Freckleton & H. Selby Vol 2 at [12.15.280]

In *Plaza 2* the issue was revisited upon an application by the government that Pollak J should reconsider his ruling on the ground of "prosecution effectiveness". He reaffirmed his view that fingerprinting does not constitute a science in terms of being connected with propositions that can be tested or verified. However, he held that fingerprints experts, whilst not scientists, possessed technical or specialised knowledge, hence their evidence should not be discounted. He reaffirmed his previous findings that the *Daubert* testing criterion was not met. Although he concluded that the proficiency tests undertaken by FBI examiners were less rigorous than they should be, he found that there was no evidence before him that the error rate of certified examiners was unacceptably high. Contrary to his previous decision, he found that the standards which control the opinion of a certified fingerprint examiner are sufficiently widely agreed upon to satisfy the *Daubert* standard. Pollak J remained of the view that the criterion of testing was unsatisfied and queried whether therefore a court should conclude that the ACE-V system had too great a likelihood of producing errors, but declined to hold that such evidence should be inadmissible. He concluded that the FBI system of fingerprint analysis, which requires only one verification, sufficiently complied with the reliability requirements of *Daubert* and *Kumho*.[304]

5. Analysis of cases

20 trial transcripts were reviewed. Of the 20 trials reviewed, 19 were District Court trials (18 in Perth, one in Albany) and one was a Supreme Court trial (in Perth). The trial dates ranged between 2008 and 2011.[305] The trials concerned a range of charges: drug-related charges [306] (9 trials), sexual offending [307] (3 trials), burglary offences (3 trials), criminal damage by fire (2 trials), murder (1 trial), conspiracy to commit indictable offence (1 trial) and fraud (1 trial).

In two trials the prosecution adduced "negative" fingerprint evidence, i.e. that no prints were located which matched those of the accused. Hence this evidence could only serve to address the potential "CSI effect"[308], and be adduced for reasons of fairness and for tactical reasons. [309]

[304] As summarised in I. Freckleton & H. Selby Vol 2 at [12.15.280]
[305] See annexed table.
[306] Possession with intent to sell or supply or (attempt) to manufacture prohibited drug
[307] (Aggravated) sexual penetration without consent. In one instance the offending was alleged to have occurred during a burglary.
[308] i.e. a potential expectation on part of the jury - fuelled by relevant TV shows – that forensic evidence will always be available in criminal investigations.
[309] I.e. leading as part of the prosecution case rather than leaving it to defence to adduce, which has the potential of making the prosecution look as if trying to hide the absence of evidence.

In only one case the question of a "match" was a live issue. In the remaining 17 cases [310] the match was not disputed. The defence was essentially that there was an explanation consistent with innocence, such as accidental contact or the timing of the contact with the relevant item.

In one case the expert's report was read into evidence. In one case the result of the analysis was adduced via the crime scene officer who has not seen the final report. The pages of the report with a summary of the findings were tendered by consent.

5.1. Qualifications

The qualifications of the expert were not canvassed in any significant detail in any of the cases, and in none of the cases were any questions asked in cross-examination. No questions were asked about how difficult it is to obtain a formal qualification as a fingerprint expert – how many years of study are required, or if anyone ever fails the final examination.

In eight cases proficiency testing received a short mention in addition to formal qualifications and experience, but no explanation was provided as to what exactly the proficiency testing involves, or how the expert performed. Only one examination-in-chief addressed the issue of how many accurate identifications were required in order to pass.

In one case the formal qualifications were not adduced at all, only the experience. This was a case in which the match was conceded from the outset in the defence opening address. In one case neither qualifications nor experience were mentioned, only that the expert was an accredited expert. This was a "negative" case and therefore counsel probably saw no need to qualify the expert.

The lack of detail in qualifying the expert may have been based on an assumption that the qualifications and the finding would not be challenged, or alternatively a belief in the "infallibility" of the expert's finding.

The practice of only fleetingly addressing an expert's qualifications makes it difficult for the fact-finder to decide how much weight to attach to that particular witness' evidence. [311] How can the jury decide on the "trustworthiness" of the expert? Based on the manner in which the qualifications were addressed in the 20 analysed cases, there

[310] i.e. not counting the two "negative" cases
[311] R. Wheate (2008) p 127

appears to be an expectation that the jury will simply accept that a police fingerprint expert is suitably qualified.

5.2. Process of fingerprint comparison

The process employed by the expert to arrive at their conclusion as to a match or elimination was not addressed at all in 13 of the 20 cases.

In six of the remaining seven cases the examination-in-chief included brief references to some aspects of the process, without explaining it fully or in any detail. The following explanations were provided by the expert when asked what the process involves:

- The expert analysed the unknown print first, then compared it to the known print.

- The expert looked at the unknown print and established that it was a palm print. Then he looked at the general ridge flow of the known print. Then he looked at other details to see if they matched.

- The expert looked for features in the unknown print and then in the known print.

- The expert looked for details in the unknown print to see if it was suitable for comparison.

- The expert provided a brief explanation as to analysis and evaluation, and explained that the comparison is done manually, either on the computer screen or with an eye glass.

- Analysis aspect (of the ACE-V method) and the various level details that can be found in a fingerprint (this was a case with a negative finding).

In none of these cases was the process or the rationale behind it fully explained. The basis for the conclusion was not explained either, although in once in one trial the prosecutor specifically asked for the basis of the expert's conclusion.

In only one case was the process explained in any significant detail. The expert explained that he looked for features in the unknown print and compared them against the features in the known print. He explained the various level details that can be found in a print, and that there is no set number but that it is a holistic approach. An identification is not made until he feels that there is sufficient quality and quantity between them to make a comparison. Interestingly, in this case the prosecutor asked the expert to demonstrate on the basis of the photograph of the print what exactly he looked

at to make a comparison, i.e. to explain the basis for declaring a match. The expert replied that he had an exemplary chart which was probably more concise than showing what he did on these particular prints. He explained on the basis of the chart how the comparison is made, but it was not entirely clear if a full analysis of the unknown print had been done before the comparison stage. Despite the relatively extensive explanation the basis for the conclusion was not explained as the expert did not explain on the basis of the actual print in question how many matching features he found, or whether the unknown and known prints shared any unusual or rare features.

The process of fingerprint analysis generated very little cross-examination. In only three of the 20 cases did cross-examination touch upon the issue, and only in one of those three cases was the issue canvassed in any meaningful way. The following issues were raised:

• A brief reference that the comparison is done by a human not by a machine. This point appears to have aimed at the potential for error, but was not further explored, presumably because the match was not disputed.

• A question how many points of similarity were required to declare a match, to which the expert replied that there was no prescribed number but in this case he had found 16 points of similarity (none these were demonstrated or explained and no further questions were asked).

• How the actual comparison is done (which had not been addressed in examination-in-chief), and that it is a visual comparison. The line of questioning appeared to aim at highlighting the subjectivity of the process. It seems to have triggered a somewhat indignant response from the expert, who responded that there was no doubt that the identification was correct.

• The abolition of the 12 point rule in 2003, a question which clearly aimed at a lack of a particular standard for declaring a match. The expert was asked how many of the identifications he would have made under the old 12 point system. The expert responded that he would have made all of them but was unable to produce any comparison charts for his identifications. The rationale for abolishing the 12 point rule was not canvassed in re-examination, nor was the basis for declaring a match.

5.3. Reliability of the expert's conclusion

The reliability of the conclusion did not receive any attention in examination-in-chief, apart from an occasional fleeting reference to peer review.

In only two cases did cross-examination address the issue. One was limited to a short reference to the possibility of a distortion of the print by movement of the finger, a matter which was not further explored, presumably because the finding was not in dispute and in fact conceded from the outset.

The other case concerned a partial palm print, which had been identified to the respective palm of the accused. In cross-examination defence queried how, given the incompleteness of the print, the expert could be confident that there was no deviation in the rest of the print. The expert simply responded that there was enough in the developed print to satisfy him with absolute confidence that the print was made by the accused. It was not explained why there was sufficient material to declare a match. The tenor of the cross-examination was that the partial print might be consistent with coming from the accused, but that it was also possible that the missing part of the partial print would be different. This suggestion was entirely rejected by the expert, but no explanation was given as to why it could be rejected, i.e. on what basis a deviation in the missing part could be excluded. Defence also put to the expert that fingerprint analysis was not an exact science as demonstrated in studies, to which the expert replied that it was a scientific process and there were many studies which proved the accuracy of the technique. The expert was not asked to elaborate on those studies.

5.4. Areas commonly addressed in examination-in-chief

The focus of examination-in-chief was on the following areas:

• The process of locating fingerprints at the crime scene and/or on an exhibit, the treatment of how to make the visible and how they are lifted (17). This was usually explored in some detail.

• The factors which affect if a fingerprint is left behind after the touching of an item, and how long it lasts (13). Again this was explored in some detail by the expert.

• What a fingerprint is and why a person would leave a fingerprint, and the uniqueness of fingerprints (although the latter did not include any references to any particular studies or experiments).

• The exact location of a print at the crime scene or on the exhibit.

5.5. Areas commonly addressed in cross-examination

The following areas were addressed in cross-examination:

• The impossibility of "aging" fingerprints (5).

• Factors which affect how long fingerprints last for and how quickly they deteriorate (3).

• The exact location of a fingerprint on an exhibit or at a crime scene (3).

• The pressure required on contact to leave a fingerprint behind (2).

• Manner of leaving bloody prints.- i.e. that a print can be left either by a hand with blood on it touching a surface, or a hand touching a surface with wet blood on the surface (1) .

These questions tie in with a defence which does not dispute the match, but suggests an explanation consistent with innocence for the leaving of the print. Examples includes accidental touching, or touching on an occasion other than during the commission of the offence.

In the case concerning the bloody print, the expert was asked in re-examination if he could comment on which of the two scenarios was the more likely one. The expert said that in his view the blood material was on the hand and then touched the surface, as there was not enough material there for someone to leave an impression by touching the surface.

The issues of distortion and whether the print was a tonal reverse or not was not canvassed.

Further areas included the following:

• The process of detecting fingerprints at a crime scene.

• Mislabelling of an exhibit (thereby wrongly concluding that a print had been left on an incriminating item, when in fact it had been left on a less incriminating item).

• Factors determining if prints were left, and possibility of individuals other than the accused touching the item without leaving a print, or a print suitable for analysis.

• Taking expert through the items which had no result incriminating the accused. (i.e. reinforcing lack of evidence.)

5.6. Miscellaneous observations

Unsubstantiated assertions:

The writer noted some instances in which the basis of an expert's assertions was not addressed. These include:

•References to studies which show that fingerprinting is "entirely accurate and correct", without mentioning any specific study or the background thereof;

• References to research as to the uniqueness of fingerprints without explaining what kind of research;

• A comment by the expert that after an individual touches an item there is probably more chance that one will not find fingerprints as opposed to finding fingerprints without explaining why, or if there is any research on this issue;

• An estimate by the expert as to the time and pressure required to leave a fingerprint on a particular exhibit, without explaining what that estimate was based on.

Underlying assumption that fingerprint analysis is a scientific process

It is noted that there were some instances in which it became apparent that either the expert or counsel proceeded on the basis that fingerprinting is a science. This included instances of the experts referring to the "basis of our science" and describing fingerprinting as a "scientific process" (without explaining what scientific principles are applied), and counsel referring to the "science" of fingerprinting".

Declarations of confidence replacing argument

As indicated above, the actual conclusion on part of the expert was rarely subject to any challenge in cross-examination. The few challenges appear to have caused some indignation on part of the expert.[312] It is noted that the challenges were met with assertions as to the reliability of the conclusion as opposed to a convincing argument as to why the challenge might be unjustified.

In one instance the expert, upon being questioned as to why in case of a partial print he could be so sure that there was no deviation in the rest of the print, declared his full confidence that the partial print was made by the accused. The expert appeared to

[312] Given that the findings are based on reading the trial transcripts as opposed to attending the actual trials, the writer is unaware of the tone in which the responses were delivered. The conclusion as to the indignation is based on the content of the responses only.

suggest that there was no possibility that there was a deviation, and that there was sufficient information to say "unequivocally" that the print was made by he accused. No explanation was provided on what basis a deviation could be excluded.

In two cases the potential for error was mentioned in cross-examination. In one case the expert responded by saying that there are lots of studies showing that fingerprint evidence is "entirely accurate and correct". No studies where cited, and no explanation was provided as to why fingerprint evidence should be considered reliable. In another case the potential for error was not expressly put to the expert, it was only hinted at by reference to the process being a visual comparison. Instead of explaining the process, the expert responded by stating that if he/she made an identification, there was "no doubt" that it was a correct identification.

Efficiency of trial process

In most cases the match was not disputed, and it seems that on that basis it was not considered necessary to lead the evidence any significant detail. In one case the expert report was tendered through the forensic examiner (who had not conducted the actual analysis), and in one case in which the match was admitted the judge indicated a preference for counsel not to explore the details of the process.

Evidence outside of field of expertise

In one case the forensic examiner who had not been asked any questions about his qualifications and expertise was asked about the factors which affect whether or not fingerprints are left behind. This was not challenged. In another case a fingerprint expert commented on the slide marks on the window depicted in one of the crime scene photos, simply citing years of experience as crime scene officer as basis for these comments. Another expert was asked to comment on the position and location of the depositor of the print based on the orientation of the print, which is probably more a matter for the jury.

5.7. Discussion of result

5.7.1. No testing of reliability

Based on the 20 cases analysed, the reliability of the fingerprint findings presented - or the trustworthiness of the evidence – is generally not explored or tested in a meaningful way.

Based on the decision of *Bennett v Police* [313] the criteria for the admission of fingerprint evidence are met without the expert going into the details of the comparison or demonstrating or describing the similarities based on which an identification was made. As discussed above, according to that decision a general description of the process and an assertion that sufficient features were present to declare a match - which is essentially what was done in the cases reviewed for this study - satisfy the criteria for the admissibility. On that basis the lack of detail as to the findings does not affect the admissibility of the evidence.[314] However, the court in *Bennett* noted that a failure of the expert to provide any details of what he observed might affect the weight of the evidence. Given that in the majority of the reviewed cases the fingerprint evidence was not in dispute, this factor is unlikely to have affected the outcome, but this might well be an issue in cases in which the match is not conceded.

From a scientific perspective though the manner in which the evidence was presented in court is not suited to ensure the reliability of the findings.

The lack of explanation as to the process makes it impossible to judge whether there might have been any flaws in the process, if the analysis can be repeated with the same result, and if, in fact, there was an independent (blind) peer review which arrived at the same conclusion. Most significantly, though, the fact-finder is left in the dark as to the basis for the conclusion. Explanations as to why there was a match are limited to the observation that there were enough similarities to declare a match, but it is entirely unclear whether this is based on a subjective assessment or whether there are any specific criteria for declaring a match (and if so, what they are).

Equally significant is the failure to canvass any possibility of an error in the identification. The question of whether fingerprints can be so similar as to be misidentified, particularly taking into account issues such as distortion, smudging or incompleteness of the unknown print, receives little (if any) attention.

Given that in some instances fingerprint evidence is explicitly referred to, and hence portrayed, as science, it seems unfortunate that the reliability of the findings is not subjected to any rigorous testing in court.

---

[313] Discussed above

[314] *Bennett* is a South Australian case and the Court of Criminal Appeal in Western Australia may or may not arrive at the same conclusion if a similar case arises in the WA jurisdiction.

5.7.2. Possible explanations for lack of focus on process and reliability of the result

The circumstances of each case are different and it is impossible to reliably ascertain on the basis of the transcript alone why the evidence adduced in a particular manner, and why it was not challenged.

Possible explanations include:

• Counsel may not be familiar with the actual process of fingerprint analysis, or any aspects thereof which might be open to challenge. There might also be a belief in the infallibility of the technique.

This could best be addressed with appropriateness training of lawyers appearing in criminal trials, and improved pre-trial communication between the expert and the lawyers, in particular thorough proofing of the expert.

• An anticipation on part of the prosecution that the result would not be in dispute, and a desire not to burden the jury with "unnecessary" explanations or a desire not to delay the proceedings with "unnecessary material".

This is a more difficult issue to address, as the efficiency of the trial process tends to be a significant consideration for an advocate. However, the fact that a prosecutor chooses to adduce fingerprint evidence means that the evidence is relevant (otherwise it should not be adduced in the first place) and the fact-finder will have to decide on the weight to be attributed to the evidence. Therefore the process and underlying basis for the expert's conclusion should at least be briefly explored in order to meet the legal requirements as set out in *Makita* and *Hillstead*. The expert could briefly outline the ACE-V process, and explain what sort of characteristics they would look for. Whilst it would be impractical to go through every single matching feature, the expert could at least show the jury a couple of matching points. From a defence perspective, of course, it would be counterproductive to challenge a favourable finding, such as a negative print.

• There is an explanation consistent with innocence therefore defence see no need to challenge the accuracy of the finding.

This is of course a forensic decision by defence counsel which will depend on the overall circumstances of the case. In some instances one might expect to find an accused's fingerprint on an item or at the crime scene, and the fingerprint evidence is just a relatively minor part of the prosecution case as it can easily be explained. However, there is no reason why defence cannot take a two-pronged approach, i.e.

query the accuracy of the finding and also suggest an explanation consistent with innocence. There is no inherent contradiction in arguing that a) there might be a question mark as to whether the print really originated from the accused, and b) if it does, the accused might have accidentally touched the item (e.g. because he/she was a resident at the house, or had come into contact with the item on another occasion).

II. DNA evidence

1. Introduction

DNA - deoxyribonucleic acid - is a molecule which encodes the genetic information in all living organisms.[315] DNA analysis has evolved to become an indispensable and routine part of forensic casework, allowing for biological material such as saliva, skin cells, or hair left behind at a crime scene to be linked to an individual. It is said to have revolutionised forensic investigations. [316]

DNA evidence is considered to be powerful evidence. [317] It has been described as "the most powerful scientific technique available [...] since the adoption of fingerprints"[318], and as possessing "a considerable aura". [319] There is a perception of DNA being evidence as "infallible". [320]

Since its introduction as a forensic tool DNA evidence has resulted in numerous convictions. It has also led to the exoneration of wrongfully convicted people, a number of whom had been convicted on the basis of unreliable results of other forensic techniques. [321] For example, since 1992 the Innocence Project has assisted over 250 people who were convicted of criminal offences to be exonerated on the basis of DNA testing.[322] DNA profiles found at a crime scene can be searched against large databases, and unsolved "cold cases" can be solved decades later by analysing degraded DNA from stored swabs or microscopic slices. DNA analysis also assists in the identification of victims of mass disasters, where physical identification might be impossible. [323]

STR[324]- based forensic DNA analysis has been accepted worldwide as reliable means of individual identification. [325] It has been suggested that DNA testing should set the standard on how forensic science should be done. [326] Faigman et al note that because the

---

[315] D.L. Faigman et al (2006) p 54
[316] M.A. Jobling & P. Gill "Encoded Evidence: DNA in Forensic Analysis" Nature Reviews (5) October 2004, 739-751, p 739
[317] Ibid p 739
[318] L.A. Foreman et al "Interpreting DNA evidence: A Review" International Statistical Review (2003), 71, 3, 473-495, p 473
[319] J. Buckleton & J. Curran "A discussion of the merits of random man not excluded and likelihood ratios" Forensic Science International: Genetics 2 (2008) 343-348, p 346
[320] L. Geddes "Between Prison and Freedom" New Scientist 14 August 2010 p 8
[321] Ibid
[322] The Innocence Project at http://www.innocenceproject.org/about/Mission-Statement.php
[323] M.A. Jobling & P. Gill (2004) p 739
[324] STR stands for short tandem repeats – see under overview.
[325] M.A. Jobling & P. Gill (2004) p 744
[326] L. Geddes (2010) p 8 quoting William Thompson (University of California); L.A. Foreman et al (2003) p 473

basic theory and most of the laboratory techniques of DNA profiling are so widely accepted in the scientific community, disputed issues in a legal context involve features unique to the forensic application of DNA analysis, or matters of laboratory technique. Examples include to what extent standard techniques have been shown to work with crime scene samples which might have been exposed to environmental factors, possible ambiguities impacting on the interpretation of results, and the validity and possible prejudicial impact of match probabilities. [327]

2. Overview of DNA

DNA is a chemical substance within the nucleus of our cells (nuclear DNA) that contains the informational code for replicating the cell.[328] DNA has been described as "our genetic blueprint"[329] or "blueprint of life"[330] as it contains all the information that an organism requires in order to function and to pass down genetic attributes to future generations.[331] DNA is a complex molecule consisting of subunits which include four nucleotide bases. Their names are abbreviated to A, T, G and C. Two strands of nucleotides are intertwined to form a double helix. [332] The DNA molecule is like a long sequence of those four letters. The chemical structure that corresponds to each letter is called a base pair. [333] The various combinations of the nucleotides or bases create the various biological differences among humans. [334]

Within human cells, nuclear DNA is divided into 23 chromosomes. Each cell contains two sets of chromosomes, one from each parent. [335] The DNA in chromosomes consists of "coding" and "non-coding" regions, of which the coding regions ("genes") contain the information necessary for the cell to make proteins.[336]

For forensic purposes it is necessary to produce a DNA profile which is highly discriminating between individuals, which depends on individuals being different at genetic level. Forensic DNA testing is based on the premise that except for identical twins, no two individuals have the same DNA. However, despite differences in

[327] D.L. Faigman et al (2006) p 57
[328] DNA can also be found in the mitochondria (mitochondrial DNA) – see J.M. Butler "Fundamentals of Forensic DNA Typing" (2010) Elsevier Inc Burlington, San Diego, London, p 375. This thesis is limited to the discussion of nuclear DNA.
[329] J.M. Butler (2010) p 19
[330] W. Goodwin et al "An Introduction to Forensic Genetics" 2007 John Wiley & Sons, Chichester UK, p7
[331] Ibid; J.M. Butler (2010) p 19
[332] D.L. Faigman et al (2006) p 90-91, 138
[333] Ibid p 91
[334] J.M. Butler (2010) p 20
[335] W. Goodwin et al (2007) p 7;J.M. Butler (2010) p 23
[336] J.M. Butler (2010) p 25

appearance, individuals are very similar at genetic level – humans share around 99.9% of their genetic code with each other. For forensic purposes there would be little value in analysing the 99.9% of the human DNA which is common between individuals. Forensic genetics focus on well characterised regions within the genome which are variable between individuals.[337]

The regions which are characterised by variable ("polymorphic") markers and hence differ between individuals are the non-coding regions, i.e. areas which do not code for genetic variation.[338] The physical position of a gene or DNA marker in a non-coding region on a chromosome is referred to as a "locus".[339] Alternative forms of a gene or section of DNA at a given genetic locus are called "allele". [340] If the two alleles at a genetic locus are different, they are called "heterozygous", if they are identical they are called "homozygous". It is essential for human identity testing that there are detectable differences in alleles at corresponding loci. The characterisation of all alleles present at a locus is called "genotype", and a DNA profile is the combination of genotypes on various loci.[341]

Many repeated DNA sequences can be found throughout the human genome. They are typically located between the genes and can therefore vary in size between individuals without impacting on their genetic health. The repeated DNA sequences are typically designated by the length of the core repeat unit, as well as the number of repeats or the overall length of the repeat region. [342] The most commonly analysed genetic variations in the forensic context are short tandem repeats (STRs), also known as microsatellites. [343] STRs are polymorphic regions of DNA where alleles differ in the number of tandemly arranged core repeats[344], so STRs are length polymorphisms. [345] STRs were first used in forensic case work in the mid-1990s and are now used as the primary tool by forensic laboratories worldwide. [346] STRs are suitable for forensic case work because the number of repeats in STR markers can vary significantly between individuals, therefore they have high discriminatory value. Since their repeat size is

[337] W. Goodwin et al (2007) p 11
[338] J.M. Butler (2010) p 25
[339] W. Goodwin et al (2007) p 142
[340] Ibid p 141
[341] J.M. Butler (2010) p 25
[342] Ibid p 147
[343] W. Goodwin et al (2007) p 12
[344] Ibid p 143
[345] Ibid p 12
[346] Ibid p 11-12

small, both alleles from a heterozygous individual have a similar size and can therefore easily be amplified by the polymerase chain reaction (PCR).[347]

3. History

The potential forensic application of DNA was first realised in 1984, when Alec Jeffreys discovered hypervariable loci known as variable number tandem repeat (VTNR) loci.[348] Whilst VNTR analysis was a powerful tool it suffered from a number of limitations because it would only work with a relatively large amount of DNA and not on degraded DNA, the comparison between laboratories was difficult and the analysis time-consuming.[349]

The first DNA-based criminal investigation was carried out using "single-locus probes", i.e. specific cloned mini-satellites that each revealed only a single, highly polymorphic restriction fragment length polymorphism, thus simplifying interpretation. [350] This was a case involving the sexual assault and murder of two girls in the UK. The murders occurred in 1983 and 1986 near the same village and had similar features, which led police to believe that they had been committed by the same offender. A local man confessed to killing one of the girls. However, his DNA did not match the DNA evidence from either crime. During a mass screening from all local men in the surrounding villages more than 4000 individuals were tested, without a match. About a year later a male was overheard to be bragging about how he had given a blood sample for a friend named Colin Pitchfork. Pitchfork was subsequently interviewed by police and a blood sample was taken from him. His DNA profile was found to match the semen from both murder scenes and he was convicted of the offences. [351] Jobling & Gill comment that Pitchfork showed "prescience in realising the power of DNA analysis" by trying to evade the mass screening of the locals. [352]

In 1983 Kary Mullis developed the polymerase chain reaction ("PCR"), which was a significant development in the history of forensic genetics. PCR enables the amplification of specific regions of DNA and significantly increases sensitivity.[353] It allows DNA profiles to be generated from just a few cells and from degraded DNA, and

[347] J.M. Butler (2010) p 148.
[348] M.A. Jobling & P. Gill (2004) p 740; W. Goodwin et al (2007) p2
[349] W. Goodwin et al (2007) p 3
[350] M.A. Jobling & P. Gill (2004) p 740
[351] J.M. Butler (2010) p 5 (box 1.2)
[352] M.A. Jobling & P. Gill (2004) p 741
[353] W. Goodwin et al (2007) p3-4; M.A. Jobling & P. Gill (2004) p 741

reduces the time required to produce a profile. [354] PCR now forms the basis for all forensic DNA typing.[355]

Apart from technical advances, quality control is another factor which had an impact on the whole field of forensic science. Legal challenges to the admissibility of DNA evidence in the USA in the late 1980s have led to increased levels of standardisation and quality control in forensic genetics, with accreditation of both laboratories and individual experts becoming increasingly important issues. As a result of the combination of technical advances, high levels of standardisation and quality control, forensic DNA analysis has been recognised as a robust and reliable forensic tool worldwide.[356]

4. Procedure

4.1. Collection and storage of biological material

The high level of sensitivity of DNA analysis can be a disadvantage in that there is a real possibility of contamination of the evidentiary material with biological material from another source. In order to avoid contamination, appropriate measures must be taken such as preserving the integrity of the crime scene, and attending officers wearing protective suits and face masks. If evidence is not properly handled it might result in cross-contamination, degradation of the crime scene samples, and confusion in the interpretation of evidence. [357]

Butler recommends the following precautions for the collection of evidence in order to preserve it properly:

• Avoid contamination of areas where DNA might be present by not touching anything with bare hands, or sneezing or coughing;

• Use latex gloves which should be changed between handling different items of evidence;

• Package each item of evidence separately;

• Stains such as blood or semen must be dried before sealing the package;

---

[354] Ibid
[355] M.A. Jobling & P. Gill (2004) p 741
[356] W. Goodwin et al (2007) p 4-5
[357] W. Goodwin et al (2007) p19

• Package samples in paper bags or envelopes as opposed to plastic bags, so as to avoid the condensation of water which can accelerate the degradation of DNA;

• Mark packages clearly with case number, item number, collection date and initial across the seal to maintain a proper chain of custody.

• Allow swabs taken from stains to air-dry without touching any others, and store them in separate envelopes. [358]

The methods used for the collection of evidence will depend on the type of biological evidence. Dry stains and contact marks on large immovable items can be sampled with sterile swabs, or the scraping or cutting of material. Epithelial cells[359] can be lifted from a surface with high quality adhesive tape. Liquid blood can be collected with a syringe or pipette, or by using a swab or piece of fabric to soak up the liquid. Smaller movable objects, or items of clothing, are usually packaged and analysed in the laboratory using the same swabbing, scraping or lifting techniques. Following allegations of sexual assault, semen can be recovered from the victim by a trained medical examiner using swabs. Other potential biological evidence might be fingernail scrapings and hair, and contact marks such as bite marks or bruising, can also be swabbed for DNA. [360] Reference samples from a suspect and in some cases the victim are usually taken with buccal swabs that are rubbed on the inside of the cheek to collect cellular material. [361]

Evidentiary material collected for DNA analysis needs to be stored in appropriate conditions - usually cold and dry - to reduce the rate of DNA degradation. [362] Incorrect handling of samples during storage and transport from the crime scene to the laboratory can render a sample unfit for analysis. For example, bloodstains should be dried prior to transport to prevent the growth of mould. [363] The exact conditions will depend on the nature of the biological material and the environment in which it is to be stored. [364]

The importance of the correct handling of DNA evidence became apparent during the high profile US trial of O J Simpson in 1994. Simpson had been charged with

[358] J.M. Butler (2010) p 82
[359] Epithelial cells are cells which are normally found on an inner or outer body surface, such as skin cells or vaginal cells – see J.M. Butler (2010) p 447
[360] W. Goodwin et al (2007) p20-21
[361] Ibid p 23
[362] W. Goodwin et al (2007) p 23; J.M. Butler (2010) p 87
[363] J.M. Butler (2010) p 87
[364] W. Goodwin et al (2997) p 23

murdering his former wife Nicole Brown Simpson, and Ronald Goldman. [365] DNA evidence was an important part of the prosecution's case, with prosecutors expecting the DNA evidence to link the accused to the crime scene. [366] Evidence collection and preservation of the evidence played in important part in the defence attack on the DNA evidence.[367] Allegations of contamination of evidence due to sloppy laboratory practices became the focus of the argument, and forensic laboratories have since improved their standards to ensure that their handling of the evidence will stand up to scrutiny. [368] In fact, in the lead-up to the preliminary hearings in the Simpson trial Nowak commented that the admissibility hearings might do more to maintain standards in forensic laboratories than the two NAS[369] reports on DNA testing. [370]

4.2. DNA extraction and quantification

Since biological evidence from a crime scene in form of stains or swabs contain a number of substances apart from DNA, the DNA molecules must be separated from other cellular material before they can be examined. [371] Proteins or other cellular material can inhibit DNA analysis, hence the separation of DNA molecules by way of extraction is necessary to produce DNA which is sufficiently pure for analysis. [372] Once the DNA has been extracted, it needs to be accurately quantified for subsequent analysis. [373]

DNA can be extracted by a number of different methods, including the Chelex 100 ® method, silica based DNA extraction, phenol-chloroform-based DNA extraction and the use of FTA® paper. [374] The different stages of DNA extraction include the disruption of the cellular membranes which result in cell lysis, protein denaturation and the separation of DNA from the denatured protein and other cellular components. [375] Goodwin et al note that some biological materials, for example semen or hair shafts, present more challenges for DNA extraction and require variations of the basis methods. DNA

---

[365] J.M. Butler (2010) p 84 (box 4.2)
[366] S. Jasanoff "The Eye of Everyman: Witnessing DNA in the Simpson Trial" Social Studies of Science, Vol 28, No 5/6 Special Issue on Contested Identities: Science, Law and Forensic Practice (Oct-Dec 1998) 713-740, p 713
[367] In the preliminary hearings concerning the admissibility of the DNA evidence, the statistical calculation as to the frequency of a DNA profile also played a significant part – R. Nowak "Forensic DNA goes to Court with O.J." Science Vol 265, 5177, 2 September 1994, 1352-1354, p 1352
[368] J.M. Butler (2010) p 84 (box 4.2)
[369] National Academy of Sciences
[370] R. Nowak (1994) p 1354
[371] J.M. Butler (2010) p 99
[372] Ibid; W. Goodwin et al (2007) p 27
[373]W. Goodwin et al (2007) p 27
[374] Ibid p 27-30
[375] Ibid p 28

extraction from semen is further complicated by the fact that it is often recovered as a mixture of spermatozoa and epithelial cells. It is possible to separate the spermatozoa from the epithelial cells by way of differential lysis. [376]

After extraction DNA needs to be quantified, i.e. measured to ascertain the accurate amount of DNA present in a sample. [377] In order to obtain the best quality results, it is necessary to add the correct amount of DNA to a PCR – too much or too little will result in a profile that is difficult or even impossible to interpret. Since biological samples from a crime scene do not tend to be in pristine conditions and might often consist of just a small number of epithelial cells, the amount of DNA that can be recovered can be very small and hard to quantify. [378] Quantification methods include visualisation on agarose gels, UV spectrophotometry, fluorescence spectrophotometry, and hybridization.[379]

4.3. The polymerase chain reaction (PCR)

PCR has the ability to make hundreds of millions of copies of a specific sequence of DNA within only a few hours. It is an enzymatic process in which a specific region of DNA is replicated over and over again, thus producing many copies of a particular DNA sequence. It has greatly benefitted forensic DNA typing, because without the ability to make multiple copies of DNA molecules, many forensic samples would be impossible to analyse, as both the quantity and quality of the sample left behind at a crime scene is limited.[380]

A PCR has the following components:

• Template DNA - PCR will work with low level of template, but if the amount of template DNA is reduced, the interpretation of profiles can become more complex;

• *Taq* DNA polymerase - an enzyme which can tolerate the high temperatures involved in PCR;

•Primers – they define the region of the genome to be analysed. It is important to design primers for forensic analysis which will bind to conserved regions of DNA, therefore effectively amplifying human DNA from all populations, whereas at the same time not binding to the DNA of other species;

[376] Ibid p 30
[377] J.M. Butler (2010) p 114; W. Goodwin et al (2007) p 32
[378] W. Goodwin et al (2007) p 32
[379] Ibid p 32-36
[380] J.M. Butler (2010) p125

• Magnesium chloride, nucleotide tri-phosphates and reaction buffer. [381]

The DNA is amplified during the cycling phase of the PCR, which consists of three stages. During the denaturation stage, the double stranded DNA molecule melts due to the high temperature, resulting in two denatured single stranded DNA molecules. During the annealing phase primers attach to two different strands of DNA. The temperature is subsequently increased, and during the extension stage the enzyme Taq polymerase finds the free ends of the primers and starts to add nucleotides which are complimentary to the template strand, which results in the end-product of two double-stranded copies of the template DNA. The usual range of PCR cycles is between 28 and 32, but where the amount of DNA is very low the number of cycles can be increased to up to 34 cycles. This is known as low copy number PCR. An increase in the number of cycles increases the possibility of contamination and extreme precautions have to be taken to avoid this. [382]

Potential difficulties affecting PCR:

Stochastic effects due to low levels of template DNA

Biological samples in a forensic context often have low levels of DNA. When very low levels of DNA are amplified, a phenomenon known as stochastic fluctuation can occur. Stochastic effects are an unequal sampling of the two alleles present from a heterozygous individual. They may result when only a few DNA molecules are used to initiate the PCR process. Stochastic effects may lead to allele dropout, which may falsely result in an allele to be taken as homozygous if the other allele is not detected. [383]

PCR inhibition

The PCR process can be affected by substances which interfere with the DNA amplification or prevent it from occurring properly. These substances can be present in DNA samples taken from a crime scene. Examples include textile dyes used in denim, or compounds from soil. These substances might be extracted together with the DNA that is to be analysed. The presence of an inhibitor during PCR might result in a loss of the alleles from the larger sized STR loci or even complete failure of all loci. [384] Some DNA extraction methods are effective at removing commonly encountered PCR

[381] As outlined by W. Goodwin et al (2007) p 40-42
[382] W. Goodwin et al (2007) p 42-44
[383] J.M. Butler (2010) p 131
[384] Ibid p 140-141

inhibitors[385], and additional purification steps can be taken to remove PCA inhibiting material.[386]

Contamination

Since PCR is sensitive to low amounts of DNA, precautions need to be taken to avoid contamination. [387] Contamination can occur during the collection of the evidentiary material[388], and at the laboratory. Scientists need to wear protective clothing (including face masks and head cover) to prevent contaminating the samples. A database of the profiles of all laboratory staff can be used to detect if any contamination could have occurred at the laboratory. Reference samples from suspects and crime scene samples should be analysed in separate areas to avoid cross-contamination. Appropriate cleaning procedures for laboratory equipment need to be in place. [389] Butler recommends that equipment for setting up PCR should be kept separate from other laboratory supplies, especially those used for the analysis of PCR products, and that aerosol-resistant pipette tips should be used and changed on every new sample in order to prevent cross-contamination during liquid transfers. [390]

Both during the extraction process and PCR positive and negative controls must be carried out to monitor for contamination. A positive control involves a PCR with DNA of a known origin and known profile. If this leads to successful analysis, it shows that the reaction worked. [391] A negative control is a sample which consists only of PCR amplification reagents without any template DNA.[392]

Goodwin et al note that previously amplified PCR products present the most potent source of contamination, hence the physical segregation of the pre-PCR and the post-PCR analysis is a fundamental feature of any laboratory that engages in PCR analysis. As a result of PCR there are millions of copies of the target sequence that can potentially contaminate subsequent reactions. A single droplet of aerosol will contain thousands of copies of the amplified target. The opening of a PCR tube will cause some aerosol spray and this may result in the transfer of the amplified product. [393] Amplified

[385] W. Goodwin et al (2007) p 45
[386] J.M. Butler (2010) p 140
[387] J.M. Butler (2010) p 141; W. Goodwin et al (2007) p 45
[388] See above
[389] W. Goodwin et al (2007) p 46-47
[390] J.M. Butler (2010) p 141-142
[391] W. Goodwin et al (2007) p 46-47
[392] J.M. Butler (2010) p 455
[393] W. Goodwin et al (2007) p 47

DNA will be preferentially copied during PCR because it is more concentrated than unamplified DNA, which will result in the masking of the unamplified DNA. [394] Goodwin et al recommend that PCR products never be brought back into the pre-PCR area of a laboratory, and that scientists who have worked in the post-PCR area do not return to the pre-PCR area without at least an overnight break. [395]

4.4. STR markers

The naming of STR systems which is commonly used today was recommended in 1993 by the DNA Commission of the International Society for Forensic Haemogenetics. Alleles are named by the number of repeats they contain.[396] Hence alleles are described with numbers – for example, an individual might have alleles 14 and 17 at a particular locus.[397] If an individual is homozygous at a particular locus, there would be two alleles with the same number.[398]

In order to allow for comparisons of results between laboratories and the development of national databases, standardisation of STR markers is required. [399] A number of commercial STR systems have been developed which test a number of specific loci. [400] The STR system commonly used in Western Australia for forensic DNA typing is *Profiler Plus* [401], which allows for the testing of nine loci and the amelogenin.[402]

In particular in cases of alleged sexual offending it will be necessary to ascertain is a particular sample came from a male or females source, in order to distinguish between material from the victim and the offender. The most popular method for gender identification is the amelogenin system, which can be performed in conjunction with STR analysis. [403] The amelogenin locus has been incorporated in all commonly used STR multiplex kits. [404] Butler notes that in rare cases a deletion of the amelogenin gene

[394] J.M. Butler (2010) p 142
[395] W. Goodwin et al (2007) p 48
[396] J.M. Butler & D.R. Reeder "Short Tandem Repeat DNA Internet Database" at http://www.cstl.nist.gov/biotech/strbase/index.htm
[397] See W. Goodwin et al (2007) p 61 table 6.2
[398] J.M. Butler (2010) p 39 figure 2.10 (c)
[399] W. Goodwin et al (2007) p 52
[400] Ibid p 52; J.M. Butler (2010) p 154-160
[401] As per Dr Gavin Turbett during lecture on 21 September 2008 "Forensic DNA Statistics" (Murdoch University)
[402] J.M. Butler (2010) p 159 (box 8.3)
[403] Ibid p 166
[404] W. Goodwin et al (2007) p 53

on the Y chromosome can result in the absence of the Y-chromosome amplicon, in which case a male sample would falsely appear as female. [405]

4.5. Measuring STR polymorphisms

After PCR, the length of the amplified products must be measured precisely, as some alleles differ only by one base pair. [406] Since a multiplex PCR[407] produces a number of different DNA fragments representing different alleles, it is necessary to separate the various molecules. [408] This is done by electrophoresis, which is a process for separating charged molecules based on their movement through a medium under the influence of an applied electric field. [409] Forensic science laboratories now employ capillary electrophoresis for the separation process. [410] For the purpose of detection of the DNA molecules following electropheric separation, most commercially available STR kits use fluorescently labelled PCR primers. [411]

During electrophoresis the labelled PCR products migrate across the capillary towards the positively charged anode, which results in their separation by size. Throughout the electrophoresis a laser is shone through the window of the capillary. As the PCR products travel past the window the laser hits the fluorescent label, which leads to the PCR products emitting fluorescent light. The light passes through a filter to remove any background noise and onto a charged device camera that detects the wavelength of the light. The information is then recorded by computer software. [412]

The output is represented as peaks in an electropherogram.[413] Since the spectra of dyes used for labelling PCR products overlap, the raw data contain peaks that contain more than one dye colour. The computer software removes spectral overlap and calculates the size of the amplified DNA fragments. The height of the peaks is measured in relative fluorescent units ("RFU") and it correlates to the amount of PCR product that is detected. The end result is an electropherogram with a series of peaks representing

---

[405] J.M. Butler (2010) p 167
[406] W. Goodwin et al (2007) p 54
[407] A multiplex PCR co-amplifies multiple regions of a genome with more than one set of primers and allows information from the different target sequences to be collected at the same time – see J.M. Butler (2010) p 454
[408] J.M. Butler (2010) p 175
[409] R.K. Roby & D. Figarelli "Amplified DNA product.separation" at http://www.nfst.org/pdi/Subject05/pdi_s05m01.htm
[410] R.K. Roby & D. Figarelli "Capillary Electrophoresis" at http://www.nfst.org.pdi/Subject05/pdi_s05m02.htm
[411] J.M. Butler (2010) p 187
[412] W. Goodwin et al (2007) p 55
[413] R.K. Roby & D. Figarelli "Capillary Electrophoresis"

different alleles. [414] Those peaks can be genotyped through the use of software, which is supplied by the instrument manufacturer. The amplified product is combined with an internal size standard which provides an internal reference to standardize the electropheric run and allows for the base pair sizes of the detected peaks to be calculated. [415]

The last step in the generation of a DNA profile consist of assigning specific alleles to the amplified PCR product, i.e. each peak is given a number which describes the structure of that allele. [416] This is done by correlating the PCR products sizes to an allelic ladder which is used like a measuring

ruler.[417] An allelic ladder is a mixture of all the common alleles at a particular locus[418] and it calibrates a series of electropheric runs.[419] The unknown peaks in the newly generated profile are compared to the allelic ladder. They should fall within a one base-pair window that is +/- 0.5 bp (base pair) of the allelic ladder size, otherwise they are classified as off-ladder alleles. The comparison to the allelic ladder can either be done manually or by using appropriate software, which will compare all the unknown alleles in the profile to the allelic ladder.[420]

4.6. Interpretation of profiles

The genotype information resulting from the comparison to the allelic ladder needs to be analysed by an experienced analyst.[421] This process can be one of the most difficult aspects of forensic DNA analysis. [422] In order to assist with the interpretation, guidelines have been developed which are aimed at ensuring that the results are robust and consistent. Guidelines are particularly important in situations in which the interpretation is more complicated, e.g. samples that contain a very small amount of DNA, degraded DNA or mixed profiles.[423] However, it is not possible to develop interpretation criteria which cover every possible circumstance. [424]

---

[414] W. Goodwin et al (2007) p 56-57
[415] B.R. McCord & E. Buel "Capillary Electrophoresis in Forensic Biology" Analytical techniques 2000 Academy Press,127-135, p 132
[416] W. Goodwin et al (2007) p 57
[417] J.M. Butler (2010) p 207
[418] W. Goodwin et al (2007) p 141
[419] B.R. McCord & E. Buel (2000) p 132
[420] W. Goodwin et al (2007) p 58-59
[421] J.M. Butler (2010) p 231
[422] D. Figarelli "Data interpretation and Allele Calls" at http://www.nfstc.org/pdi/Subject06/pdi_s06_m03.htm
[423] W. Goodwin et al (2007) p 65
[424] D. Figarelli "Data Interpretation..."

4.6.1. Factors potentially affecting interpretation of genotype results

There are a number of factors which can cause ambiguity in the interpretation of DNA profiles. With low quantities of DNA, it can be difficult to distinguish low level peaks from technical artefacts. Most laboratories have established peak-height thresholds for "scoring" an allele, i.e. a peak will only be accepted as a true allele if its height, which is measured in RFUs, exceeds a certain standard value.[425]

Artefacts are a result of chemistry and instrument-related issues. They include dye blobs, spikes and noise. Dry blobs are disassociated primer dyes. They tend to be wider than real peaks, and can mask real data. Spikes are narrow peaks which can be caused by voltage fluctuation or the presence of minor air bubbles in the capillary. Noise describes a series of background peaks along the baseline. It occurs in all samples, and can be caused by various factors, for example current fluctuations. If the noise is close enough to threshold values, it can be confused with a true allele or "mask" a true allele. [426]

Other factors include stutter peaks, split peaks and pull-ups. Stutter peaks are produced during the amplification of an STR allele by strand slippage during PCA, which results in peaks one repeat unit smaller or larger than the true allele. Threshold limits are used to identify and interpret stutter peaks, which is particularly important when interpreting mixtures. Stutter peaks are typically less than 15 % of the main peak. [427] Stutters may make the interpretation of mixtures more difficult if the mixtures contain peaks at a low height. [428]

Split peaks occur during PCR if the polymerase is unable to complete the extension for all amplicons. [429] This will result in an allele of interest being represented by two peaks which are one base pair apart. [430] This might cause problems in the interpretation when alleles are present which differ only by one base pair. [431]

"Pull-ups" occur if the detection instrument fails to properly resolve the dye colours used to label STR amplicons, which leads to the peak of another colour being "pulled

[425] R. Vossbrink "Data Troubleshooting" at http://www.nfstc.org/pdi/Subject06/pdi_s06_m02.htm
[426] Ibid
[427] W. Goodwin et al (2007) p 65
[428] T.M. Clayton et al "Analysis and interpretation of mixed forensic stains using DNA STR profiling" Forensic Science International 91 (1998) 55-77, p 58. For further discussion regarding the interpretation of mixtures, see below.
[429] R. Vossbrink "Data troubleshooting"
[430] J.M. Butler (2010) p 218
[431] W. Goodwin et al (2007) p 66

up". [432] This might create false peaks at the loci of different dye colours. Whilst "pull-ups" can usually be recognised by careful analysis of the position of peaks across the colour spectrum, it is possible that an analyst fails to observe them, especially if their result is consistent with the analyst's expectations.[433]

A further issue is variation in peak height in heterozygous loci, which can occur if one allele is amplified more efficiently than another due to chance events. Laboratories commonly require the smaller peak of a locus to be within 60% of the bigger peak. In good quality products the smaller peak tends to be approximately 90% of the size of the bigger peak. [434]

An allele drop-out occurs when one or more alleles are not present in a typed sample. It can be caused by a number of reasons. The original quantity of DNA might have been too small, leading to a failure to amplify all the alleles present in the sample. A failure to amplify alleles might also be caused by a mutation in the primer binding site. An allele might also drop out because it is too small for the usual "allele calling range" and hence remain undetected. [435]

Degraded DNA leads to a DNA profile in which the smaller loci are over-amplified whereas the larger alleles might be barely detectable, or even drop out altogether. This complicates the interpretation of profiles, especially of homozygous loci are detected – they might be truly homozygous, but it is also possible that one allele dropped out. [436] A reduction in the peak height might also lead to peaks which are difficult to distinguish from background noise.[437]

4.6.2. Interpretation of mixtures

A mixture arises when more than one individual contribute to a sample. A number of factors indicate whether a tested DNA sample contains a mixed DNA profile: More than two peaks in the expected size range at a particular locus, a severe height imbalance between heterozygous alleles at a locus, and stutter product which appears to be abnormally high.[438]

---

[432] J.M. Butler (2010) p 219
[433] R. Vossbrink "Data troubleshooting"
[434] W. Goodwin et al (2007) p 70
[435] R. Vossbrink "Data troubleshooting"
[436] W. Goodwin et al (2007) p 71-73
[437] R. Vossbrink "DNA trouble-shooting"
[438] J.M. Butler (2010) p 322

Mixed profiles need to be interpreted against a background of artefacts, including stutter peaks and "null alleles" (i.e. undetected alleles [439]), with stutter products presenting the greatest challenge in interpreting a mixture and designating the appropriate alleles. [440] In mixed profiles in which the minor contributor's allelic peaks are of similar height as that of stutter peaks, a peak in a stutter position might be a stutter peak, an allelic peak or overlapping allelic peak and stutter peaks. [441] The German Stain Commission recommends that when in doubt as to whether a peak is a stutter peak or a true allele, the peak should be considered a true allele and part of the DNA profile, and should be included in the statistical calculation.[442]

If an analyst has determined that the DNA profile is most likely a mixed profile, the possible number of contributors must be ascertained. The number of alleles at each locus and their relative peak heights provide useful information. For example, in a mixture containing individuals who are heterozygous at one particular locus, the maximum number of alleles at that locus would be four (but see below for possible exceptions). Five or six alleles at a particular locus indicate three or more contributors. [443]

Generally the locus with the greatest number of allelic peaks provides the basis for an estimate of the minimum number of contributors, e.g. five alleles at a locus are consistent with coming from at least three individuals. However, in rare instances an individual might have a tri-allelic pattern presenting as three peaks at a locus, consequently a five allele pattern might be a result of two contributors, one of whom carries a tri-allelic profile. [444]

Budowle et al suggest that the true number of contributors to a mixture cannot be determined conclusively. An estimation of the minimum number of contributors should not be mistaken as a designation of the absolute number of individuals who must have

[439] Ibid p 456
[440] Ibid p 325-237
[441] B. Budowle et al "Mixture Interpretation: Defining the Relevant Features for Guidelines for the Assessment of Mixed DNA Profiles in Forensic Casework" J Forensic Science, July 2009, Vol 54, No 4, 810-821, p 817
[442] P.M. Schneider et al "The German Stain Commission: recommendations for the interpretation of mixed stains" Int J Legal Med (2009) 123:1-5, p 2
[443] T.M. Clayton et al (1998) p 60
[444] B. Budowle et al (2009) p 813-814

contributed to a profile, nor does it imply that a mixture of three individuals could not possibly be a mixture of only two individuals. [445]

Clayton et al suggest that for two-person mixtures the next step after determining the number of contributors is to determine the approximate ratio (varying proportions of a mixture) of the components in the mixture. The admixture ratio at each locus remains approximately the same after amplification. [446] Consequently the peak areas and heights in an electropherogram can usually be related back to the amount of DNA template components included in the mixed sample. Mixture rations cannot always be accurately calculated at each locus, especially if there are shared alleles between the contributors. Stutter products and peak height imbalance also complicate the estimation of ratios. The amelogenin marker might assist in determining whether the major contributor is male or female. [447]

However, the distinction between major and minor contributors is only possible if there is a distinct contrast in signal intensity between the various alleles. [448]

The next step requires the consideration of all possible genotype combinations at each locus.[449] Depending on the type of mixture, it may not be possible to unambiguously attribute the alleles to single sources.[450] Budowle et al distinguish between "resolvable" or "distinguishable" mixtures, and "unresolvable" or "indistinguishable" mixtures. Mixed profiles are usually resolvable when two contributors donate different amounts of DNA to the mixture, which allows the distinction between the minor and major contributor. Budowle et al note the importance of criteria to define what constitutes a minor and a major profile in a mixture. [451] However, even in a two-person mixture with major/minor contributors it may not be possible to conclusively determine the profile of the minor contributor: Due to potential difficulties in distinguishing the minor peaks from stutter peaks, the resultant profile for the minor component might be ambiguous. [452] Further, the major contributor might mask the minor contributor's alleles at some loci, which might lead to those alleles being undetectable. [453]

---

[445] Ibid p 814
[446] T.M. Clayton et al (1998) p 60-62
[447] J.M. Butler (2010) p 326
[448] Figarelli "Data Interpretation..."
[449] J.M.Butler (2010) p 326
[450] B. Budowle et al (2009) p 814-815
[451] Ibid p 814-815
[452] T.M. Clayton et al (1998) p 63
[453] B. Budowle et al (2009) p 815

When contributors to a mixture share one or more alleles, the alleles are "masked" which may make it difficult to ascertain the contributing genotypes. [454] Butler provides the example of two individuals having genotypes 23,24 and 24,24 at the FGA locus. A mixture ratio of 1:1 will produce a ratio of 1:3 for the 23;24 peak areas. Without any further information, the mixture could be interpreted as a homozygous allele with a large stutter product. However, the examination of other loci with unshared alleles might allow for the sample to be dissected properly into its components.[455]

Mixtures are usually unresolvable when multiple donors contribute similar amounts of DNA, and it is not possible to attribute at least one of the profiles to a known donor, e.g. from the epithelial fraction of a vaginal swab. Mixtures with major and minor components may have unresolvable contributors at the major or minor contributions, or both. For example, a locus might have five alleles, four of which can be grouped as major component, based on their size. The four major alleles are an unresolvable mixture. The minor contributor might be homozygous at the smaller peak, or heterozygous with the second allele being masked by any of the other four alleles, hence the genotype of the minor contributor cannot be resolved either. [456]

Budowle et al note that it may not be possible to interpret some mixtures, and that those tend to be mixtures of at least three contributors where quantitative "deconvolution" is more complex. Depending on the complexity, such mixtures might provide information which is only useful for exclusionary purposes but not for inclusionary/statistical statements.[457]

In some circumstances it may be appropriate to proceed on the assumption that a profile from a particular individual forms part of the mixed profile, and subtract that profile from the mixture.[458] For example, a sample taken from an identified anatomical location, e.g. a vaginal swab, will usually provide a DNA result from the individual from whom the sample was taken. Any DNA typing result consistent with that profile can reasonably be subtracted from the mixed profile to attempt to deduce the profiles of other contributors. [459] Budowle et al note that in cases where the subtraction approach is

[454] J.M. Butler (2010) p 320-323
[455] Ibid p 323
[456] B. Budowle et al (2009) p 815
[457] Ibid p 815
[458] T.M. Clayton et al (1998) p 64
[459] B. Budowle et al (2009) p 815

taken, the assumptions and reasons justifying this approach must be described and documented. [460]

The higher the number of possible contributors to a mixture, the more difficult is becomes to "deconvolute" a resolvable mixture or determine the potential contributing genotypes to an unresolvable mixture, due to the increased potential for allelic overlap. As a consequence of allelic overlap, an allelic peak may be a result of multiple copies of an allele from various donors as opposed to two copies from a homozygous donor, or a single copy allele from a heterozygous donor. Alleles must be attributed on the basis of relative peak heights across all observed peaks. However, this method might not always produce unambiguous results. For example, a profile of 15, 16, 19 with corresponding peak heights of 300, 650 and 375 RFU is consistent with a homozygous contributor of 16,16 and a heterozygous contributor of 15, 19, but also with two heterozygous contributors of 15,16 and 16,19. Further, the slightly unequal amplification of two allelic peaks during PCR increases the difficulty of ascertaining the contributing genotypes in a multi-contributor profile.[461]

The last step in mixture analysis is to compare the genotype profiles for the possible components in the mixture with the profile from the reference samples, which in cases concerning sexual offending are usually the reference samples from the suspect and the victim. [462]

The three possible conclusions are exclusion, inclusion or inconclusive.[463] If a reference sample has alleles which are not observed in the mixed profile, and their absence cannot be explained by degradation of the evidence sample, the donor of the reference sample can be excluded[464] , i.e. that person shall not be considered as a possible contributor to the mixture.[465] An inclusion occurs when the alleles identified in the reference sample are identified as part of the mixed profile.[466] In that case the donor of the reference profile shall be considered as a possible contributor to the stain.[467] Budowle et al note that a conclusion regarding an inclusion requires both a qualitative

[460] Ibid p 816
[461] Ibid
[462] J.M.Butler (201) p 326-327
[463] B. Budowle et al (2009) p 818
[464] Ibid
[465] P.M. Schneider et al (2008) p 2
[466] B. Budowle et al (2009) p 818
[467] P.M. Schneider et al (2008) p 2

assessment (presence of an allele) and quantitative assessment, i.e. consideration of potential genotypes taking into account the relative peak heights.[468]

For unresolvable mixtures, all allelic peaks are considered collectively in order to determine which loci can be used for statistical purposes. If any peak heights at a particular locus are below the threshold, the locus cannot be used for statistical purposes. However, the alleles can still be used for exclusionary purposes.[469]

Butler notes that some laboratories may not follow the step of fully deciphering the genotype possibilities and assigning them to the major or minor contributors, and simply include or exclude a suspect's profile from the crime scene mixture. If all of the alleles in a suspect's profile are represented, the suspect cannot be excluded.[470]

If a profile is too complicated to interpret, it is reported as "inconclusive", which might be expressed as "no meaningful statistic can be applied".[471]

4.6.3. Classification of mixed stains

The German Stain Commission recommends that mixed stains be classified as follows:

• Type A - stains which have no obvious major contributor and no evidence of stochastic effects;

• Type B – stains where major and minor components can clearly be distinguished, with consistent peak height ratios of 4:1 between major and minor component across all heterozygous loci, and no stochastic effects;

• Type C – stains with no major components and evidence of stochastic effects.[472]

Depending on the type of stain, different statistical calculations may be appropriate for the type of mixture. [473]

4.6.4. Subjectivity affecting interpretation

Given that DNA profiles can be ambiguous due to factors such as missing alleles, mixtures and stutter peaks, DNA analysts will regularly have to decide whether to report a profile in the context of missing alleles, or additional alleles which do not

[468] B. Budowle et al (2009) p 816
[469] Ibid p 818
[470] J.M. Butler (2010) p 330
[471] P. Gill et al "Interpretation of complex DNA profiles using empirical models and a method to measure their robustness" Forensic Science International: Genetics 2 (2008) 91-103, p 91-92
[472] P.M. Schneider et al (2008) p2
[473] P.M. Schneider et al (2008) p3-4. See also discussion as to statistical calculations below.

match the suspect. This can lead to inconsistencies with some experts applying a probative value to a result, whereas others might be more cautious and report an inconclusive result which neither excludes nor includes the suspect. [474]

An analyst's subjectivity could influence the interpretation of a DNA profile and hence the result. [475] DNA analysts have to make certain allowances when assessing whether or not a suspect can be included or excluded from a mixture, given the potential difficulties affecting the interpretation of mixtures such as:

• problems determining the exact number of contributors;

• inability to tell which alleles belong to which contributor (hence at each locus there might be number of different potential genotypes for a contributor);

• uncertainty if all alleles of all contributors have been detected. [476]

Thompson notes that this creates the potential for "target-shifting", i.e. an interpretation of the unknown mixtures which fits with a particular expectation based on knowledge of the reference profile – "hitting the target with DNA evidence".[477] He describes an informal experiment he conducted with three different groups of DNA experts. All three groups were shown the same evidentiary mixed profile, but each group was given a different profile of a different "suspect". Neither the "suspect's" profile presented to the first group nor the victim's profile accounted for all peaks in the evidentiary profile. The experts took the view that the alleles which did not fit were not true alleles but artefacts. The second group of experts considered the peak which the first group had dismissed as an artefact as a true allele, which meant that it fitted in with the profile of the "suspect" presented to that group. The fact that the suspect's second allele at that locus was not detected in the evidentiary profile was explained with an off-ladder allele detected at that locus "masking" the suspect's allele. The third group supported the inclusion of the third "suspect", and explained the fact that not all of his alleles appeared in the evidentiary sample with allelic drop-out and "masking".[478]

Thompson suggests that "target-shifting" can be avoided by "sequential unmasking". This means that before looking at a reference sample an analyst would first look at the

[474] P. Gill et al (2008) "Interpretation of complex profiles..." p 91
[475] L. Geddes (2010) p 8-9
[476] W.C. Thompson "Painting the target around the matching profile: the Texas sharpshooter fallacy in forensic DNA interpretation" Law, Probability and Risk (2009), 8, 257-276, p 258
[477] Ibid p258-260
[478] Ibid p 261-262

unknown sample and determine the alleles, the number of contributors and the probability of allele drop-out. The analyst should then make a record of the genotypes which would lead to an individual being excluded or included at each locus. The reference samples would then be unmasked sequentially, starting with those from expected contributors to a mixture (e.g. the victim in a sexual assault case). The analyst would then compute the frequency of individuals who would be included as possible contributors and document an unbiased assessment of the genotypes of possible contributors, hence "fixing the target and computing its size". Only after this has been completed would the analyst determine whether the suspects have the genotypes required "to hit the target".[479]

4.7. Statistical calculation – significance of the evidence

If the unknown DNA profile matches the profile from a reference sample, it becomes necessary to determine the significance of this finding. In criminal trials the question for the jury is what conclusion can be drawn from a matching profile – did it come from the same individual, or is it possible that somebody else is the source of the unknown sample, i.e. that the samples only match by chance? [480]

Given that not every single person's DNA profile is known, the possibility of a random match has to be extrapolated from smaller population data sets. In order to estimate the probability of a random match, allele frequencies are collected from various ethnic and racial sample sets. [481] The occurrence of alleles within the define population is recorded on an "allelic frequency database". [482] The expected genotype frequency at each locus is calculated on the basis of observed allele frequencies and principles of population genetics. [483]

In the context of forensic genetics, the term "population" means a group of people sharing common ancestry and its classification is quite broad, combining many subgroups that might differ in culture, language and religion in groups such as

[479] Ibid p 273
[480] J.M. Butler (2010) p 229, 243
[481] Ibid p 229
[482] W. Goodwin et al (2007) p 78
[483] J.M. Butler (2010) p 229, W. Goodwin et al (2007) p 78

"Caucasian", "East Asian" etc. [484] Allele frequencies for each locus might differ between various ethnic populations. [485]

Whilst in some cases the ethnic origins of material recovered from a crime scene are known, for example if a witness is able to describe the ethic appearance of an offender, in other cases there may be no information as to an offender's ethnicity. In countries with large different ethnic groups the profile frequency is often calculated by using an allele database for each major population group and using the most conservative profile frequency. [486]

Goodwin et al point out that the more alleles that are measured as a part of the allelic database, the more accurate it will be. However, given that not all alleles in a large population are measured and included in the database, there will be some inaccuracies based on the limited size of the database. Whilst this will not affect common alleles to a significant degree, the impact of limited sampling can have a big impact on rare alleles which can easily be underrepresented in a frequency database. [487]

The limitations of allele frequency databases can be addressed with various approaches which are outlined by Goodwin et al. The "allele ceiling principle" addresses the situation in which a very rare allele may not appear at all in the frequency database, which would then lead to an allele frequency of zero. This can be addressed by setting a minimum allele frequency, and adjusting any allele which falls under this frequency to this figure. The "Balding correction"[488] for size bias compensates for the limitations of allele frequency databases caused by sampling effects by adding the alleles of the unknown sample and reference sample to the frequency database in cases where the two samples match. This leads to a recalculation of the frequency. This approach has the greatest impact in cases of small databases or when an allele is rare. [489]

Goodwin et al further note the potential need to allow for the presence of subpopulations in the calculation of profile frequencies. Even within the same broad ethnic group the population is not homogenous but comprises related subpopulations, which are formed because people have children with partners from the same

[484] W. Goodwin et al (2007) p 75
[485] For example see J.M. Butler et al "Allele frequencies for 15 autosomal STR loci on US Caucasian, African American and Hispanic populations" Journal of Forensic Sciences, July 2003, Vol 48 (4), 908-911
[486] W. Goodwin et al (2007) p 83
[487] Ibid p 78-79
[488] This method was suggested by DJ Balding – see W. Goodwin et al (2007) p 80 and fn 20
[489] W. Goodwin et al (2007) p 78-83

geographical area or social group, i.e. mating might not be random. Within a subpopulation there is a higher degree of relatedness between individuals than there is to the whole population, i.e. a higher possibility of individuals sharing some genetic markers. This might lead to error in the calculation of profile frequencies. This can be addressed by the use of a theta value in calculating the profile frequency, which in most legal systems varies between 0.01 and 0.03.[490]

There are a number of different statistical approaches regarding the evaluation of DNA evidence[491], which are outlined below.

4.7.1. Random match probability

The "random match probability" is the probability that an individual selected at random has the same DNA profile as an accused person[492], i.e. the probability that a randomly selected person unrelated to the accused who was not the source of the unknown sample would happen to match.[493] The match probability calculates the chance of two unrelated individuals sharing the same DNA profile. [494]

The match probability is calculated by multiplying the individual allele frequencies in the profile in question. The value of the match probability will be lower with an increasing number of tested loci, and will substantially increase in the following scenarios:

• The number of loci is reduced because of a partial profile (where the DNA is degraded);

• If a suspect and a perpetrator are related and therefore share many alleles;

• If a suspect and a perpetrator originate from the same subpopulation. As the frequency of alleles and DNA profiles can vary between subpopulations, guidelines are now applied to ensure that match probabilities quoted in court are conservative, i.e. favour the accused.[495]

The use of multiple STR kits may result in match probabilities which by far exceed the number of people on the planet. [496] In the UK the approach to such large numbers has

[490] Ibid p 80-82
[491] Ibid p 88
[492] Ibid
[493] W.C. Thompson (2009) p 259
[494] M.A. Jobling & P. Gill (2004) p 742
[495] Ibid
[496] W. Goodwin et al (2007) p 88

been to use a ceiling principle, i.e. using a match probability of 1 in a billion – a value which is much lower than the most common profile frequency even under consideration of conservative corrections. [497] Goodwin et al comment that the "ceiling principle" approach is pragmatic rather than being built on scientific merit. [498]

Butler notes the importance of correctly expressing the random match probability, and recommends that the random match probability be stated in the following terms: " [T]he probability of selecting the observed profile from a population of random unrelated individuals is expected to be 1 in 15,000 based on the alleles present in this sample". [499] If the random match probability is incorrectly worded, it may result in the fallacy of the "transposed conditional", i.e. confusing the match probability with the probability of a DNA profile coming from someone else, or the probability of an accused person having committed the offence.[500] This is also known as the "prosecutor's fallacy". [501] Foreman et al demonstrate this with a quote the following passage from the transcript of the UK case of Doheny, who was tried for sexual offences in 1990 and whose conviction was challenged on appeal:

"Forensic scientist: 'I calculated the chance of finding all these bands and the conventional blood groups to be about 1 in 40 million.'

Judge: 'The likelihood of it being anyone other than Alan Doheny?'

Forensic scientist: 'Is about 1 in 40 million.' " [502]

The appeal which was heard together with another appeal on the basis of misrepresentation of the statistical evidence [503] resulted in a judgement which provided recommendations as to the manner in which DNA evidence should be reported, including a recommendation that it was not the role of the DNA expert to comment on the likelihood of the accused leaving the crime scene sample.[504]

Butler also notes the problem of the "defence attorney's fallacy" which assumes that everyone else with the same genotype has an equal chance of committing the offence, disregarding factors such as access to the crime scene, motive and alibis. Butler cautions

[497] Ibid p 82 and 88
[498] Ibid p 88
[499] J.M. Butler (2010) p 251
[500] Ibid; L.A. Foreman et al (2003) p 475
[501] J.M. Butler (2010) p 251
[502] L.A. Foreman et al (2003) p 475
[503] *Doheny & Adams* [1997] 1 Cr.App.R 369 – see L.A. Foreman et al at p 476
[504] L.A. Foreman et al (2003) p 476

against considering DNA evidence and corresponding frequency estimates in a vacuum without any other contextual information. [505]

4.7.2. Likelihood ratio

A different way of assessing the weight of the comparison between the unknown profile and the known profile is the likelihood ratio ("LR"), which involves a comparison of the probabilities of the evidence under two alternative and mutually exclusive propositions/hypotheses. [506] In a criminal case this will be the ratio of the prosecution hypothesis that the unknown DNA profile originated from the suspect, and the defence hypothesis that the unknown DNA profile did not originate from the suspect but from another individual. [507] A likelihood statement might be expressed as follows:"DNA analysis of the blood stain from the crime scene gave a full DNA profile that matched that of the suspect. If this blood did not come from the suspect then the STR profile must match by chance. The results of the DNA analysis are approximately 1 million times more likely if the DNA came from the suspect than if the DNA came from a random unrelated male in the population." [508]

Cook et al note that whilst in criminal matters the propositions can often be limited to a prosecution and defence proposition, the clear specification of those propositions can be difficult. Cook et al suggest that there are three broad levels of propositions: Level 1 relates to the source of the trace material, level 2 relates to activities and level 3 relates to the offence. This is described as the "hierarchy of propositions".[509] An example for the three levels of propositions is the following:

Level 1 (source): "The semen came from Mr B" vs. "The semen came from some other man".

Level 2 (activity):"Mr B had sexual intercourse with Ms Y" vs. "Some other man had sexual intercourse with Ms Y".

Level 3 (offence):"Mr B raped Ms Y" vs. "Some other man raped Ms Y".[510]

---

[505] J.M. Butler (2010) p 251
[506] Ibid
[507] W. Goodwin et al (2007) p 89-91
[508] W. Goodwin et al (2007) p 91
[509] R. Cook et al "A model for case assessment and interpretation" Science & Justice 1998; 38(3):151-156, p 153
[510] R. Cook et al "A hierarchy of propositions: Deciding which level to address in casework" Science & Justice 1998; 38 (4):231-239, p 232

Level 1 propositions generally require little circumstantial information, whereas level 2 propositions require a framework of circumstances. The less information a scientist has, the lower the level of propositions they can address. The higher level of propositions addressed by a scientist, the more their expertise comes into play. Evidence in relation to a level 2 proposition might require expertise in assessing probabilities of transfer and persistence. Level 3 propositions are outside the domain of a scientist and a matter for the jury to consider. [511]

Likelihood ratios are primarily used for the interpretation of mixed DNA profiles. [512] However, for a more complex mixture the "Random man not excluded" calculation, which is discussed below, may be more appropriate. Schneider et al recommend that the likelihood ratio be used for mixtures in which the number of contributors can be determined, and unambiguous DNA profiles are observed across all loci.[513]

4.7.3. Random man not excluded

The other main method for the statistical interpretation of mixed DNA profiles - apart from the likelihood ratio – is the "random man not excluded" ("RMNE") calculation, or "cumulative probability of inclusion" ("CPI"). [514] This method seeks to determine the fraction of the population that would not be excluded as a contributor to the mixed profile. It involves a two-step process: The first step determines if a suspect is excluded. The reliability of the method depends to a significant degree on this first step. The second step is the calculation of the statistics, which calculates the probability that one or both alleles of the contributor are outside the set of alleles detected in the mixed profile. [515]

Buckleton & Curran note that some information commonly used in the exclusion phase - such as the potential number of contributors, the profiles of individuals who can safely be assumed to be in the mixture and peak heights – is typically not used in the calculation of the statistics. For example, a profile shows three peaks (a, b, c) at different peak heights and the victim is ab and the suspect cc. Based on the circumstances of the offence the victim can reasonably be assumed to have contributed to the mixed profile. Based on peak heights the suspect cannot be excluded, but ac or bc genotypes would be excluded. However, the classic RMNE calculation returns a

[511] Ibid p 232-234
[512] D.L. Faigman et al (2006) p 73
[513] P.M. Schneider et al (2008) p 3
[514] J. Buckleton & J. Curran (2008) p 343
[515] Ibid p 343 and 347

probability which includes the ac and bc genotypes, although it would be possible to modify the statistics to include on the cc genotype. [516]

Buckleton & Curran argue that whilst in most cases the "wastage of evidence" leads to a conservative statistic, this is only the case if at the exclusion stage care is taken to use the information present such peak heights and number of contributors to exclude wrongly implicated contributors. They recommend that before a decision is made to leave out any locus that may have allele dropout or where the suspect has an allele that is not present in the mixture, that particular locus is critically examined for exclusionary material. [517]

Buckleton & Curran further express the view that whilst it is reasonable to resolve true uncertainty in favour of a suspect, it is not reasonable to provide a low estimated evidential value where no real uncertainty exists. They argue that is scientifically undesirable if the RMNE method wastes evidence and produces a conservative statistic.[518]

Thompson notes that whilst the RMNE method is considered to be very conservative, it may not always be conservative enough because it is based on the premise that all alleles of all contributors have been detected. However, as he observed during his experiment with the three groups of experts[519], an analyst might not necessarily assume that all alleles have been detected when not all of the suspect's alleles as per reference profile show in the evidentiary sample, and this is explained with allele dropout. [520]

LR or RMNE?

Buckleton & Curran note that some mixtures are too complex for likelihood ratio methods – mixtures which may have eight or more peaks of varying heights at a single locus. Current likelihood ratio methods start to struggle with three person mixtures. [521] In Western Australia the RMNE-method is generally used for DNA mixtures which involve three or more contributors. [522]

---

[516] Ibid p 344
[517] Ibid p 345
[518] Ibid p 345
[519] See above
[520] C.W. Thompson (2009) p 264
[521] J. Buckleton & J. Curran (2008) p 346
[522] As per Dr Gavin Turbett during lecture on 21 September 2008 "Forensic DNA Statistics" (Murdoch University)

If a major contributor can clearly be made out in a mixture, the major profile can be treated like a single-source profile and the calculations can be performed accordingly[523], i.e. the random match probability can be applied.

4.8. Recent scrutiny of DNA evidence

In Australia DNA evidence has recently come under scrutiny in the context of the wrongful conviction of F A Jama for rape, a conviction which was based entirely on DNA evidence. The background to this matter and the result of the subsequent inquiry are set out in the report by the Honourable Vincent AO QC. [524]

In 2008 F A Jama was convicted of and sentenced for raping a 48 old woman in a night club in 2006. The alleged victim had been found unconscious in a toilet cubicle which was locked from the inside, approximately 30 minutes after her arrival at the club. She had no recollection of what had occurred. She believed that alcohol consumption could not account for her unconsciousness. Since she feared that she may have been given a drug and been sexually assaulted, the police became involved. A medical examination was conducted the following morning and forensic swabs were taken from the alleged victim. Only 28 hours previously the same doctor at the same location had taken forensic samples from another woman, who had engaged in sexual activity with Mr Jama. No charges had been laid in relation to the other woman. [525]

There was only one single piece of evidence against Mr Jama, namely the presence of DNA on a slide and a swab collected during the forensic examination of the alleged victim which - based on the evidence of a scientist – could be attributed to an "extraordinarily high level of mathematical probability" to Mr Jama. [526]

There was no evidence that the alleged victim had been drugged. A toxicological investigation only detected the presence of alcohol and a prescription drug in the victim's system. [527] Based on the alleged victim's evidence as to her movements after entering the club, Mr Jama would have had very limited, if any, opportunity to spike her drink with a drug. [528] The DNA attributed to Mr Jama was only found on one of the two

[523] P.M. Schneider et al (2008) p 3
[524] F.H.R.Vincent AO, QC "Inquiry into the circumstances that led to the conviction of Mr Farah Abdulkadir Jama" Victorian Government Printer May 2010
[525] Ibid p 13
[526] Ibid p 9
[527] Ibid p 14
[528] Ibid p 16

endocervical swabs and on neither of the two high vaginal swabs, nor was anything found on the clothing of the alleged victim. The amount on the swab was considered to be small in the context of a penile/vaginal rape. [529] The club at which the offence allegedly occurred was targeted to a different age group than that of Mr Jama, it was approximately 15 km away from his home and there was no evidence (apart from the DNA) that Mr Jama had ever been there. Mr Jama was not captured on the CCTV footage and none of the staff at the club recognised Mr Jama when shown a photo of him. Further police inquiries failed to establish a link between Mr Jama and the crime scene, and the vicinity of the crime scene. [530] Given that two male staff members had difficulties moving the alleged victim from the toilet area to the back stage area and had to drag her across the floor at times, it is difficult to imagine how Mr Jama – a dark skinned young man – could have moved the alleged victim without anyone noticing. If the rape had taken place inside the toilet cubicle, Mr Jama would have had to climb over the top of the cubicle to get out (given that it was locked from the inside), thereby exposing himself to a significant risk of detection. It was also unclear where else (i.e. if not in the toilet cubicle) the alleged offence could have taken place.[531] Based on the DNA evidence, the prosecution against Mr Jama proceeded, despite there was no other evidence which linked him to the alleged crime scene, and although police were "unable to develop a realistic scenario or theory of how, when and where a rape could have been perpetrated". [532]

Given that the case against Mr Jama rested entirely on the DNA evidence, the prosecution made further inquiries regarding the laboratory processes, which confirmed the result and that there was no reasonable likelihood of contamination. However, it seems that the possibility of contamination of the samples at a place other than the laboratory was not considered. [533] Vincent AO QC criticises that the prosecution did not seek to obtain any detailed information in relation to the other matter concerning Mr Jama, although his DNA had only become available because of his possible involvement in that other matter. If this had been investigated, the fact that the samples were obtained from the two women at a common location and by the same forensic officer would have become apparent, and may have alerted the prosecution to a

[529] Ibid p 16
[530] Ibid p 17
[531] Ibid p 34-35
[532] Ibid p 30
[533] Ibid p 32

potential problem.[534] Mr Jama's defence were unaware that the two sets of material had been obtained by the same doctor and at the same location, and focussed on the interpretation of the results, contending that it must have been the DNA of an unknown third person. [535] The directions of the trial judge did not include any warnings as to the proper use and the limitations of the DNA evidence, in particular a warning not to equate the statistical probability of a match with the likelihood of Mr Jama committing the offence. [536]

The report concludes that there was a high possibility of contamination of the swab and slide obtained in the examination of the alleged victim as a result of transference of material containing Mr Jama's DNA from the other woman who was examined in the same environment and by the same doctor. [537]

The report strongly criticises the handling of this case. Vincent AO QJ noted that "[t]he DNA evidence appears to have been viewed as possessing an almost mystical infallibility that enabled its surroundings to be disregarded" [538], resulting in a "patently absurd" outcome. [539] He further noted that "the DNA evidence was perceived as so powerful by all involved in the case that none of the filters upon which our system of criminal justice depends to minimise the risk of a miscarriage of justice, operated effectively at any stage until a matter of weeks, before Mr Jama's appeal was expected to be heard."[540] He criticised that the reliability of the DNA evidence appears to have been accepted unreservedly and thereby seems to have "confined thought" [541] in a manner which caused those involved to ignore all improbabilities and unexplained aspects which objectively could be regarded as militating against a conviction. [542]

Acknowledging the value of DNA evidence in the investigation and prosecution of criminal offences Vincent AO QC warns of the challenges and dangers that this kind of evidence presents if those involved in criminal prosecutions fail to understand its character and limitations and to ensure that it is properly used.[543]

---

[534] Ibid p 35-36
[535] Ibid p 39
[536] Ibid p 43
[537] Ibid p 24
[538] Ibid p 11
[539] Ibid
[540] Ibid
[541] Ibid p 37
[542] Ibid
[543] Ibid p 11

4.9. Case law – Australia

Some older decisions focus on the use which a jury can make of DNA evidence. For example, in *R v Pantoja* [544] the court of appeal confirmed that the trial judge's direction that a match only means that a sample could have come from the accused, but cannot prove that it did come from the accused, was appropriate. It further noted that evidence of a DNA match is of little use unless there is evidence as to the probability of the match having occurred by chance.

Vincent AO QC suggests that Australian courts have been very reluctant to test the admissibility of DNA evidence on the basis of its unduly prejudicial effect, thus leaving the jury with little assistance.[545] Edmond notes that the more recent admissibility decisions tend to stress the validation or reliability of the technique. [546]

In *R v Gallagher* [547] the DNA profile obtained from a shoe which was found at the victim's house matched that of the accused. The admissibility of the DNA evidence was challenged on the basis that the reliability of the Profiler Plus system (which had been employed in the analysis) had not been demonstrated and that it had not been subject to an acceptable "validation exercise".[548] The application to exclude the DNA evidence was dismissed. The reliability of Profiler Plus was also unsuccessfully challenged during a voir dire in *R v Karger*. [549]

In *Forbes v R* [550] the appellant argued that his conviction for unlawful sexual intercourse was unsafe because due to the nature of the DNA evidence - which was the only evidence identifying the accused - the verdict relied entirely on a statistical analysis which was insufficient to remove all reasonable doubt. The victim did not know the perpetrator and was unable to identify the perpetrator during a photo board identification. DNA samples obtained from the victim's clothing showed a partial DNA profile from at least three contributors and there was a strong and extremely strong likelihood ratio that the appellant contributed to that profile. Semen detected on the victim's pants provided extremely strong evidence for the conclusion that the appellant was the source of that profile. The appellant argued that because the scientist could only

[544] [1998] NSWCA 565 (5 November 1998)
[545] F.H.R Vincent AO QC (2010) p 43
[546] G. Edmond "Specialised Knowledge, the Exclusionary Discretions and Reliability: Reassessing Incriminating Expert Evidence" 2008 UNSW Law Journal Vol 31(1), 1-55, at fn 175 referring to *R v Gallagher* and *R v Karger*
[547] [2001] NSWSC462 (4 May 2001)
[548] at [6]
[549] No SCCRM 98-224 [2001] SASC (29 March 2001)
[550] [2009] ACTCA 10 (19 June 2009)

express the result of the DNA analysis in terms of a likelihood ratio - as opposed to declaring that the accused is the source of the DNA profile - in cases where there is no other evidence such as identification evidence or propensity evidence, the accused must be acquitted. The appellant did not argue the limited value of the DNA evidence on the basis of problems with the testing, or potential contamination, or extent and nature of the database. [551] The court noted that there was no authority supporting the appellant's submission .[552] The court rejected the appellant's submission and noted that evidence of the likelihood ratio based on the statistical calculation was clearly admissible and could in some cases be highly probative. [553]

This matter proceeded to the High Court on the basis that DNA should not be the basis for a conviction in cases where there was no other evidence. The High Court refused special leave to appeal. [554] The appellant contended that due to the statistical figures in which the DNA evidence is presented, it belonged more the "realm of estimate" than amounting to factual evidence. [555] It appears that the appellant sought to contrast the likelihood ratio used in the presentation of DNA evidence against fingerprint evidence which is commonly presented as a positive identification. Bell J noted that for the purpose of fingerprint evidence which concludes that a fingerprint is identical to that of an accused, the underlying assumption is that no two people share the same prints but this has never been established as a fact. She noted that DNA evidence is not given in terms of identity for two reasons, namely that the entire genome has not been tested, and the entire population of the world has not been tested - therefore, as "a matter of rigorous science" an opinion of identity cannot be expressed in the context of DNA evidence. Bell J appears to have been of the view that the fact that DNA evidence – unlike fingerprint evidence – is expressed in terms of a likelihood ratio as opposed to a positive identification reflected the "more rigorous approach as far as the science in DNA is concerned".[556]

The applicant, on the other hand, appears to have considered the more cautious expression of DNA evidence as a weakness compared to fingerprint evidence. The applicant contended that the acceptance of the assumption that fingerprint evidence is unique provides a premise which justifies fingerprint evidence, but this was not the case

[551] at [34]
[552] at [38]
[553] at [40]-[41]
[554] [2010] HCATransc 120 (18 May 2010)
[555] Ibid
[556] Ibid

in relation to DNA because of a recurring frequency of DNA profiles within the limited survey of the human genome.[557]

It should be noted that the circumstances in *Forbes* differ from those in *Jama* in that the victim in *Forbes* had a clear recollection of the sexual assault, and that the potentially exculpatory evidence such as the victim's failure to identify the perpetrator on photo board, or the fact that her estimate of her attacker's age did not match that of the accused, were explicable in the circumstances. [558] Further, unlike in *Jama,* the circumstances of the case did not militate against an involvement of the accused.

The admissibility of the DNA evidence was considered in the West Australian case of *Mukevski v The State of Western Australia*. [559] The prosecution adduced evidence of the DNA mixture on a cloth wrapped around the drug bags. The missed DNA profile found on both sides of the cloth was consistent with having come from three individuals. The chance of a randomly chosen individual other than the accused having a DNA profile which would not exclude that individual as a contributor to the mixture was less than 1 on 34 in relation to one of the profiles, and 1 in 217 in relation to the other profile. Defence challenged the admissibility of the DNA evidence on the basis that is was speculative and had no probative value. This was based on caveats in the DNA expert's opinion that due to the complex nature of the DNA profile the non-exclusion of an individual may be co-incidental, and the exclusion rations of 1 in 34 and 1 in 217. [560] The trial judge acknowledged the limited probative value of the DNA evidence, but nevertheless ruled the evidence admissible. The Court of Appeal confirmed that the evidence was properly admitted. The probative value of the evidence lay in its capacity to show that the accused could not be excluded. [561] The Court of Appeal also noted that the trial judge had drawn the limitations of the evidence to the jury's attention, and therefore it was unlikely that the jury would have attributed more weight to the evidence as was warranted. [562]

In the appeal *R v Karger* [563] the court held that in the absence of counsel or the witnesses misstating the effect of the statistical evidence by treating the likelihood ratio as if it expressed the probability that the incriminating stain was that of the accused, or

[557] Ibid
[558] [2009] ACTCA 10 at [43]
[559] [2010] WASCA 138
[560] at [14]
[561] at [33]
[562] at [36]
[563] No SCCRM 01-69 [2002] SASC 294 (30 August 2002)

probability of guilt, a specific warning to the jury against the dangers of misusing the statistical evidence was not required.

5. Transcript analysis

20 cases were reviewed. Of the 20 trials reviewed, two were Supreme Court trials and 18 were District Court trials. The trial dates ranged between 2008 and 2011. [564] The trials involved a range of charges: Drug offences[565](five trials), sexual offences[566] (eight trials), assault type offences[567] (four trials), armed robbery (one trial), murder (one trial) and stealing a motor vehicle and reckless driving (one trial).

In one trial defence called their own DNA expert.

In two cases the DNA result was "negative" in the sense that no DNA or no male DNA was detected. One of these cases was a sexual assault in which a DNA result would most likely have been expected by the jury. The DNA evidence was highly relevant to the defence and possible explanations as to its absence were highly significant for the prosecution.

In two cases there was no DNA evidence incriminating the accused as the amount was either too low to be interpreted, or the profile did not match that of the accused.

The matters involving sexual allegations were defended on the following grounds: consent (three cases), honest and reasonable mistake as to consent, identity of the offender, denial of alleged conduct, i.e. sexual activity did not take place or a different (less serious) activity took place (three cases). The other matters were defended on the basis of identity, lack of involvement (co-accused did it) or lack of knowledge of the drugs, drug paraphernalia or hydroponic equipment.

No issue was taken as to the expert's conclusion, i.e. in no case was it suggested that the interpretation was erroneous or ambiguous, or that any errors had occurred during the procedure.

Rather, the DNA results and/or their significance were challenged on the following grounds:

---

[564] See annexed table.

[565] Possession of prohibited drug with intent to sell/supply, manufacture or attempted manufacture of prohibited drug.

[566] Sexual penetration without consent, aggravated sexual penetration without consent, indecent dealing, sexual penetration of child under 16. In two cases the alleged offending occurred in the context of a burglary.

[567] Unlawful wounding, assault occasioning bodily harm, acts with intent to cause harm/grievous bodily harm

• Possibility of transfer of DNA: This was raised in seven cases, and included the possibility of transfer of DNA from one part on a piece of clothing to another part of the same piece of clothing (in a case where the exact location was relevant).

• Significance of the statistical weighting – the low figure provided in the RMNE calculation means that a lot of people cannot be excluded (in a case where DNA was relevant for identification purposes).

• Possible inaccuracy of RMNE calculation as related people had not been taken into account.

• Inability to "age" DNA, i.e. the relevant biological material could have been left on another occasion and unrelated to the offending (five cases).

• In cases in which no DNA was detected, or the detected profile did not match that of the accused, defence stressed the significance of lack of DNA and attempted to argue that absence of evidence amounted to evidence of absence.

• Innocent explanation for the accused's contact with the item – this was argued in four cases. (For example, the item was his but he had lent it to a friend.)

• Other people are involved – this was an instance in which the accused was excluded as a donor to the mixture.

5.1. Collection of exhibits

The officer who collected the exhibits was called as a witness in 17 of the 20 cases. In five cases the examination included explanations as to the packaging and storage of the exhibits. Contamination was not an issue although protective clothing (gloves) was mentioned. In ten of the 17 cases no cross-examination was conducted. Continuity of the exhibits was not challenged, and the possibility of contamination was only very briefly implied in a couple of questions (how often the officers changed their gloves and at what point in time, which items were packaged together and that the officer only received the items from the victim and did not seize them himself). Other questions included the exact location of the exhibit at the crime scene and which exhibits were ultimately analysed.

In five of the eight cases involving charges of sexual assault the doctor or nurse who took swabs from the victim was called and in one case her statement was read into evidence. Only one case resulted in detailed cross-examination as to the procedure of

taking swabs. This was a case in which potential transfer of the accused's DNA during this procedure was the main defence argument. (The accused admitted to penile/vaginal penetration but denied penile/anal penetration). In two cases cross-examination only clarified the position of the swabbed areas and the basis for the decision where to take swabs from.

Evidence as to the taking of forensic samples from the accused was adduced in four cases. Cross-examination was very limited (timing and clarification of procedure) and only in one case (where scrapings were taken from underneath the accused's fingernails) did cross-examination focus on the preservation of evidence (i.e. asking questions about whether the accused had washed his hands and was wearing gloves).

5.2. Qualification of the DNA expert (including defence expert)

15 of the 21 experts were "qualified" only briefly, by stating their formal qualifications and experience. Five experts were "qualified" in more detail by providing information as to what their current roles involved, and previously held positions. In one case the expert's qualifications were not adduced at all other than stating that the expert was a forensic scientist, and where he/she worked.

In one case the expert mentioned that he/she had given evidence in the past both for the prosecution and the defence.

The expertise of the expert was not subject to any cross-examination. However, in one case the expert's evidence was objected to on the basis that is was outside of the expert's field of expertise. The objection was made when the prosecutor asked the expert if DNA would always be recovered if a person had come into contact with an item (a question which is commonly addressed by the DNA expert – see below). In this case the absence of DNA matching that of the accused on relevant items and the absence of DNA matching that of the victim on the accused's clothing was highly relevant to the defence case, which argued that the accused was not involved in the offence. The prosecution needed to provide a possible explanation for the absence of DNA. Defence submitted that the question by the prosecutor fell in the area of cytology and that the expert was not qualified to answer it. The judge invited the prosecutor to qualify the expert in more detail. After the witness was able to refer to specific literature on the relevant topic, defence conceded that the witness was qualified to answer the question.

In one case the prosecutor commented that the experience of the forensic crime scene officer was not contentious. This resulted in a comment by the judge that the jury were entitled to hear it.

In one case the doctor who examined the victim in a sexual assault matter had a medical degree and also a degree in science and molecular biology. She gave evidence about possible explanations why the accused's DNA was not found. There was no objection, and in the light of her qualification she was probably able to comment on this. However, only the formal qualification was established and her experience in DNA work was not, so her expertise in that area was only marginally established.

5.3. Identification of biological material on an item

The manner of detecting stains or biological material on an item was canvassed in all cases which involved relevant exhibits, including:

• Rapid stain identification test to detect saliva - which enzyme the expert looks for and if false positives are possible;

• Presumptive tests for semen, saliva and blood;

• Microscopic check for semen;

• Lifting of skin cells with a tape;

• Swabbing of items.

The presumptive tests were not explained in much detail. In some instances it was mentioned that the tests were presumptive only, and that a test might for example be positive for blood, but in the end no DNA profile might be obtained. The ability to isolate sperm cells from other material was mentioned in two cases.

Cross- examination on this issue tended to be very limited. Only on one occasion was the possibility of substances other than blood generating a false positive canvassed to some degree by cross-examining counsel. On another occasion counsel confirmed that there are also confirmatory tests for blood (which had not been performed in this case). However, this was not a real issue and there seemed to be no dispute that the substance in question was in fact blood. Another issue in this context was whether a presumptive test would be capable of picking up the weak presence of blood. On one occasion in which skin cells had been lifted with a tape, counsel wanted to know if the expert was able to tell which end of the tape the DNA had come from.

5.4. Explanation as to what DNA and a DNA profile is

In 19 of the twenty cases the prosecutor asked the expert what DNA is, and related issues such as where in the body it can be found, which biological substances contain DNA and its discriminatory power and forensic relevance. In one case this question was not specifically canvassed and appears to have been considered common knowledge. In 15 cases the expert explained the relevance of different loci and their variability. The explanations ranged from fairly detailed explanations as to the number of loci to fairly general explanations (to the effect that certain locations are tested).

Again this are generated almost no cross-examination, except for a short confirmation of the evidence-in-chief that DNA is left behind in bodily fluids or skin cells. On one occasion defence counsel noted that it is possible to test up to 16 loci and whether this would not increase the accuracy of the result (compared to the nine loci commonly tested in Western Australia). In this instance defence counsel also raised instances overseas where unrelated people allegedly matched at all 10 loci, but this was not explored in much detail.

5.5. Inability to "age" DNA

The inability to "age" DNA, i.e. inability to tell how long DNA had been present on a particular item, was raised in three cases during the evidence-in-chief. This issue was raised in five cross-examinations and was directed at demonstrating that an accused might have deposited their DNA on an occasion other than the offence, e.g. might have touched an item for an innocent purpose, or might have been at/in the vicinity of the crime scene on a different occasion prior to the offence.

5.6. Factors which affect whether DNA is left behind or detected after contact with an item

This was raised "in-chief" in 19 cases. The significance for the prosecution was to rebut any suggestion that the absence of a DNA profile at the crime scene or on an exhibit should be interpreted as evidence that the accused had not been in contact with the relevant item. In this context the following issues were discussed:

• Good and bad "shedders" (i.e. individuals shedding DNA at different rates). In a couple of cases the DNA expert illustrated this with the "steering wheel" experiment, in which a number of staff members of the laboratory had swabbed the steering wheel of their cars and checked for DNA. Some detected their own DNA, others did not;

• Potential barriers such as gloves;

• Levels of DNA might be too low to detect;

• Effect of cleaning of items;

• Environmental factors and degradation of DNA;

• Bacteria destroying DNA[568];

• Sampling the "wrong" part of the exhibit;

• Nature of the surfaces (rough versus smooth) – in some cases questions were asked about specific exhibits and their ability to retain DNA and the recovery rate (e.g. clip seal bags).

In one case of an alleged sexual assault no DNA profile matching that of the accused was found on the intimate swabs taken from the victim. The circumstances of the case were such that a jury most likely would have expected a "positive" DNA result. Hence the lack of a positive finding presented a potential difficulty for the prosecution case, and was a very significant piece of evidence for the defence. (Sexual intercourse was not conceded.) When asked by the prosecutor if during penile/vaginal intercourse transference of DNA between the parties would be expected, the expert noted that based on experience but also based on international literature in almost 50% of sexual assault cases no DNA is recovered, hence the absence of DNA is inconclusive and does not mean that the alleged act did not occur. From a scientific point of view it would have been useful to learn more about the background to this percentage figure and what research has been conducted in this area. In particular it would have been useful to know if the figure is based on cases in which the allegations of sexual assault are based on the victim's evidence only, or if there was any additional evidence supporting the allegations (such as admissions or medical evidence). This was not explored either in-chief or in cross-examination. Interestingly, defence counsel asked whether the wearing of a condom could explain the lack of DNA – a question which in the circumstances would have been expected from prosecution rather than defence.

Questions in cross-examination as to the relevance of a "negative" finding were predictably and understandably aimed at promoting the defence case theory that absence of evidence is indeed evidence of absence, i.e. emphasising the fact that the lack of

[568] This was in the context of an allegation of anal penetration, and the question of the likelihood of detecting DNA in the victim's anus.

DNA meant favoured the defence case that the accused was not involved. The following issues were raised in this context:

•Ability to detect even very small amounts of DNA and cells, and that it lasts long time unless exposed to environmental factors;

• Occasions/activities during which one might leave DNA behind;

• Rough surfaces retain DNA particularly well;

• Blood swab as good source of DNA;

• The absence of DNA might well mean that a person did not touch an item;

• Factors impacting on degradation of DNA;

• That it is not unusual finding sperm in first void urine of victim (in allegations of sexual offending);

• If exhibit was also fingerprinted and if it would have been possible obtaining DNA from a fingerprint;

• Blood is a good source of DNA and in most cases involving blood DNA is recovered;

• Leaving DNA behind depends on a number of factors, for example how firm the touch is;

• Even though a particular surface might be bad at retaining DNA, it is still possible to leave DNA on it;

• A lack of DNA means that the accused did not touch the item – it is noteworthy that in this case defence counsel did not suggest non-contact as a plausible explanation for the lack of DNA, but as an inevitable conclusion. Whether this was done due to a lack of knowledge or simply to reinforce the idea in the mind of the jury is unclear.

5.7. Process of extracting and amplifying DNA

The process of extracting and amplifying DNA was mentioned in four cases during the examination-in-chief. This included explanations as to the extraction, quantification and amplification of DNA, the PCR process, how an electropherogram is generated and that it shows the allele peaks for each locus.

In two cases the expert clarified that he/she did do all the work associated with the entire process, and that his/her role was the interpretation of the result.

These aspects of the process did not generate any questions in cross-examination.

5.8. Commercial kit used

In only one case the expert explained that the commercial kit used has been validated, and the importance of validation to ensure the accuracy of the findings. There was no cross-examination on this issue.

5.9. Interpretation of the results

It is noted that in 16 out of the 20 cases the finding of the expert was stated without providing an explanation as to the basis for the finding, i.e. did not provide any explanation - by way of electropherogram, genotyper, allele table/chart, or simply verbal explanation – as to why an accused's profile matched or did not match the profile on an exhibit, or why an accused could be excluded or not be excluded from the mixture.

In the four cases in which the basis for the finding was explained with specific reference to the relevant DNA profiles (as proposed to a general explanation as to DNA analysis) the following is noted:

• In once case the expert referred to the electropherogram and explained the peaks, stutter peaks, number of contributors, minor/major profiles, background noise and cut-off levels;

• In one case the expert provided the electropherogram and explained the mixtures;

• In one case the genotypers and the DNA table of results were tendered, but the expert was not asked to explain these in any detail so it is not clear if the jury would have understood the documents;

• In one case the expert explained the result in detail with the assistance of the "DNA table"[569].

The remaining 16 cases included the two cases in which no DNA profile was recovered. In two of these cases the DNA result was conceded. The following is noted in relation to these 16 cases:

[569] Meaning the summary table which summarises the results of each exhibit at each locus.

• In one case the process of interpreting the profiles and comparing the unknown profile to the known profile was very well explained in general terms, but the actual result was not explained with the assistance of the resulting electropherograms;

• Two cases contained an explanation how an electropherogram works and what it shows and how many peaks one would expect to find at each locus;

• In one case the expert was asked what they look for when comparing DNA profiles, and the only explanation provided is that the profiles were compared and matched.

Other issues which were raised during the evidence included the following:

• The expert can only say that the profile matches the profile of an accused, not that it is the accused's DNA on an item;

• In cases on mixtures the expert can only say that an accused might have contributed to the mixture because the allele could have also come from someone else – expert explained allele combinations;

• Difference between no DNA profile recovered and no reportable DNA profile recovered;

• The difference between an a major and a minor contributor;

• A match can only be declared if the alleles on all loci match;

• What a partial DNA profile is.

In cross-examination the following points were raised:

• Repetition of negative findings;

• The expert was asked to explain loci and alleles in more details (which had not been done during examination-in-chief) and that if one (allele) number does not match, a person can be excluded;

• The expert was asked to explain on the basis of the "graphs" how the accused is excluded from mixture (the electropherogram was not shown during examination-in-chief);

• The expert was asked to look at the graphs which incriminated somebody else;

• The expert was asked to explain on the basis of the result table the loci and alleles, and that it is the combination which makes a profile unique (again in a case where this was not explained in detail during the examination-in-chief);

• Inability to allocate specific alleles to a specific individual in a mixture;

• The genotyper (of a mixture from which the accused could not be excluded) was placed on the document camera (which had not been done during the examination-in-chief) and the expert was asked how DNA is interpreted from the various peaks. The genotyper was tendered by defence;

• If a large amount of DNA (as indicated in genotyper) indicates saliva rather than skin cells as the source of the DNA (a question most likely aimed at suggesting that accused used item differently from the purpose which was alleged and explaining why major contributor profile on the items matched profile of the accused);

• Defence tendered the genotypers of profiles from which the accused can be excluded;

• Repetition of results but showing the DNA tables (which had not been shown during the examination-in-chief).

In summary, no issue was taken with the actual results. Cross-examination focussed on emphasising the results supporting the defence case (i.e. no match, exclusion, and/or implication of another person) and clarifying the results with the assistance of the relevant graphs or tables. As to the latter, this should ideally have been done during the examination-in-chief in order to provide a basis for the results.

5.10. Mixtures

In 15 of the 20 cases some or all of the profiles were mixtures. Specifically in relation to mixtures, the following issues were raised:

• The meaning of "not excluded";

• What a mixture is and difficulties in interpretation (three cases);

• Different contributors might leave different amounts behind – major/minor and that peak height can be used to ascertain this;

• Peak height indicates another male in the mixture (defence expert);

• Why in mixture the expert cannot say it is a match, only that the accused cannot be excluded and why any non-exclusion could be co-incidental;

• Difficulties in interpretation if there is no major/minor profile;

• Potential explanation for an additional allele – artefact, third person, transfer.

The following is noteworthy:

• In once case the expert simply stated the minimum number of contributors and that accused is a possible contributor (no explanation provided);

• In once case the expert distinguished between minor/major contributor without explanation what that means;

• In one case the only result implicating the accused was clip seal bag mixture. The accused could not be excluded, but the DNA signal was so weak that no statistical weighting could be attached and any non-exclusion might have been co-incidental. This result was challenged on the basis of secondary transfer, but could also have been challenged on the basis of co-incidental non-exclusion, and – given the lack of any statistical weighting – irrelevance.

In cross-examination the following questions/issues were raised:

• The male profile in the mixture could match that of co-accused (note that the expert declined to comment as the threshold was too low);

• The genotyper was placed on the document camera and the expert explained background noises and artefacts and how to distinguish them from true alleles, and the need for threshold values;

• That the expert cannot include or exclude the accused to which the expert responded that he/she cannot exclude the accused but due to number of contributors no statistical weighting can be attached to this. Interestingly during the examination-in-chief the prosecutor had only adduced the results of the various exhibits which had not generated a profile; and the fact that there was a mixed profile but in relation to mixed profiles all that could be said is whether or not an individual can or cannot be excluded – without any mention of the result in relation to the accused. The prosecutor presumably took the view that given the lack of a statistical weighting, the result was irrelevant and inadmissible. The result was only introduced via cross-examination by defence.

• If the mixture (from which the accused was excluded) had been tested against the profiles of XYZ. Defence then sought a court order requesting expert to test mixture against the DNA database. This was done overnight and resulted in a list of over 400 people who could possibly have a profile that could be in the mixture. The first eleven definitely could not be excluded, for the rest not enough DNA to say if they could be excluded or not (based on NR profile). The witness explained on what basis individuals are included in the database.

• In one case defence counsel suggested that the accused could be excluded. The expert replied that the accused could only be excluded as the major contributor. Defence then suggested that a particular (matching) allele is very common and that almost everyone in the courtroom would have it, to which expert responded that he/she in fact does not have this particular allele at that locus. However, the expert agreed that the result could be co-incidental.

5.11. Statistical calculation

Given that a number of cases included single-source profiles as well as mixtures (both two-person mixtures and more complex mixtures), different calculations - random match probability, likelihood ration and random man not excluded calculation – were adduced in the same case. It is noted that there was never an explanation as to the reason for which different calculations were used, which might be confusing for a jury. The following issues were addressed in the context of the statistical calculations:

• How the statistics are generated i.e. multiply rarity of each locus and number of repeats;

• In mixtures statistics become more complicated and sometimes there are no statistics available at all;

• A partial profile results in a lower statistical weighting;

• Why they use only the most conservative calculation (in relation to ethnicity);

• The expert explained RMNE calculation – they would have to test x number of people before finding someone who could also be a possible contributor. The expert also explained that four loci were excluded and the calculation when based on the strength of the mixture;

• A brief explanation that statistics are based on Western Australian population data;

• Short explanation of random match probability;

• The purpose of the statistical calculations.

The following issues were raised in cross-examination:

• If the statistics would change if accused had a number of brothers of the same ethnicity;

• The low RMNE figure means that lots of people could not be excluded from the mixture, and how many people in WA could not be excluded?

• If correction factor for ethnicity is applied to mixtures;

• That the RMNE calculation in this case does not consider related people;

• That the RMNE result means the probability of "it being someone else" is 1 in xxx (defence counsel's fallacy). The expert clarified that the result only means the chance of someone else having a profile which would fit into this mixture.

• Emphasising alleles which are do not match those of the accused, including non-reportable alleles;

• Clarification of the random match probability, namely that this means the chance of someone other than, and unrelated to, the accused having the same profile.

In one case the judge asked the expert to clarify that the result did not mean it was the accused's DNA, so expert explained that the stats meant the chances of the same profile occurring within a certain population

5.12. Contamination

This was not a major issue.

• The possibility of cross-contamination of items if they are not separately packed was raised in one case by both the prosecution and defence but not in a detailed way;

• In a case where one items was contaminated with staff DNA the prosecution adduced evidence of how this is detected and the precautions which are taken to avoid this from occurring;

• How exhibits are stored at the laboratory, and that they are stored away from reference samples;

• One case included a detailed explanation by the expert as to how latex gloves need to be put on to avoid contaminating the glove whilst putting it on, and how to avoid contamination whilst wearing gloves.

5.13. Transfer of DNA

This issue was only briefly raised during examination-in-chief in two cases. Issues addressed were the factors affecting transfer (such as lack of protective clothing, failure to package exhibits separately) and if any tests had been done as to the amount of DNA that would be expected in cases of transfer.

The issue of transfer was raised during cross-examination in the following scenarios:

• Possibility of transfer from one exhibit to another due to failure to package separately;

• Unspecific and very general mention of the possibility of transfer (two cases);

• Possibility of transfer from one person to another (not explored in any detail);

• Transfer from one person to another and possibly during medical examination of victim;

• Possibility of transfer by latex gloves (in two cases);

• Possibility of blood being transferred onto item of clothing by someone else i.e. not through direct contact with the victim.

5.14. Quality control

The issue of quality control and accuracy of results was addressed during examination-in-chief as follows:

• Peer review and accreditation of the laboratory (two cases);

• Brief mention of quality assurance (no details provided);

• Audits of the laboratory to avoid errors;

• NATA accreditation.

Quality assurance was not canvassed during cross-examination at all – there were no questions as to the results of the peer reviewers or the proficiency tests, or the audits.

5.15. Miscellaneous observations

Time constraints

In some instances counsel appeared to have been under pressure to present the evidence as quickly as possible:

• In one case the judge wanted to know what the issue was when defence said they wanted to call their own expert. The judge suggested liaising with the prosecution to see if the defence expert's report could go into evidence by consent.

• One judge queried the necessity to put up the DNA graph (by defence) given that there was no controversy in relation to the result. When told that this was for the understanding of the jury, the judge indicated that he/she did not want any more graphs unless there was a particular reason for it. The DNA graphs had not been shown during the examination-in-chief.

• When one expert tried to explain which loci are analysed for forensic purposes, the judge queried the necessity to explore this, whereupon the prosecutor proceeded to the next question. Later during the examination-in-chief the issue of alleles became relevant, and the judge wanted the expert to explain in one sentence what an allele is. The question of the different loci also became important when a partial profile was discussed. An explanation at the beginning of the expert's evidence would have provided useful and necessary background information.

Inaccurate wording of result

• In one opening address counsel said that "the accused's DNA" was found on an item of clothing belonging to the complainant.[570] It is not clear if this was simply "sloppy" wording, or whether counsel did not appreciate the exact meaning of the DNA result.

• During one cross-examination counsel referred to results as "matched" when in fact the result was "not excluded" which was noted and objected to. It is not clear if counsel simply confused the calculations or did not understand the distinction.

[570] Given that the closing addresses are not transcribed, I was unable to check if the forensic result had been described accurately in the closing address.

• During one cross-examination defence counsel suggested to the expert that one sample contained DNA with a high chance that it "belonged to" the co-accused. The expert said that the sample matched the co-accused's profile, which triggered a comment by defence counsel that the expert was going to use that terminology every time the question was asked (to which the expert said "yes"). It appeared that defence counsel tried to convert a "match" into a statement that it was a particular person's (namely co-accused's) DNA. Whether this was done simply for effect on the jury or if counsel did not know the difference is not clear.

• In once instance defence counsel suggested to the expert in the context of a RMNE ratio that this means the probability of it being someone else. The witness corrected him and explained that it is the chance of someone else having a profile that could fit into that mixture.

• In one cross-examination defence suggested that the lack of a DNA profile on an exhibit which matched the accused's profile meant that the accused had not been in touch with that item, as opposed to non-contact being a possible explanation. Again it is not clear if defence seriously thought that the lack of DNA was conclusive proof of non-contact, or whether this was a deliberate choice of words to create that impression in the minds of the jury.

Jury question

• In once case the judge received a question from the jury as to how long DNA would last on a particular item. This was before the expert was excused and the judge put the question to the expert after re-examination.

Fear of prosecution overstating results

• In the case in which defence wanted to call their own expert although the result was not disputed, it was on the basis that in the experience of defence counsel the prosecution experts go just a little bit further. No explanation was given as to what exactly that meant, but defence seemed to be concerned about the prosecution expert overstating the result.

• In one case defence counsel objected to the DNA evidence because of its prejudicial effect. The accused's DNA profile matched the profile obtained from some blood which had been found close to the scene of the attack, in a public place. Defence submitted

that because the expert could not say how long the blood had been there for, and because the prosecution would say his blood was there "so he must be guilty", the evidence should not be admitted. This argument was unsuccessful. The judge noted that the DNA evidence was one piece of circumstantial evidence against the accused and needed to be considered in the context of the entire case.

The power of DNA evidence

• In one case defence counsel warned the jury of the "CSI" effect during the opening address and urged them to consider if the DNA evidence really had the significance which the prosecution claimed it had.

• In another case where the (negative) result suited the defence case, defence emphasised in cross-examination that "from the point of view of science" their client was excluded from the various samples, and we know as "a matter of science" that the swabs was a single-source profile and not a mixture.

• The prosecutor asked the expert if DNA was a well recognised science. The expert answered that it was, and explained about how the commercial kits are validated.

• Defence counsel asked the expert for a "scientific explanation" as to how a DNA profile which matched that of the victim ended up on the co-accused's jumper (which the expert declined to comment on). This was obviously a question which the expert could not answer and it is not clear if it was asked as a result of ignorance or for effect.

Cautious approach by the experts

It was noted that the prosecution DNA experts[571] were careful not to overstate the evidence, to ensure that that there were no misunderstandings as to the meaning of the results, and not to overstep the limits of their expertise or comment on matters outside their knowledge:

• One expert said he could not say that DNA is unique but it would be extremely unlikely that two random people (who are not identical twins) share the same DNA.

[571] Only one defence expert was called so it is impossible to make any general observations as to the approach of the defence experts and if there would have been any difference to the prosecution experts.

• One expert declined to comment on whether blood would be found on someone's shoe after kicking a person because this was outside their field of expertise.

• In one case the prosecutor took great care to clarify in examination-in-chief what the limitations of the evidence are and what the statistics do not mean – i.e. you can only say that the DNA profile matches that of the accused, not that it is his DNA. "Cannot be excluded" does not mean it is the accused's DNA.

• One DNA expert declined to comment on how quickly DNA would be broken down by UV exposure.

In cases when the experts disagreed with a proposition by defence, they provided reasons for it.

Interpretation error

• Only in one case did the prosecutor ask the expert what would happen if the peer reviewer disagreed and if they had disagreed in this case (which they had not).

Tendering of DNA charts/result tables

This was objected to in one case on the basis that it may lead to confusion and speculation. The judge allowed it as an aid but not to supplant to evidence of the expert.

If the basis for the result and the result itself is explained adequately, this should not cause any concerns in the first place.

Common knowledge

In one case no attempt was made to explain what DNA is, and its discriminatory power. It seems that this was considered to be common knowledge.

5.16. Discussion of result

5.16.1. Reliability

In comparison to the fingerprint evidence the DNA evidence tended to at least address some aspects of the procedure. In particular, in the majority of cases it was explained that certain loci are tested, and what the basis for a match is.[572]

[572] It is, of course, the nature if fingerprint analysis that the basis for a match is not clearly defined – see above.

The actual method, however, was only rarely explained, and only in four cases was extraction and amplification mentioned. Given that PCR is a method which is generally accepted as sound (see above), there is arguably little need to adduce this in any great detail, but given that the resulting electropherograms provide the basis for the expert's conclusion it might be advisable to least briefly explain how they are generated.

Given that the integrity of the exhibits is essential in order to obtain accurate results, the issue of contamination and prevention of contamination received only limited attention, and tended to be addressed in general terms only. More detailed information as to the collection, transportation and storage of the exhibits seems appropriate, as well as the handling of the exhibits in the laboratory.

As to the explanation of the actual findings, it is noted that whilst aspects of the findings and the basis for the findings were usually mentioned (e.g. what a mixed profile is, that it is more difficult to interpret, the use of threshold figures which means that some profiles cannot be interpreted etc), only in four cases was full information provided to the court, i.e. was the expert asked to explain on the basis of either the graphs or the DNA charts/result tables why a profile matched or did not match, or why person could not be excluded. The remaining cases essentially amounted to "ipse dixits", although the experts would undoubtedly have been able to produce the graphs and tables if requested to do so, and explain the findings to the court. As outlined above, on some occasions the first time the graphs were presented and explained to the jury was during cross-examination. Given that the prosecution adduces the evidence as part of the State's case, the basis for the finding should be explained during the examination-in-chief. It is also noted that even where the DNA chart/table is produced, this does not inform the jury of the potential difficulties in the interpretation due to issues such as artefacts and the like. Hence in order to understand the "full picture" it would seem necessary that the jury sees at least one graph to get an impression of the process and difficulties of interpretation.

In relation to the statistics, there seems to be an awareness of the importance to explain what the statistics mean and do not mean. There were no instances of the prosecutor's fallacy and only one instance of defence counsel's fallacy[573]. The fact that different statistical calculations are used by the same expert and in the same trial (depending on the type of profile) is likely to lead so some confusion on part of the jurors, and the

[573] However, given that closing addresses are not generally transcribed, the writer is unable to comment whether or not any problems arose during closing addresses.

reason for the different types of calculation did not receive any attention in the cases which were reviewed.

The issue of bias was not explored at all. No questions were asked at what point in time the expert became aware of the profile in the reference sample, i.e. of the unknown sample had been fully assessed and analysed before the expert compared the profiles.

The proficiency of the individual experts was not subject to any scrutiny, and only in five cases were the experts "qualified" in more detail. Whilst the expert's qualifications were not in issue, in one case it became necessary to qualify the expert in more detail further down the track during examination-in-chief, when defence objected to a question as being outside the expert's field of expertise – see above. Whilst the objection was rather unusual in the sense that the same question is commonly asked during evidence-in-chief, a failure to properly adduce an expert's qualification can be a point of appeal, and might of course impact on the weight that a jury attributes to his/her findings.

Based on the results of the cases reviewed, the reliability of the method and the accuracy of the findings in relation to DNA evidence are not usually explored in court. Whilst the accuracy of the results was not subject to any meaningful challenge (as defence focussed on issues such as the meaning of the result, innocent explanation or transference), it is noted that decisions such as *Makita* and *Hillstead* require the basis for an opinion to be explained.

However, it is also noted that - based on the cases which have been analysed – DNA evidence seems generally be adduced in more detail than fingerprint evidence, and greater care is taken to explain the limitations of the evidence.

5.16.2. Possible reasons for the result

The fact that the expert's findings were not subject to any serious challenge might have been a reason why the basis for the findings and details of the procedure received relatively little attention. It would be interesting to see if the manner of adducing DNA differs in cases where the DNA result is a pivotal piece of evidence in the prosecution case and/or is strongly challenged.

It is also possible that counsel lack the necessary knowledge to ask the relevant questions, either in examination-in-chief, or in cross-examination.

Time constraints and pressure from the court (whether real or perceived) might also play a role and result in counsel only adducing the very basics, and not to "hold up" proceedings by showing complicated graphs and the like to the jury.

III FURTHER AREAS FOR RESEARCH

The results of this research are based on a limited number of cases, and in none of the cases did the State's case rest entirely on the DNA and/or fingerprint evidence, nor were the actual findings disputed. Further research in this area might include a review of cases in which the forensic results were contentious, or cases in which the State's case depended to a significant degree on the forensic result. It would also be useful to analyse more Supreme Court cases in order to find out if the presentation changes in more serious matters such as homicides or armed robberies.

Further areas of research might include the following:

• Review of cases which involve more "obscure" forensic techniques such as shoeprint comparison and similar – will this lead to a more thorough exploration of the technique and the results in court?

• Lawyers' knowledge of the relevant areas – are they aware of the potential difficulties with the accuracy of results in DNA and fingerprint evidence? Are they familiar with the process? Are they familiar with the problem areas (such as interpretation of DNA mixture)? Are they aware of the areas which might be open to challenge? Or is there a belief in the infallibility of the evidence?

• How many cases do not even go to trial because the accused pleads guilty on the basis of forensic evidence?

• Do the experts feel that they were asked the right questions in court?

IV OVERALL CONCLUSION

It has been suggested that a defendant in a criminal trial who is confronted with incriminating expert evidence is placed at a disadvantage because the prosecution expert implicitly has the approval of their scientific institution, the prosecution and the court. [574] Edmond argues that where a certain type of evidence is used repeatedly, such as DNA, there is even a greater need for the prosecution to test the reliability of the

[574] G. Edmond (2008) p 37-38

evidence. He argues that judges, prosecutors and experts should not remain indifferent to the issue of reliability and that a failure to take reliability seriously undermines the fairness of criminal trials and threatens the veracity of the outcomes. [575]

Based on this study it appears that at least in relation to the two very well established and commonly used forensic techniques fingerprint analysis and DNA the issue of reliability does not attract much attention in court. Rather, it appears that there is an underlying assumption that the expert's finding is correct. This applies in particular to fingerprint evidence – as discussed, the technique is rarely touched upon, and an expert's ipse dixit appears to be an accepted way of testimony.

The writer is not suggesting that any of the results in the cases which were reviewed were, in fact, unreliable or wrong. The topic of this study is simply to ascertain if - from a scientific point of view - the reliability was adequately tested in court. Due to the limited number of cases reviewed, the results present a snapshot only, and further research would be required to make a valid judgement on the ability of the adversarial system to handle expert evidence. However, this study allows the conclusion that the overall trend in relation to expert evidence is to focus on the results and not on the manner in which the result was obtained. Education of lawyers both in relation to their obligations and specifically in the relevant forensic areas would be a significant step towards an improvement in the area of expert evidence. Clearly it would be impossible and unrealistic to demand that lawyers become experts themselves. However, there is no reason why lawyers should not be trained at least in the most commonly used forensic techniques and provided with a basic understanding of the procedures and potential problems, in order to provide them with the necessary background to enable them to ask the right questions.

[575] Ibid

References

Australian Law Reform Commission, ALRC Report 102 "*Uniform Evidence Law – 9.The opinion rule and its exceptions"* at http://www.austlii.edu.au/au/other/alrc/publications/reports/102/14.html#Heading106

Berger, M.A. *"The Supreme Court's Trilogy on the Admissibility of Expert Evidence*" Reference Manual on Scientific Evidence, 2nd edition, Federal Judicial Center 2000, available online from http://air.fjc.gov/public/fcjweb.nsf/pages/16

Buckleton, J; Curran, J. *"A discussion of the merits of random man not excluded and likelihood ratios"* Forensic Science International: Genetics 2 (2008) 343-348 available online from www.sciencedirect.com

Budowle, B. et al "*Mixture Interpretation: Defining the Relevant Features for Guidelines for the Assessment of Mixed DNA Profiles in Forensic Casework*" J Forensic Sci, July 2009, Vol.54, No.4, 810-821 available online from www.blackwell-synergy.com

Bush, L. *"The Authority of Fingerprint Experts: Is it Based on Belief or Science?"* Journal of Forensic Identification 59 (6) 2009, 599-608

Butler, J.M. "*Fundamentals of Forensic DNA Typing*" copyright 2010 Elsevier Inc Burlington, San Diego, London

Butler, J.M.; Reeder, D.R. *"Short Tandem Repeat DNA Internet Database*" at http://www.cstl.nist.gov/biotech/strbase/index.htm

Butler, J.M. et al "*Allele frequencies for 15 autosomal STR loci on U.S Caucasian, African American, and Hispanic populations"* Journal of Forensic Sciences, July 2003, Vol 48 (4), 908-911 available at http://www.cstl.nist.gov/biotech/strbase/pub-pres/Butler2003a.pdf

Chalmers, A.F. *"What is this thing called science?"* 3rd edition University of Queensland Press 1999

Champod, C. et al "*Fingerprints and Other Ridge Skin Impressions"* 2004 CRC Press LLC Boca Raton, London, New York, Washington DC

Clayton, T.M. et al *"Analysis and interpretation of mixed forensic stains using DNA STR profiling"* Forensic Science International 91 (1998) 55-77

Cole, S.A. "*Suspect Identities. A history of fingerprinting and criminal identification."* Harvard University Press, Cambridge (Massachusetts) London (England) 2001

Collins English Dictionary 3rd edition Harper Collins Publishers Glasgow 1991

Collins, J.; Jarvis, J.*"The wrongful conviction of Forensic Science"* 2008 Crime Lab Report at www.crimlabreport.com/library/pdf/wrongful_convictions.pdf

Committee on Identifying the Need of the Forensic Science Community; Committee on Science, Technology and Law Police and Global Affairs; Committee on Applied and Theoretical Statistics Division on Engineering and Physical Sciences; National Research Council of the National Academies "*Strengthening Forensic Science in the United States - A Path Forward"* The National Academies Press Washington D.C. 2009 (Cited as "National Research Council")

Cook, R. et al "*A model for case assessment and interpretation*" Science & Justice 1998; 38 (3):151-156

Cook, R. et al "A *hierarchy of propositions: Deciding which level to address in casework"* Science & Justice 1998; 38 (4): 231-239

Dror, I.E.; Mnookin, J.L.*"The use of technology in human expert domains: challenges and risks arising from the use of automated fingerprint identification systems in forensic science"* Law, Probability and Risk Advance Access, published January 22, 2010, 1-21

Dror, I.E. et al "*Cognitive issues in fingerprint analysis: Inter and intra-expert consistency and the effect of a 'target' comparison"* Forensic Science International 208 (2011) 10-17 available online from www.elsevier.com/locate/forsciint

Dror, I.E.; Cole, S.A.*"The vision in "blind" justice: Expert perception, judgment, and visual cognition in forensic pattern recognition."* Psychonomic Bulletin & Review 17(2) 2010 161-167

Edmond, G. "*Specialised Knowledge, the Exclusionary Discretions and Reliability: Reassessing Incriminating Expert Evidence"* 2008 UNSW Law Journal Vol 31(1) 1 – 55

Edmond, G; Mercer, D.*"Keeping 'Junk ' History, Philosophy and Sociology of Science out of the Courtroom: Problems with the Reception of Daubert v Merrell Dow Pharmaceuticals Inc"* 1997 UNSW Law Journal Vol 20(1) 48-100

Faigman, D.L. et al *"Science in the law. Standards, statistics and research issues."* American casebook series. West Group, St Paul Minn. 2002

Faigman, D.L. et al *"Modern Scientific Evidence"* 2006 Student edition Thomson West

Faust, D. et al *"The Admissibility of Behavioural Science Evidence in the Courtroom: The Translation of Legal to Scientific Concepts and back"* Ann Rev Clin Psychol. 2010.6:49-77 available online from clinpsy.annualreviews.org

Figarelli, D. *"Data interpretation & Allele Calls"* at http://www.nfstc.org/pdi/Subject06/pdi_s06_m03.htm

Foreman, L.A. et al *"Interpreting DNA evidence: A Review"* International Statistical Review (2003), 71, 3, 473-495, Printed in The Netherlands copyright International Statistical Institute

Foster, K.R; Huber, P.W.*"Judging Science. Scientific Knowledge and the Federal Courts"*1999 The MIT Press Cambridge - Massachusetts, London - England

Freckleton, I.; Selby, H "*Expert Evidence*." Loose-leaf Series: LBC Practical Law Library, 2001 Thompson Legal & Regulatory Limited (The Law Book Company) published in Sydney by Lawbook Co

Freckleton, I. et al "*Australian Judicial Perspectives on Expert Evidence: An Empirical Study"* Published 1999 by the Australian Institute of Judicial Administration Incorporated, Carlton Victoria.

Freckleton, I. et al "A*ustralian Magistrates' Perspectives on Expert Evidence: A Comparative Study"* Published 2001 by the Australian Institute of Judicial Administration Incorporated, Carlton Victoria.

Garrett, R.J. "*Memo to IAI Members"* dated 19 February 2009 available online from http://www.theiai.org/current_affairs/

Geddes, L."*Between Prison and Freedom*" New Scientist 14 August 2010

Gill, P. et al "*Interpretation of complex DNA profiles using empirical models and a method to measure their robustness"* Forensic Science International: Genetics 2 (2008) 91-103 available online from www.sciencedirect.com

Gold, A.D. "*Expert evidence in criminal law: The scientific approach*" 2nd edition 2009 published by Irwin Law Inc, Toronto

Goodstein, D. *"How Science Works"* Reference Manual on Scientific Evidence, 2nd edition, Federal Judicial Center 2000, available online from http://air.fjc.gov/public/fcjweb.nsf/pages/16

Goodwin, W. et al "*An Introduction to Forensic Genetics*" copyright 2007 John Wiley & Sons Ltd, Chichester UK

Grivas, C.R.; Komar, D.A. "*Kumho, Daubert, and the Nature of Scientific Inquiry: Implications for Forensic Anthropology*" in Journal of Forensic Sciences, July 2005, Vol.53, No.4, 1-6 available online from www.blackwell-synergy.com (copy contained in Course Reader "Ethics and Research Methods on Forensic Science" 2010 Semester 1,UWA, compiled by Dr Franklin D)

Haack, S."*Trial and Error: The Supreme Court's Philosophy of Science*" American Journal of Public Health, 2005; 95, S1, 66-73

Ives, J.A; Giordano, J. "*Unusual Claims, Normative Process: On the Use and Stringency of the Scientific Method"* Forschende Komplementärmedizin 2007, 14; 138-139 published online June 8, 2007, available online from www.karger.com.fok (copy contained in Course Reader "Ethics and Research Methods on Forensic Science" 2010 Semester 1,UWA, compiled by Dr Franklin D)

Jasanoff, S.*"The Eye of Everyman: Witnessing DNA in the Simpson Trial*" Social Studies of Science Vol 28, No 5/6 Special Issue on Contested Identities: Science, Law and Forensic Practice (Oct-Dec 1998) pp 713-740 available online from http://www.jstor.org/stable/285515

Jobling, M.A.; Gill, P."*Encoded Evidence: DNA in Forensic Analysis*" Nature Reviews (5) October 2004 739-751 available at www.nature.com/reviews/genetics

Langenburg, G. "*Deposition of Bloody Friction Ridge Impressions*" Journal of Forensic Identification 58(3) 2008 pp 355-389

Langenburg, G. et al "*Testing for Potential Contextual Bias Effects During the Verification Stage of the ACE-V Methodology when Conducting Fingerprint Comparisons"* J Forensic Sci, May 2009, Vol 54 (3), 571-582 available online from www.blackwell-synergy.com

Knisely, K."*A Student Handbook for Writing in Biology*" 2nd edition 2005 Sinauer Associates, Sunderland, Massachusetts

McCord, B.R; Buel, E. "*Capillary Electrophoresis in Forensic Biology*" Analytical Techniques © 2000 Academic Press, 127-135

Mercer, D. *"Science, Legitimacy and 'Folk Epistemology' in Medicine and Law: Parallels between Legal Reforms to the Admissibility of Expert Evidence and Evidence-Based Medicine"* 2008 Social Epistemology 22:4, 405-423

Merritt, C."*Forensic science in the dock*" The Australian 3 April 2010

Mnookin, J.L. *"The validity of latent fingerprint identification: Confessions of a fingerprinting moderate"* 2008 Law Probability and Risk 7:127 (quoted by National Research Council at p 142)

Noon, R.K *"Scientific Method. Applications in Failure Investigation and Forensic Science"* CRC Press 2009

Nowak, R.*"Forensic DNA Goes to Court with O.J."* Science Vol 265, 5177, 2 September 1994, p 1352-1354

Roby, R.K; Figarelli, D. "*Amplified DNA product separation*" at http://www.nfst.org/pdi/Subject05/pdi_s05m01.htm

Roby, R.K; Figarelli, D.*"Capillary Electrophoresis*" at http://www.nfst.org.pdi/Subject05/pdi_s05m02.htm

Punch, K.F. *"Introduction to social research*" 2nd edition 2005 Sage Publications Ltd London-Thousand Oaks- New Delhi-Singapore

Saks, M.J.; Faigman, D.L. *"Expert Evidence After Daubert*" Annual Review Law Soc. Sci. 2005.1:105-30 (Downloaded from arjournals.annualreviews.org by University Of Western Australia)

Schiffer, B.; Champod, C."*The potential (negative) influence of observational biases at the analysis stage of fingermark individualisation"* Forensic Science International 167 (2007) 116-120 available online from www.elsevier.com/locate/forsciint

Schneider, P M; et al "*The German Stain Commission: recommendations for the interpretation of mixed stains*" Int J Legal Med (2009) 123:1-5 published online 5 July 2008© Springer-Verlag 2008

Scientific Working Group on Friction Ridge Analysis, Study and Technology "*Strengthening Forensic Science in the United States: A Path Forward – Position Statement"* available online from http://www.swgfast.org/

Thompson, W.C. "*Painting the target around the matching profile: the Texas sharpshooter fallacy in forensic DNA interpretation*" Law, Probability and Risk (2009) 8, 257-276 (downloaded from lpr.oxfordjournals.org on 20 April 2011)

Tuthill, H."*Individualization: Principles and Procedures in Criminalistics*" Lightning Powder Co Inc., Salem Oregon USA

Vincent AO QC, F.H.R. *"Inquiry into the circumstances that led to the conviction of Mr Farah Abdulkadir Jama"* Victorian Government Printer May 2010

Vossbrink, R."*Data Troubleshooting*" at http://www.nfstc.org/pdi/Subject06/pdi_s06_m02.htm

Welsh, S.M. "*Advice to a New Science Teacher: The Importance of Establishing a Theme in Teaching Scientific Explanations"* Journal of Science, Education and Technology, Vol 11, No 1, March 2002, 93-95

Wheate, R. "*Australian forensic scientists: a view from the witness box"* Australian Journal of Forensic Sciences Vol 40 No 2 December 2008 123-146 (available online at http://search.informit.com.au/fullText;dn=200901862jres=APAFT)

Williams, B. K "*Logic and Science in Wildlife Biology*" The Journal of Wildlife management Vol 61, No 4, October 1997, 1007-1015

Websites:

http://www.shirleymckie.com

http://www.fbi.gov/

http://innocenceproject.org/

Case Law:

Bennett v Police [2005] SASC 167 (4 May 2005)

Clark v Ryan [1960] HCA 42; (1960) 103 CLR 486

Daubert v Merrell Dow Pharmaceuticals, Inc 509 U.S. 579 (1993)

Farrell v R [1998] HCA 50; 194 CLR 286; 155 ALR 652; 72 ALJR 1292

Forbes v R [2009] ACTCA 10

Forbes v R [2010] HCA Transcripts 120 (18 May 2010)

Frye v U.S. 293 F. 1013 (D C Cir 1923)

General Electric & Co v Joiner 522 U.S. 136 (1997)

HG v R [1999] HCA; 197 CLR 414; 160 ALR 554; 73 ALJR 281

Hillstead v The Queen [2005] WASCA 116

Kozul v The Queen (1981) CLR 221

Makita (Australia) Pty Ltd v Sprowles [2001] NSWCA 305

Mallard v The Queen [2003] WASCA 296

Mickelberg v The Queen (1989) 167 CLR 259; 86 ALR 321; [1989] HCA 35

Moreshead v Police [1999] SASC 162

Mukevski v The State of Western Australia [2010] WASCA 138

Osland v R [1998] HCA 75; 197 CLR 316; 159 ALR 170

R v Buckley[1999] EWCA Crim 1191

R v Lawless [1974] VR 398

R v Parker [1912] VLR 152

R v SMR [2002] NSWCCA 258

The Queen v Broughton, unreported, Court of Criminal Appeal Queensland C.A. No 55 of 1988, 22 September 1988

United States v Plaza 179 F Supp 2d 492 (2002)

United States v Pollak 188 F Supp 2d 549 (2002)

Wallace and The Queen [2010] NZCA 46

Annexure A

Table of reviewed fingerprint cases

Indictment number	**Trial commencement date**	**Offence type**
ALB 86/2009	16.2.2010	drugs
S166/2010	8.6.2010	homicide
146/2010	29.3.2010	sexual
1419/2009	16.2.2010	burglary
1219/2009	16.11.2009	drugs
1486/2008	9.3.2009	fraud
1264/2006	22.7.2009	drugs
2/2010	7.4.2010	burglary
990/2008	10.11.2008	damage by fire
403/2009	31.8.2009	drugs
271/2006	21.1.2008	drugs
1538/2009	20.4.2010	drugs
802/2009	9.11.2009	conspiracy
350/2009	2.6.2009	burglary
1350/2007	19.5.2009	drugs
695/2010	23.11.2010	damage by fire
586/2010	26.7.2010	drugs
967/2010	8.11.2010	drugs
568/2010	7.9.2010	sexual
1320/2010	17.1.2011	burglary/sexual

Annexure B

Table of reviewed DNA cases

Indictment number	Trial commencement date	Offence Type
S166/2009	8.6.2010	homicide
271/2006	21.1.2008	drugs
350/2009	2.6.2009	burglary/sexual
S153/2008	11.5.2009	armed robbery
968/2010	14.2.2011	assault
1538/2009	20.4.2010	drugs
2/2010	7.4.2010	burglary
1350/2007	19.5.2009	drugs
586/2010	26.7.2010	drugs
967/2010	8.11.2010	drugs
568/2010	7.9.2010	sexual
1026/2008	10.3.2009	sexual
311/2009	24.8.2009	steal motor vehicle/reckless driving
1307/2008	14.4.2009	assault
4/11	21.2.2011	burglary/assault
769/2010	22.11.2010	sexual
1645/2008	6.7.2009	sexual
791/2008	3.3.2009	sexual
1750/2009	15.2.2010	sexual
1603/2008	30.3.2009	burglary/sexual