

Draft guidance: Cognitive bias effects relevant to forensic science examinations

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1. INTRODUCTION

- 1.1.1 A key requirement of the Forensic Science Regulator's Codes of Practice and Conduct for forensic science providers and practitioners (the Codes) is that they "Act with honesty, integrity, objectivity and impartiality..." (p9 bullet point 2).
- 1.1.2 However many fields of forensic science include subjective assessment and comparison stages that are potentially susceptible to unconscious personal bias (cognitive contamination), which in turn could undermine the objectivity and impartiality of the forensic process. The focus of this appendix to the Codes is on providing general guidance on cognitive bias relevant to forensic examinations with the aim of alerting readers on how to recognise it and therefore help safeguard against biasing effects, through adherence to good practice. This document also provides examples of good practice for specific subject areas listed in sections 7 to 12. This document sets out the policy to ensure the format and content of all annexes issued by the Regulator are consistent.

2. EFFECTIVE DATE

- 2.1.1 This is a draft issue of this document for consultation.

3. SCOPE

- 3.1.1 These guidelines are limited to the consideration of cognitive bias within processes associated with forensic science examinations at scenes and within the laboratory only and therefore do not cover the wider aspects of the criminal justice system (CJS) such as court processes including activities of the judiciary/legal profession.

4. MODIFICATIONS

- 4.1.1 This is a draft issue of this document.

5. TERMS AND DEFINITIONS

- 5.1.1 **Anchoring or focalism:** The tendency to rely too heavily on one piece of information when making decisions.
- 5.1.2 **Blinding:** Shielding the forensic examiner from information about the case that is not required in order to conduct the examination.
- 5.1.3 **Cognitive bias:** a pattern of deviation in judgement whereby inferences about other people and situations may be drawn in an illogical fashion.
- 5.1.4 **Confirmation bias:** The tendency to test hypotheses by looking for confirming evidence rather than potentially conflicting evidence.
- 5.1.5 **Contextual bias:** The tendency for a consideration to be influenced by background information.
- 5.1.6 **Debias:** The reduction or elimination of the impact of bias in decision making and problem solving.

- 5.1.7 **Expectation bias:** also known as experimenter's bias, is where the expectation of what you will find affects what you do actually find.
- 5.1.8 **Photogrammetry:** The art science and technology of obtaining reliable information about physical objects through the processes of recording measuring and interpreting photographic images.
- 5.1.9 **Psychological contamination:** Exposure to other information which is irrelevant to their assessment but introduces unconscious bias into their findings.
- 5.1.10 **Reconstructive effects:** The tendency when people rely on memory, to fill in gaps on recall with what they believe should have happened.
- 5.1.11 **Role effects:** The tendency for individuals to identify themselves as part of a team with common goals which may introduce subconscious bias.

6. AN EXPLANATION AND BRIEF OVERVIEW OF COGNITIVE BIAS

6.1 Overview

- 6.1.1 Cognition is the mental process of knowing, including awareness, perception, reasoning and judgement¹, and is distinct from emotion and volition². Cognitive bias may be defined as a pattern of deviation in judgement whereby inferences about other people and situations may be drawn in an illogical fashion³. We all tend to display bias in judgements that we make in everyday life, indeed this is a natural element of the human psyche: Jumping to a conclusion, tunnel vision, only seeing what we want to see, being influenced by the views of others, are all behaviours we recognise in ourselves and others. However whilst such biases may be commonplace and part of human nature, it is essential to guard against these in forensic science, where many processes require subjective evaluations and interpretations. The consequences of cognitive bias may be far-reaching: decisions by the investigator to follow a particular line of enquiry, the CPS to prosecute or not, and decisions in the CJS as to guilt or innocence of an individual upon which may rest their liberty or even their life in some jurisdictions, frequently depends on the reliability of the forensic evidence and the conclusions drawn from its interpretation.
- 6.1.2 Cognitive bias has been identified as a potential issue within criminal justice systems since the 1970s^{4,5,6}, and in more recent years some high profile cases

¹ The American Heritage® Science Dictionary Copyright © 2005

² The Concise Oxford Dictionary, 18th edition

³ Haselton, M. G., Nettle, D., & Andrews, P. W. (2005). *The evolution of cognitive bias*. In D. M. Buss (Ed.), *The Handbook of Evolutionary Psychology*: Hoboken, NJ, US: John Wiley & Sons Inc. pp. 724–746

⁴ Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185, 1124–1131. <http://dx.doi.org/10.1126/science.185.4157.1124>

⁵ Charlton, D., Fraser-Mackenzie, P.A.F. & Dror I.E. (2010). Emotional experiences and motivating factors associated with fingerprint analysis. *Journal of Forensic Sciences*, 55, p385-393

including false positive fingerprint identifications^{7,8} have brought the issue into sharp relief. This has been reinforced by an assessment of forensic science published in 2009 by the US National Academy of Sciences in which a diverse range of forensic disciplines within the USA were identified to have wide-ranging issues including lack of validation, standardisation, reliability, accuracy and potential for bias⁹.

6.2 Categories of cognitive bias

6.2.1 There are a number of categories of cognitive bias, including those described briefly below; some are very similar and can sometimes apply in combination in real life situations. Further information on different sources of bias in forensic science is provided in a paper by Dror¹⁰.

6.2.1.1 **Expectation bias**, also known as experimenter's bias, is where the expectation of what you will find affects what you do actually find i.e. where there is scope for ambiguity, people only see what they expect to see. For example, an experimenter may disbelieve or downgrade the significance of findings that conflict with their original expectations, whilst believing and certifying material that supports preexisting expectations. This is also closely related to observer expectancy effects in which a researcher unconsciously manipulates an experiment or data interpretation in order to find a result consistent with expectations.

6.2.1.2 **Confirmation bias** is closely related to expectation bias, whereby people test hypotheses by looking for confirming evidence rather than potentially conflicting evidence^{11,12}. For example, in the evaluation of DNA mixtures, if the reference sample is compared before the crime profile has been interpreted, confirmation bias would result if the analyst then looked only for features supporting the inclusion of the reference profile within the mixture. Some verification processes have potential for confirmation bias if the verifier has knowledge of the original examiner's findings before reaching their own conclusions. They may also be influenced by the experience or status of the previous examiner where these are known to them (so-called conformity effects, and institutional bias).

⁶ Dror, I.E., Peron, A.E., Hind, S.-L. & Charlton, D. (2005), When emotions get the better of us: The effect of contextual top-down processing on matching fingerprints. *Applied Cognitive Psychology*, 19, p799-809.

⁷ Office of the Inspector General (2006). A review of the FBI's handling of the Brandon Mayfield case. Office of the Inspector General, Oversight & Review Division, US Department of Justice.

⁸ Campbell, A. (2011). The fingerprint inquiry report. Available at: <http://www.thefingerprintinquiryscotland.org.uk/inquiry/3127-2.html>

⁹ NAS. (2009). Strengthening forensic science in the United States: A path forward. Washington, DC: National Academy of Sciences, National Academies Press.

¹⁰ Dror, I.E. (2009) How can Francis Bacon help forensic science? The four idols of human biases. *Jurimetrics*, 50, p93-110

¹¹ Balcetis, E., Dunning, D. (2006) See What You Want to See: Motivational Influences on Visual Perception, *Journal of Personality & Social Psychology*, Vol.91, No.4, p612-625

¹² Sanitioso, R., Kunda, Z., Fong, G.T., 1990. Motivated Recruitment of Autobiographical Memories, *Journal of Personality & Social Psychology*, 59 p229-241

- 6.2.1.3 Examples such as a request to “Quickly check this match” demonstrate the potential for confirmation bias in verification processes.
- 6.2.1.4 **Anchoring effects** or focalism is closely related to both the above and occurs when an individual relies too heavily on an initial piece of information when making subsequent judgements, which are then interpreted based around the anchor. For example investigators may fix too readily on a specific subject early on in an investigation and look to explain the circumstances around that person, whilst subsequently ignoring simpler alternative explanations of what may have happened, or who else may have committed the crime.
- 6.2.1.5 **Contextual bias** is where someone has other information aside from that being considered which influences (either consciously or unconsciously) the outcome of the consideration. Psychological research has demonstrated that perception is responsive to both the individual’s psychological and cognitive state along with the environment in which they are operating. For example, a scientist working within a police laboratory could be influenced by knowing that detectives believe they have a strong suspect, or that the suspect has already confessed to having committed the crime. Provision of information not required by the scientist to undertake their evaluation and that potentially influences this type of biasing has been termed ‘psychological contamination’ or ‘cognitive contamination’¹³, as opposed to the more widely understood issue within forensic science of ‘physical contamination’¹⁴.
- 6.2.1.6 **Role effects** are where scientists identify themselves within adversarial judicial systems as part of either the prosecution or defence teams, and this may introduce subconscious bias which can influence decisions especially where some ambiguity exists. In fibre examinations when potential contact between two textile items is under consideration but no matching fibres are found, cognitive bias may be seen from a scientist acting on behalf of the prosecution, and interpreting the findings as neutral rather than considering whether the absence of matching fibres might support the view that the contact had not occurred. Role effects are differentiated from a similar effect called motivational bias, which is often considered separately to cognitive biases. Motivational bias occurs where, for example, motivational influence on decision making results in information consistent with a favoured conclusion tending to be subject to a lower level of scrutiny than information which may support a less favoured outcome^{15,16}. An extreme example of this is where an individual wants one side

¹³ Dror, I.E. (2013) Practical solutions to cognitive and human factor challenges in forensic science. *Forensic Science Policy & management* 4 p1-9.

¹⁴ Kassin, S.M. et al (2013). The forensic confirmation bias: Problems, perspectives, and proposed solutions. *Journal of Applied Research in Memory and Cognition*. 2, p42-52

¹⁵ Pyszczynski, T., Greenberg, J., 1987 Toward an Integration of Cognitive & Motivational Perspectives on Social Inference: A biased Hypothesis-testing Model, *Advances in Experimental Social Psychology*, vol 20 p297-340.

¹⁶ Dawson, E., Gilovich, T., Regan, D. T., 2002 Motivated Reasoning and Performance on the Wason Selection Task, *Personality & Social Psychology Bulletin*, 28 p1379-1387

to win and when in doubt will always make a conscious decision in one direction i.e. to routinely inculcate (or conversely exculpate) suspects; examples of such misconduct have been well documented¹⁷.

6.2.1.7 **Reconstructive effects**¹⁸ can occur when people rely on memory rather than taking contemporaneous notes: people tend to subsequently fill in gaps with what they believe should have happened and so may be influenced by protocol requirements when recalling events some time later from memory.

6.3 Academic research into cognitive bias in forensic science

6.3.1 Academic research into cognitive bias in forensic science, conducted through both experimentation and identification of examples from past cases, has indicated that effectively any technique or process which includes subjective assessment and comparison is potentially susceptible to bias. A particularly useful overview of this topic has been published recently by Kassin et al¹⁹. Other research papers have describe studies on bias in DNA mixture interpretation²⁰, fingerprint comparison^{21,22}, handwriting comparison²³, fire investigation²⁴, forensic odontology²⁵, bullet comparisons²⁶, hair comparison²⁷, and forensic anthropology²⁸. The extent of the issue in real life has yet to be fully evaluated, however it is likely to be highly variable depending on the type of forensic analysis being conducted and the extent of safeguards built into the

¹⁷ Giannelli P.C. (2010) Independent crime laboratories: the problem of motivational and cognitive bias: Utah Law Review 2, p247-256

¹⁸ Risinger, D.M. et al (2002) The Daubert/Kumho Implications of Observer Effects in Forensic Science: Hidden Problems of Expectation and Suggestion Author(s): California Law Review, Vol. 90, No. 1, pp. 1-56

¹⁹ Kassin, S.M. et al (2013). The forensic confirmation bias: Problems, perspectives, and proposed solutions. Journal of Applied Research in Memory and Cognition. 2, p42-52

²⁰ Dror, I. & Hampikian, G. (2011). Subjectivity and bias in forensic DNA mixture interpretation. Sci. Justice 51 p204-208

²¹ Dror, I. et al (2006 check) Contextual Information Renders Experts Vulnerable to Making Erroneous Identifications: Forensic Science International 156 74-78

²² Dror, I.E & Charlton, D. (2006) Why experts make errors, J. Forensic Identif. 56 600–616.

²³ Found, B. & Ganas, F. (2013) The management of domain irrelevant context information in forensic handwriting examination casework, Sci. Justice 53 p154–158.

²⁴ Bieber, P. (2012) Measuring the impact of cognitive bias in fire investigation. International symposium on fire investigation. Sci. Technol. (2012) p3–15.

²⁵ Page, M. et al (2012), Context effects and observer bias—implications for forensic odontology, J. Forensic Sci. 57 p108–112.

²⁶ Kerstholt, J., Eikelboom, A., Dijkman, T., Stoel, R., Hermsen, R., van Leuven, B., Does suggestive information cause a confirmation bias in bullet comparisons? (2010) *Forensic Science International* **198** 138–142

²⁷ Miller, L. (1987) Procedural Bias in Forensic Science Examinations of Human Hair, Law and Human Behaviour 11(2) p157-163

²⁸ S. Nakhaeizadeh, et al., Cognitive bias in forensic anthropology: Visual assessment of skeletal remains is susceptible to confirmation bias, Sci. Justice (2013), <http://dx.doi.org/10.1016/j.scijus.2013.11.003>

processes within which organisations or individuals are working. From a global perspective, it will also depend on the overarching quality requirements and expectations of the particular justice system within which the outcomes are delivered.

6.4 Bias countermeasures (also known as “Debiasing techniques”)

6.4.1 Blinding precautions

- 6.4.1.1 Providing the forensic examiner only with information about the case that is required in order to conduct an effective examination is the most powerful means of safeguarding against the introduction of contextual bias. Such information could be for example a statement from the victim, and for this reason direct contact with the investigating officer should be avoided prior to assessment. That said, it should be borne in mind that the information required may vary from case to case, and it is hard to perform case assessment and interpretation effectively without having access to background information. For example, targeting effectively for “touch” DNA may require information from witness statements.
- 6.4.1.2 Most forensic science providers would be able to control the flow of information to analysts, however some forensic science practitioners are in sole practice and the instructing agency needs to have role and therefore a working knowledge. In such situations, the practitioner may need to ensure the officer in the case is well aware of appropriate information, images and disclosure through the investigation.
- 6.4.1.3 Good practice in forensic science requires that independent checking of critical findings is undertaken (Codes 15.3.2). Independent checking that minimizes the risk of cognitive bias would entail assessment without knowing the outcome of the initial analysis, or even where practicable the identity of the original examiner in order to avoid confirmation bias.

6.4.2 Structured approach

- 6.4.2.1 Application of a structured approach to performing a comparison and arriving at a decision using an essentially “linear” process can effectively reduce or eliminate the influence of the target (i.e. information pertaining to suspect) from the conclusions drawn. A good example of a general methodology for undertaking comparisons is “Analysis, Comparison Evaluation and Verification” (ACE-V). It is the most commonly accepted approach to fingerprint comparison in the UK and USA. The sequence of working is: i) an examiner analyses a mark: ii) the examiner then compares the mark to a known print: iii) having compared the images, the examiner evaluates what they have seen and reaches a decision iv) the results are then subject to verification by one additional examiner or more. Although most literature sets out the ACE-V process as a sequential process it is in fact not linear in application to fingerprint comparisons – the Analysis phase can be revisited in a well-structured way

during the comparison phase. However the evaluation is a separate stage as described.

6.4.2.2 Another framework that has been applied to give structure to the evaluation of scientific findings is the Case Assessment and Interpretation (CAI) model^{29,30}: this helps scientists design effective, efficient, and robust case-examination strategies. The CAI model is founded on Bayesian³¹ thinking and provides clarity on the role of forensic scientists within the criminal justice process. It also encourages consistency of approach, and helps direct research effort. In common with ACE-V it describes an approach in which examination and analysis of scene-related material is undertaken prior to assessment. However whilst ACE-V often entails some re-iteration of the assessment process, CAI is essentially a linear approach and both provide a practical means of safeguarding against confirmation bias. Further information on the CAI-type approach is given in section 7.

6.4.3 **Method development**

6.4.3.1 As the potential for cognitive bias arises at different stages in the examination process, method development ought to look at risks or perceived risks in the method and apply the most practicable control strategy. It ought to be borne in mind that simply because there is a risk of an event, it doesn't mean it automatically manifests itself affecting critical judgment.

6.4.3.2 Having a complete picture is often vital for constructing and testing relevant hypothesis and propositions. However if knowing about certain aspects are assessed to work against the objective process in a particular method (i.e. assessment recommends a blinding method is used), then the methodology right down to design and content of paperwork as well as interaction with the officers in the case might be considered. If the whole case file is handed over to an analyst with all the extraneous detail, then even if there is no perceptible bias there is the perception that it could have occurred and may be open to challenge in court.

6.4.4 **Awareness, training and competence assessment**

6.4.4 It is not sufficient to simply have well defined evaluation procedures in place as outlined above: practitioners need to be aware of the risks and issues arising from cognitive bias, and to receive substantial training in how to overcome these in their respective roles. Similarly those involved in method development require training regarding the risks and issues so that they are best equipped to design out cognitive bias from processes as far as is practicable.

²⁹ Cook, R. et al (1998a) A model for case assessment and interpretation. *Science and Justice* 38: 151-156.

³⁰ Association of Forensic Science Providers. (2009). Standards for the formulation of evaluative forensic science expert opinion. *Sci. Justice* 49, 161–164.10.1016/j.scijus.2009.11.004

³¹ The use or application of Bayes' Theorem, a mathematical formula that can be applied to update probabilities of issues in the light of new evidence.

6.4.4.2 Given that susceptibility to psychological and cognitive influences varies between individuals, there may be merit in assessing these susceptibilities as part of the recruitment or selection procedures for new staff, such as the recruitment testing procedure for fingerprint examiners developed by Dror et al³². Competence in applying evaluative processes should be formally assessed prior to commencing casework and thereafter on a regular basis. This may be achieved through a proficiency testing programme, utilizing mocked up casework samples for which the expected outcomes of testing and evaluation are known. Whilst blind trials are effectively the gold standard in providing the most reliable indicator of real-life performance, in reality they can be very time-consuming and challenging to set up, especially in avoiding alerting the person being assessed that it is a trial rather than another piece of casework. Good practice adopted by many laboratories is to undertake a mixed programme of both declared and undeclared trials, with the proficiency of all individuals tested on a regular basis.

6.4.5 **Avoidance of reconstructive effects**

6.4.5.1 The taking of contemporaneous notes or technical records is another stipulation in the Codes (section 15.2.3) Adherence with this requirement wherever it is practicable to do so at and at all stages in the collection and processing of forensic evidence provides the best safeguard against potential reconstructive effects.

6.4.6 **Avoidance of role effects**

6.4.6.1 Role effects whereby scientists are subconsciously influenced by acting on behalf of the defence or prosecution are difficult to demonstrably eliminate given the adversarial nature of the CJS within the UK, and which are potentially compounded by the pressures of a commercial market in which a supplier/customer relationship for the delivery of forensic science is the norm. These pressures apply whether an FSP is providing contracted services to the prosecuting side or to the defence, or in the case of police laboratories in providing services to an internal customer.

6.4.6.2 However a wider customer is being served here i.e. the CJS, not just the defence or prosecution sides paying for the services: the Regulator's Codes of Conduct for forensic science stipulate that practitioners shall:

- a. Have an overriding duty to the court and to the administration of justice, and,
- b. Act with honesty integrity and impartiality.

6.4.6.3 This is reinforced in section 7.2 of the Regulator's Codes of practice, in which conflicts of interest, perceived or otherwise, and threats to impartiality of a practitioner are identified, including the following:

- a. Being the sole reviewer of their critical findings.

³² Charlton, D., Fraser-Mackenzie, P.A.F. & Dror I.E. (2010). Emotional experiences and motivating factors associated with fingerprint analysis. *Journal of Forensic Sciences*, 55, p385-393

- b. Being over-familiar with or trusting another person instead of relying on objective evidence.
- c. Having organisational and management structures that could be perceived to reward, encourage or support bias, where for example a culture of performance measurement and time pressures could potentially pressurize examiners into biasing decisions.

6.4.6.4 Whilst point c) may be erring towards misconduct rather than being a cognitive phenomenon, the overriding issue with all these points is the effect of subconscious influences on impartiality. Furthermore, compliance with the ISO 17025 quality standard which is an integral requirement of the Codes stipulates that personnel undertaking the analyses shall be free from any undue commercial, financial and other pressures which might influence their technical judgement. In other words, organisational systems and safeguards are required to ensure scientists are insulated from potential biasing pressures.

6.4.6.5 The Criminal Procedure Rules state in part 33.2 that (1) An expert must help the court to achieve the overriding objective by giving objective, unbiased opinion on matters within his expertise; (2) This duty overrides any obligation to the person from whom he receives instructions or by whom he is paid; (3) This duty includes an obligation to inform all parties and the court if the expert's opinion changes from that contained in a report served as evidence or given in a statement. Every expert report must contain a statement that the expert understands his duty to the court, and has complied and will continue to comply with that duty.

6.4.6.6 Adoption of a structured approach such as the CAI principles as described in 4.3.1.2 and expanded further in section 6 below, in which consideration of both prosecution and defence hypotheses, can help ensure evidence is evaluated and presented in a more balanced manner, regardless of defence or prosecution role. This requires that:

- a. Experience is brought to bear by a person who has all the information regarding the case in formulating a coherent strategy that underpins the rationale for analytical submissions;
- b. Analysis is undertaken only with relevant facts disclosed to the analyst; and,
- c. The results of the analysis are reviewed and interpreted from the perspective of the whole case, and should accept the conclusions drawn by the analyst.

7. A GENERIC PROCESS TO MANAGE COGNITIVE BIAS FOR A RANGE OF FORENSIC EVIDENCE TYPES

7.1 The role of the investigating officer or instructing authority

7.1.1 Appropriate flow of information is very important in all cases, one limiting factor in the assistance forensic science can give to the investigation is pertinent information not being passed on. Contextual or case information can be made available for the leading examiner for case building purpose, the lead can then ensure analysts receive information appropriate for that stage, while still

ensuring proper case assessment can be made and the most appropriate techniques are used.

- 7.1.2 However, when instructing experts in sole practice, a greater onus is placed on the investigating officer (or instructing authority) to manage the flow of information. The expert is still likely to need the contextual or case information, but this may be required to be held back until certain analytical stages are complete.
- 7.1.3 However, anybody instructing experts should always think hard about including comments such as the ‘suspect admitted to the crime’, ‘we already have a DNA match’, or even in the question asked ‘...can you identify whether suspect A (the stabber) is carrying anything and, if he is, what that item is...’ Being exposed to such information doesn’t automatically result in a biased decision, but it can influence and should be guarded against.³³
- 7.1.4 The investigating officers or instructing authority should deal with the following in their forensic strategy:
- a. information flow based upon the nature of the evidence type, the phase of the analysis and the capability of the forensic science provider.
 - i. Is the provider able to apply any debiasing techniques themselves i.e. a larger provider will probably control the flow of information to the analyst?
 - ii. Is this a smaller provider or niche specialism where the lead examiner is the sole examiner? If this is the case then agree with them beforehand how the initial, and sometimes follow up, communications might be best handled.

7.2 The role of the scientist in the analysis or initial evaluation stage

- 7.2.1 The analyst should know through their training that they must stay separate from the rest of the investigation and accept the fact that they should undertake the analysis “blind”, and not to seek other information beyond what is required, in order to protect their impartiality. If potentially biasing information is inadvertently disclosed to them, for example that someone is in custody or has confessed, the lead scientist should be informed that this has happened.

7.3 The role of a forensic expert

- 7.3.1 The role of the forensic science expert is to evaluate scientific findings and the results of analytical tests in the context of the relevant case circumstances. An expert opinion should meet the criteria that it is balanced, robust, logical and transparent³⁴:

³³ In R v Rogers [2013] EWCA Crim 2406 the Court of Appeal (Criminal Division) rejected the argument the admission of a police officer’s identification of the accused from photographs after being informed that there was a DNA match rendered the trial unfair or conviction unsafe.

³⁴ Cook, R. et al (1998a) A model for case assessment and interpretation. Science and Justice 38: 151-156.

- a. Balanced – the expert has considered both the prosecution and defence views in their evaluation
- b. Robust – it is based on data that are available for inspection and discussion
- c. Logical – in the approach taken to the evaluation
- d. Transparent - another suitably qualified scientist could follow all the steps and decisions taken³⁵.

7.3.2 If all of the above criteria are met, then any difference of opinion between experts could be limited to a well-defined part of the opinion rather than being a general disagreement, as well as identifying the reasons for each of the opinions. This is most helpful to the court in identifying the areas of dispute between scientists.

7.4 Process Outline

7.4.1 A very brief outline of forensic process within the laboratory is as follows:

- a. Define requirement
- b. Develop examination strategy
- c. Agree examination strategy with client
- d. Carry out forensic examinations and analyses
- e. Review quality and content of examination results
- f. Compare the results with the reference samples and marks
- g. Evaluate and interpret the scientific findings and analytical tests
- h. Verification by second expert
- i. Communicate the scientific findings and analytical tests

7.4.2 During this process it is the responsibility of the expert to record, retain and reveal their work. This requires that they:

- a. Record all information received
- b. Record details of interpretation

7.4.3 Risks of cognitive bias

7.4.4 If it is not practical to mitigate or control the main forms of cognitive bias then the following may occur:

- a. An incorrect conclusion may be made.
- b. A critical check might be inadvertently administrative or cursory

7.4.5 The evidence may be challenged.

7.4.6 The risks associated with relying on the scientific findings and analytical results as a way of assigning a weight of evidence are that:

7.4.7 It can be difficult to consider alternative hypotheses since knowledge of the actual outcome provides a source of confirmation bias.

³⁵ Association of Forensic Science Providers. (2009). Standards for the formulation of evaluative forensic science expert opinion. *Sci. Justice* 49, 161–164.10.1016/j.scijus.2009.11.004

7.4.8 The limitations of the examination and tests performed can be overlooked when evaluating the findings.

7.4.9 Risk management in all disciplines usually starts with an assessment, and a process map detailing the critical control points as required in the Codes (19.4.2.) for building in contamination controls during method development may be useful for this purpose. This practice should identify the stages where individuals being knowledge rich is not ideal and stages where being knowledge poor is damaging. This approach can inform the examination strategy as well as communication strategy. As the officer in the case may have a role, such a visual tool might be included in officer awareness training or supplied as service information.

7.5 Mitigation strategies to reduce the risk of cognitive bias:

7.5.1 The expert goes through a formal process of pre-assessing the expected probabilities for an exhaustive range of possible outcomes, in as many or as few categories as is sensible for the examination, recording their opinions.

7.5.2 Each category in the exhaustive list of outcomes is considered firstly under the assumption that the prosecution hypothesis is true, and secondly under the assumption that the defence hypothesis is true.

7.5.3 These are used to provide an expected outcome which may be either qualitative or quantitative with the latter expressed as a Likelihood Ratio (LR).

7.5.4 The background data and experience used for assessing the expected outcomes are documented and any gaps identified.

7.5.5 A second expert carries out the same process independently, without viewing the decisions made by first examiner and the experts jointly agree the expected outcomes.

7.5.6 Posterior probabilities are not provided for evaluation of findings³⁶.

7.6 Recommended good practice

7.6.1 Define requirement³⁷:

- a. Identify whether the scientist's role in the case is investigative (intelligence) or evaluative (judicial).
- b. Seek clarity on which tests are required, the purpose and how this fits into the hierarchy of sub-source (e.g. touch DNA), source, activity and offence level propositions^{38,39}.

³⁶ The posterior probability is the conditional probability assigned after the scientific evidence has been taken into account; so considers the probability of the hypothesis *given* the evidence. This is an example of the prosecutors fallacy or transposed conditional. The scientist should provide the probability of the evidence *given* the hypothesis.

³⁷ Cook, R. et al (1998b). A hierarchy of propositions: Deciding which level to address in casework. *Science and Justice* 38:231-239.

7.6.2 Develop examination strategy:

- a. Formulate relevant prosecution and defence alternatives based on the case circumstances and information provided.
- b. Consider any agreed assumptions that are used in formulating these alternatives.
- c. Use assessment of possible outcomes to determine which tests are most informative and discriminating.
- d. Use this pre-assessment to assign a weight to an exhaustive list of possible outcomes, giving the expected outcome for each, expressed as a Likelihood Ratio (LR) where these are quantitative.

7.6.3 This approach provides clarity on the alternatives being considered, and the pre-assessment of weight for all outcomes avoids the potential bias of using the observed results to assign weight of evidence.

7.6.4 **Carry out forensic examinations and analyses**

7.6.5 Review quality and content of examination results: decisions on the suitability of the results and marks for later comparison are made at this stage, to avoid post-comparison rationalisation of opinion on quality.

7.6.6 Compare the results with the reference samples and marks: quality and suitability of the questioned result has already been assessed so this is not influenced by the reference result.

7.6.7 **Evaluate and interpret the scientific findings and analytical tests**

7.6.8 Verification by second expert: independent review at this stage in advance of communicating the result to the client.

7.6.9 Communicate the scientific findings and analytical tests.

7.6.10 Interpret the scientific findings and analytical tests:

- a. Confirmation bias is mitigated by using the LR or qualitative expectation which has already been assigned to each outcome, before the examinations and tests have been performed.
- b. Pre-assessment enables the scientist to explain how the weight of evidence has been assigned.
- c. Provide details of the assumptions that have been made.
- d. Give the basis of the expert opinion and specify the propositions considered, with reasoning for these, based on the case context.
- e. Include any limitation of the opinion.
- f. Describe the range of other opinions.

³⁸ Jackson, G. et al (2006) The nature of forensic science opinion--a possible framework to guide thinking and practice in investigations and in court proceedings. *Science & Justice* □ : Journal of the Forensic Science Society 46, 33–44.

³⁹ RSS Practitioner Guide No 4: Case Assessment and Interpretation of Expert Evidence, Graham Jackson, Colin Aitken, Paul Roberts.

8. GOOD PRACTICE GUIDELINES - SCENES OF CRIME

8.1.1 The police response to a reported crime requires many factors to be taken into consideration and for priorities to be balanced accordingly. Preserving the scene, securing evidence, speed of response including making most effective use of the “Golden Hour”, proportionate use of resources based on the seriousness of the crime: all are potentially conflicting in their requirements, and all are overridden by the most pressing priority of all, the preservation of life.

8.1.2 Within this context and from the outset of the investigation, the investigative team seeks to answer many questions that will assist in making sense of the incident under investigation. Frequently the answers to these questions can be provided by material which is obvious and readily to hand, but there will also be gaps. The latter may be filled by gathering of further information or material, identified during the course of the investigative decision-making process, and which may be present at the scene of crime, at other related sites or from other sources⁴⁰.

8.2 Scene of crime process

8.2.1 Serious crime

8.2.1.1 In major or serious crime investigations, forensic science resources are called upon by the Crime Scene Manager to attend the scene based on the specific needs of a case, especially where other evidence to detect the case is not readily available, and these resources are in proportion to the seriousness of the crime. Prior to entering the secured and controlled scene the examiners (e.g. Crime Scene Examiners, forensic scientists) are briefed regarding the scenario being evaluated and the questions that need to be answered. However, the emphasis here is on ensuring that relevant expertise is deployed with the capacity to look at the case and the inquiry to determine what value may be added and what inferences may be drawn from the collection and analysis of physical evidence⁴¹.

8.2.2 Volume crime

8.2.2 The process for volume crime is markedly different to serious crime, due primarily to significant financial constraints impacting on time, personnel and other resources available. Therefore these processes deployed are about maximizing the benefits from these limited resources as a whole rather than for each crime that is reported. The process constitutes the following steps:

8.2.2.2 On notification of a crime, the police call handler has to make a decision based on information received, and guided by force policy regarding response to volume crime incidents, on whether or not to dispatch a police officer to attend.

⁴⁰ National Centre for Policing Excellence (2006) Murder investigation manual

⁴¹ Tilley, N. & Townsley, M. (2009) Forensic science in UK policing: strategies, tactics and effectiveness. Published in Handbook of Forensic Science eds J. Fraser & R. Williams p359-379

- 8.2.2.3 If a police officer is dispatched to attend the scene they may collect physical evidence themselves or will determine whether a crime scene examiner is to be called to examine the scene for any physical evidence.
- 8.2.2.4 If an examiner attends the scene, they may be briefed regarding the offence and what might be most usefully looked for, in advance of their searching for and recovering physical evidence from the scene.
- 8.2.2.5 Recovered evidence is packaged labelled and transported back to police facilities, after which a decision is made on what if any evidence is subsequently processed³⁵.

8.2.3 **Crime scene activities and risk of bias**

- 8.2.3.1 Whilst some crime scene studies have been published by criminology specialists^{42,43}, cognitive bias at scenes of crime has been less comprehensively evaluated than other areas of forensic activity. Nevertheless its potential impact may be significant: for example, it could result in failure to secure the required evidence if a crime scene investigation is closed prematurely resulting in crucial evidence being lost; it could mislead an investigation by investigators focusing too early and incorrectly on a false lead, so that other evidence is potentially overlooked; or if undertaken incorrectly activities could result in “psychological contamination” of evidence downstream in the forensic analysis and interpretation processes.
- 8.2.4 Both volume and serious crime scene activities may be prone to errors and bias. For volume crime, given the severe time constraints, there is little scope to undertake anything more than a basic examination and recovery of evidence: focus is likely to be concentrated on the aspects of the case which are known from past experience to be most likely to yield fruitful results, e.g. fingerprints and DNA collection at the point of entry in a house burglary or vehicle theft, and on items which may have been handled or discarded at the scene, which the victim may be able to assist in identifying. Conversely, in major crime, context may be more of an issue with a risk that forensic strategies are written with a pre-conceived ‘story’ in mind.
- 8.2.5 Opportunities for cognitive bias can be usefully considered within the context of activities related to the crime scene, which can be categorised as follows, as applied to serious crimes unless otherwise stated and is adapted from a conference presentation⁴⁴:

⁴² Lingwood, J., Smith, L.L., & Bond, J.W. (in press) 'Amateur vs professional: Does the recovery of forensic evidence differ depending on who assesses the crime scene?' *International Journal of Police Science and Management*

⁴³ Adderley, R., Smith, L.L., Bond, J.W., & Smith, M. (2012) 'Physiological measurement of crime scene investigator stress' *International Journal of Police Science and Management* 14 (2): 166-176.

⁴⁴ Fraser, J. (2013) Crime scene examination –final frontier or forgotten function? Paper presented at Forensic Horizons 2013: supporting research and development & delivering best practice for the justice system

8.2.6 **Gathering of information prior to scene attendance**

8.2.6.1 Prior to scene attendance information is gathered from any available source regarding the incident to be investigated. This may include witness or victim accounts as to what is alleged to have happened and by their nature these may be consciously or unconsciously biased. With volume crime, decisions on whether or not to attend the scene may be based on this potentially biased information and could therefore affect whether the crime is even investigated at all.

8.2.7 **Controlling the forensic process at scenes**

8.2.7.1 This entails creating inner and outer cordons to secure the scene, and establishing a common approach pathway. The cognitive processes entail determining locations and boundaries of the scene and the entry/exit points of the offender, based on observations, information received and inferences. Whilst there may be scope for bias to affect these decisions for example the past experiences of an individual on which they may base their decisions are subjective may not be reflective of typical scenes. However other factors may be more relevant, and have more impact in real life such as convenience: for example establishing the boundary by taping from lamppost to lamppost is commonplace simply because they are already there.

8.2.8 **Creating a record of the scene**

8.2.8.1 This includes image capture and writing notes and statements. The cognitive processes include selection of equipment, plus decisions on which images to capture, and entails assessment of the current case needs plus some anticipation of future needs. Depending on Force requirements, these may allow wide variation in how findings are documented and are therefore open to subjectivity. Depending on how the written record is crafted, there is a risk that contextual or confirmation bias may be introduced downstream in the investigative process. A gross example is “item X was recovered from suspect Y, a known repeat offender”.

8.2.9 **Undertaking forensic examinations at scenes**

8.2.9.1 This requires an understanding of the investigative needs of the case, plus to observe, discover and recover evidence to meet both these present needs and those anticipated for the future. If guidance for these decision-making processes is not explicitly documented then actions taken at this stage are largely reliant on the examiners intuition and tacit knowledge, which in turn are susceptible to bias.

8.2.10 **Packaging, storing, labelling and transporting recovered items**

8.2.10.1 These actions are largely procedural rather than cognitive. However there is still scope for introduction of psychological contamination if inappropriate information is included on the labelling of recovered items, as described in section 6.2.1.3.

8.3 **Bias Countermeasures and good practice**

8.3.1 It is impossible to undertake certain tasks effectively without being provided with context within which to operate, and this is certainly true with scenes of crime

investigations, where some briefing regarding the alleged crime and circumstances are an essential starting point for the examiner's activities. Examiners must be safeguarded against the risks of contextual and other biases through their training and through adherence to formal documented evidence-based guidance. Of necessity such guidance may be more prescriptive in volume crime where scenarios under investigation are relatively consistent scene to scene and are amenable to application of highly directive, standardised and efficient approaches. For example an examiner is better able to make a balanced and informed decision on which parts of a scene to sample for touch DNA analysis if they are armed with knowledge of Force-wide success rates from the substrates available, rather than relying on their own subjective experience of outcomes from just a few of their own cases. However it is also essential that volume crime investigators are trained not to "switch off": given their extensive experience of volume crime scenes, they are better placed than anyone else to identify anything slightly out of the ordinary and therefore potentially indicative of an alternative explanation to that posited by the victim which may be biased or even completely false, e.g. identify evidence that a "burglary" has been staged in order to make a false claim on insurance.

8.3.2 Serious crime investigations of necessity require much more latitude in terms of approach by examiners, although fact-based guidance regarding approaches at their disposal is just as important as in volume crime. Regardless of this latitude of approach it must be demonstrably systematic and it is essential that examiners fully and contemporaneously document information regarding their examination. The latter provides transparency to the process, and is of particular value in:

- a. subsequently reviewing the case internally to identify whether issues may have been introduced due to bias, and
- b. facilitating review by the defence⁴⁵.

8.3.3 Communication of the examiners findings to others through written reports rather than verbal updates, whilst slower, is preferable as the former provides less risk of introducing bias into the transfer of information.

8.3.4 The activities of examiners are guided at the outset by briefing regarding the scenario being evaluated and the questions that need to be answered (6.1.1). Some may be readily answered by material that is easily available but there will also be gaps that cannot be filled⁴⁶. Under these circumstances good practice has been identified of building hypotheses which can help bridge the knowledge gap and indicate where further material may be gathered⁴⁷.

8.3.5 The key points when building hypotheses have been identified in this guidance as follows:

⁴⁵ Butt, L. (2013) The forensic confirmation bias: Problems, perspectives, and proposed solutions – Commentary by a forensic examiner. *Journal of Applied Research in Memory and Cognition* 2 p59–60

⁴⁶ National Centre for Policing Excellence (2006) *Murder investigation manual*

⁴⁷ ACPO (2005) *Practice Advice on Core Investigative Doctrine*

- a. Ensuring a thorough understanding of the relevance and reliability of all material gathered;
- b. Ensuring that the investigative and evidential test has been applied to all the material gathered in the investigation;
- c. Ensuring there is sufficient knowledge of the subject matter to interpret the material correctly;
- d. Defining a clear objective for the hypothesis;
- e. Developing hypotheses that 'best fit' with the known material;
- f. Consulting colleagues and experts to formulate hypotheses;
- g. Ensuring sufficient resources are available to develop or test the hypotheses;
- h. Ensuring that hypotheses-building is proportionate to the seriousness of the offence.

8.3.6 This guidance emphasises that these assumptions must be developed objectively and that investigators should be aware of the dangers of making assumptions or believing that assumptions made by others are fact. It further states that where assumptions are used to develop hypotheses this should be made explicit.

8.3.7 In some circumstances where collection and analysis of physical evidence is complex spanning several different evidence types, a co-ordination and integration role is required to be undertaken by experienced forensic practitioners, termed crime scene coordinators, or 'Byford Scientists'. These liaise with senior investigating officers in overseeing the collection of physical evidence and ensuring that the disparate strands of forensic analysis are brought together and appropriate inferences are drawn⁴⁸. This role was introduced after an HMIC inquiry into failings in the Yorkshire Ripper Inquiry⁴⁹ due to important leads not being followed up, and false ones being persisted with i.e. classic anchoring effects. It is also important that those undertaking this integration role are also aware of, and thereby safeguard against the fact that these activities are also fraught with potential bias and it may be appropriate under certain circumstances for the coordinators to act as gatekeepers for contextual information and only impart to practitioners information required to fulfill their tasks⁵⁰.

⁴⁸ Tilley, N. & Townsley, M. (2009) Forensic science in UK policing: strategies, tactics and effectiveness. Published in Handbook of Forensic Science eds J. Fraser & R. Williams p359-379

⁴⁹ Byford, L. (1982) Report by Sir Lawrence Byford into the police handling of the Yorkshire Ripper case. London: Home Office (Released in June 2006, under the Freedom of Information Act)

⁵⁰ Charman, S. (2013) The forensic confirmation bias: A problem of evidence integration, not just evidence evaluation. Journal of Applied Research in Memory and Cognition 2 (2013) 56–58

9. DNA MIXTURES GOOD PRACTICE GUIDANCE

9.1 Outline of the Forensic Process Involving DNA Mixture Interpretation

9.1.1

The generic forensic process that encompasses the interpretation and reporting of DNA profiling results, including complex DNA results, can be briefly described as follows and in figure 1:

- a. Items are received along with case information and questions to be addressed by the scientific work.
- b. The case information, supplied by the law enforcement customer, is used to direct the DNA recovery and analysis strategy, ideally within a framework of appropriate propositions.
- c. If non-complex DNA results are obtained that match a suspect, an appropriate random match probability or Likelihood Ratio (LR) estimate is assigned.
- d. If complex mixed DNA results are obtained that can be numerically evaluated the probability of the mixed result is calculated under appropriate prosecution and defence hypotheses and a LR is assigned.
- e. If complex DNA results are obtained that do not lend themselves to statistical evaluation, in some circumstances, a qualitative assessment is made and an opinion about the significance of the DNA results can be put forward.
- f. Findings are checked by a competent colleague/peer.
- g. A statement or report is issued.
- h. The scientist may be called to court to give oral testimony.

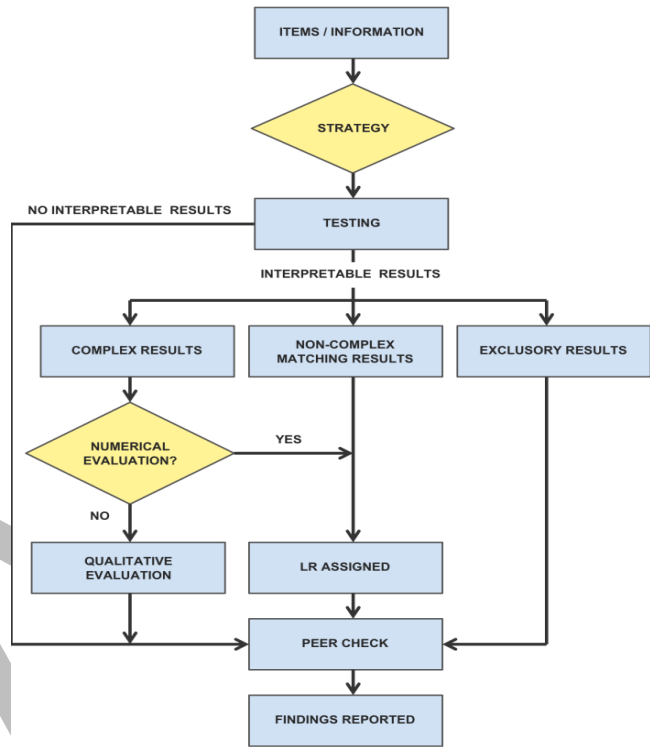


Figure 1: Outline of the Forensic Process Involving DNA Mixture Interpretation

9.2 The Risk of Cognitive Bias in DNA Mixture Interpretation

9.2.1 General Considerations

9.2.1.1 Just like other areas of science, the interpretation of DNA profiles can potentially be affected by some form of unconscious and unintended bias⁵¹. This can occur at points in the interpretation process where scientists are free to make decisions or put forward opinions that are formed outside of the mechanical application of a set of rules. Such opinions and decisions can be described as being subjective, since they arise from the individual's mental capabilities, relevant experiences, depth of knowledge and skill as well as any cognitive influences impacting on them at the time both manifest and unapprehended. Usually decisions are made and opinions are formed in the context of the information the scientist has been given about the case.

9.2.1.2 The interpretation of complex DNA mixtures requires care and skill and often includes a degree of qualitative and subjective decision-making. Indeed, regardless of any case-specific contextual information, practitioners may have a higher expectation of observing DNA profile matches simply because samples were submitted for analysis by police investigators.

9.2.2 General Conditions Impacting on the Level of Cognitive Bias Risk

9.2.3 Within DNA mixture interpretation there is a spectrum of bias risk that is shaped by multiple factors including the following:

- a. Risks are low when results are clear and unambiguous and greater when results are complex, of poor quality and there is an increased reliance on subjective opinion.
- b. Risks are lower when there is a methodical approach with defined standards built on principles that have been tested and validated, and greater when the approach is un-researched, ad hoc and personal to the operator.
- c. Risks are lower when operators and checkers are well trained, experienced and continuously meet acceptable standards of competence; they are greater when operators and checkers are inexperienced, unmonitored and left to adopt their own approach.
- d. Risks are lower when interpretation is checked by a competent peer who conducts a separate interpretation fully independent and without influence from the reporting scientist. Risks are higher when checking is less rigorous and/or conducted collaboratively.

⁵¹ Dror, I. & Hampikian, G. (2011). Subjectivity and bias in forensic DNA mixture interpretation. *Sci. Justice* 51 p204-208.

Risk Source	Low risk	High risk
Result Quality	Results are clear and unambiguous	Results are complex, of poor quality and there is an increased reliance on subjective opinion.
Interpretation Approach	There is a methodical approach with defined standards built on principles that have been tested and validated	The approach is un-researched, ad hoc and personal to the operator.
Operator Competence	Operators are well trained, experienced and continuously meet acceptable standards of competence	Operators are inexperienced, unmonitored and left to adopt their own approach.
Checking	Full independent reinterpretation	Checking is conducted collaboratively

Table 1. Summary of Conditions Impacting on the Risk of Cognitive Bias

9.2.4 **Advancing Technology**

9.2.5 DNA testing technology continues to develop apace. In addition to the routine application of enhanced sensitivity techniques, today’s new multiplexes frequently achieve results from low quantities of DNA (low template samples). The incidence of complex mixtures and of low template profiles exhibiting stochastic effects is increasing and so the conditions in which subjective opinion tends to be relied upon are more commonly encountered. As a consequence, there is an increasing risk of cognitive contamination affecting DNA evidence.

9.2.6 **Contemporaneous Case and Reference Sample Interpretation**

9.2.6 A substantial part of the risk relating to DNA mixture interpretation arises if the case sample is interpreted alongside the reference sample, or if the case sample interpretation is revised after examination of the reference sample. For example, during the interpretation of a two-person mixture (when the interpretation is not conditioned on the presence of an undisputed DNA source) knowledge of the reference sample may result in confirmation bias in the genotype combinations that are included or excluded as being possible, based on allele quantities.

9.2.7 **Use of Qualitative and/or Subjective Approaches**

9.2.7.1 Significant risk is also associated with the use of qualitative and subjective evaluation approaches that have increased considerably since the recent publication of the judgment in *R v Dlugosz et al* (*R v Dlugosz, R v Pickering and R v MDS* [2013] EWCA Crim 2). The Dlugosz judgment has been taken as a broad license to allow the qualitative evaluation of complex results and subjective expressions of evidential weight when a statistical approach is either difficult or considered inappropriate. Such non-statistical assessments can only

be conducted by comparing a reference sample directly with the complex result from the case sample and drawing conclusions based on the presence of alleles in common between case sample and reference sample, the absence of particular alleles and inferences from allele quantities. The Dlugosz judgment does specify safeguards that relate to whether or not such an evaluation can be considered admissible as evidence and how the evidence should be presented. The safeguards require that the expert is experienced, that the extent of their experience is explained for the consideration of the jury and that caveats relating to the limitations of the findings are clearly explained. Whilst the safeguards might seem reasonable they are dependent on the following underlying assumptions that might be considered dubitable in some circumstances:

- a. That general familiarity with complex DNA mixtures and numerical evaluation methods is wholly relevant to the use of what is essentially a new and un-researched evaluative practice; and
- b. Such experience enables the practitioner to form safe, reliable opinions relating to sources of DNA within complex mixtures.

9.2.7.2 To provide assurance in the use of methods that rely on the accuracy of such assumptions, it would assist if clear standards were developed relating to the circumstances in which such an approach is valid and when it is not. Also testing the performance of individual practitioners against developed standards would reduce the risk of inaccurate estimates of evidential strength having an impact in criminal trials. Current application of qualitative methods appears to be largely *ad hoc* without specifically designed controls. If effective quality, training and competency measures are in place, the impacts of cognitive contamination can be minimized.

9.2.8 Potential Oversights in DNA Interpretation Induced By Cognitive Bias

9.2.8.1 Unconscious cognitive bias has the potential to manifest itself as a skewed evaluation, partly because its influence can increase the likelihood of oversights during the DNA interpretation process. Some possible oversights are described below; most are applicable regardless of whether a numerical or qualitative approach is applied and, with most, the risk is either reduced or eliminated if an assessment is made without knowledge of the reference sample result.

Examples include:

- a. Restricted assumptions about numbers of contributors.
- b. Automatic assumptions that a part of a mixture has originated from one individual.
- c. Underestimating the significance of non-matching peaks when they can be considered sub-threshold or designated as artifacts.
- d. Underestimating the uncertainty introduced by stochastic effects.
- e. Overestimating the significance of unconfirmed matching peaks.
- f. Underestimating the significance of unconfirmed non-matching peaks.
- g. Taking account of matching alleles where their presence is uncertain due to masking by other components of the mixture.
- h. Double counting peaks as homozygous that do not clearly represent a double contribution when the subject is homozygous.

- i. Over emphasizing the absence of non-matching alleles when it is not clear if contributors are fully represented.

9.2.9 Further Flaws Potentially Induced by Cognitive Bias

9.2.9.1 The following points describe some further flaws that may be induced or exacerbated by cognitive bias. Most of these are afforded some latitude by the way in which disclosure tends to be approached by defendants and their representatives. The rules of disclosure within the legal system of England and Wales require no prior disclosure of the defendant's account. This often means that the DNA scientist is required to make their own, uninformed suppositions about appropriate defence hypotheses when deciding on analysis strategy and conducting their evaluation:

- a. Greater focus on strategies for DNA recovery and testing that are likely prove a case rather than disprove a case.
- b. Choice of propositions that maximize the strength of evidence against the suspect.
- c. Observations that support the defence case are less rigorously considered or evaluated and are not given their true weight, particularly relating to the absence of evidence.
- d. Failure to express alternative explanations.
- e. Reluctance to express doubt particularly during oral evidence at court.

9.3 Case Examples Where Cognitive Bias May Have Contributed to Error

9.3.1 In this section, the identity of specific cases or the practitioners involved are not disclosed; rather, anonymised issues are described in several real cases that may have been caused or exacerbated by unintended cognitive bias. The examples are from cases in which the authors of this guidance had direct experience; all were reported in 2013. They stem from inaccurate evaluations or misleading descriptions of complex DNA mixtures, all biased in favour of the prosecution's case. It is, of course, not possible to be certain to what extent the issues were influenced by cognitive bias or some other source of inaccuracy but they illustrate the difficulties that relate to non-numerical evaluation of complex DNA results. As such, they are helpful in identifying procedural steps and controls that are likely to be effective to both limit cognitive bias and/or demonstrate that it has not occurred.

9.3.2 Qualitative evaluation shown to be at odds with numerical evaluation

9.3.2.1 A complex mixed DNA result from a case sample contained alleles in common with profiles in all four reference samples that were compared in the case. Most of the alleles in the case sample profile matched Subject X. No statistical analysis was conducted initially but, based on the reporting scientist's experience, s/he gave the opinion the result provided "at least moderate support" for the assertion that some of the DNA on the swabs came from Subject X. The results were later interpreted with the aid of LikeLTD⁵², recently

⁵² There are several relatively recently developed software programs that are available to providers and are designed to aid the numerical evaluation of some types of complex DNA profiles including complex mixtures.

developed software that is capable of numerical evaluation of some types of complex DNA mixture. The use of this software produced a LR of 4 indicating that, based on commonly accepted verbal descriptors, the strength of support should more fairly have been described as “weak”.

9.3.3 **Implying the absence of alleles is due to masking by a major component**

9.3.3.1 One case relates to a duplicated, standard sensitivity test on vaginal swabs containing a trace of semen. A full, major component profile was obtained matching the complainant, together with a number of low-level minor component bands that were all present in the defendant’s profile. Six duplicated bands in the minor component all matched the defendant and a further five unduplicated bands also matched the defendant. The unduplicated bands were described as unconfirmed. No other, non-matching, minor component bands were visible in either duplicate test and the ratio of the major component to the minor would not have allowed the identification of minor component alleles that were masked by the major component. Comparison of one duplicate result with the other showed that significant stochastic variation, including allelic drop-out, was a reality within these samples. It was not possible to tell whether or not there was full representation of the DNA source(s) within the minor component across the duplicates or to use peak quantities to determine whether there was more than a singular contribution from a specific minor component allele. In the presence of the jury, the scientist was invited to add up the number of alleles in the mixed profile that matched with the suspect’s profile. The response was that there were six confirmed bands, five unconfirmed bands, seven that were shared with the major component profile and one further because the suspect was homozygous at one position. The scientist concluded that there were nineteen out of a possible twenty alleles matching the suspect within the mixed profile. There was no attempt to explain that the possible presence of minor component alleles in positions where the minor component would have been invisible was completely neutral to prosecution and defence hypotheses. There was a significant risk that this description of the evidence would be misleading to the jury in favour of the prosecution’s case. There may be issues here relating to the approach to quality at the parent laboratory, in particular with the monitoring of competence and/or the support and training provided to reporting officers in the specialist field of low template mixture interpretation. Where there is a lack of understanding of evidence the potential for cognitive contamination is increased.

9.3.4 **Ignoring the possibility that a sub-threshold peak is an intrinsic allele**

9.3.4.1 This example relates to a major/minor mixed result from a standard sensitivity test in which a statistical evaluation of eight low level alleles in the minor component was reported. The low level alleles could only have been from the suspect if several of his alleles were not visible due to allelic drop-out. A sub-

The following have been used in criminal trials in the UK: *LikeLTD*, developed by David Balding, Professor of Statistical Genetics at University College London. *STRmix*, developed by forensic experts at ESR Ltd in New Zealand (J. Bright and J. Buckleton) and at Forensic Science South Australia (D. Taylor). *TrueAllele®*, developed by Mark Perlin of Cybergenetics in the USA.

threshold peak, distinct from background and with acceptable allelic morphology was present in one of two duplicates and did not match an allele in the suspect's profile. The presence of this peak was presumably considered a spurious occurrence (drop-in or artefact) and was not taken into consideration for the purpose of the statistical evaluation; its presence was not otherwise mentioned in the scientist's report. Although this peak did not satisfy the criteria to be included as a confirmed component of the profile, further testing may have clarified the presence of the peak and if not, a more appropriate statistical approach could have been taken. Failing to take account of the peak or to attempt to replicate it through further work may have been a consequence of cognitive bias.

9.3.5 **Assuming all DNA bands in a low level profile are from the same person**

9.3.5.1 This assumption is often made but not always explicitly stated and, based on the quality of the profile and nature of the mixture, there are varying extents to which it can be justified. In low-level profiles it is important for the scientist to consider whether or not it is appropriate to use the result for comparison purposes and to consider the possible number of contributors prior to comparing to any reference sample. When mixed DNA profiles are interpreted alongside reference sample(s) without any prior assessment of their suitability for comparison, the risk of cognitive bias increases substantially.

9.3.6 **Only addressing the prosecution's case when a suspect cannot be excluded**

9.3.6.1 This relates to cases in which the complexity of the DNA result is such that it cannot provide evidence of inclusion but is only suitable to exclude individuals as a possible contributing source. The assertion that an individual cannot be excluded as a possible contributor to such a mixture is often reported without the qualification that there are many other individuals with different profiles who similarly could not be excluded. Only expressing an inability to exclude the presence of the defendant's DNA from a case sample invites an interpretation by jurors that favours the prosecution's case more than is justified.

9.4 **Mitigation strategies currently deployed in the UK and overseas**

9.4.1 Below are examples of mitigation strategies that are variously used in current practice. All are experience-based examples of good practice in appropriate circumstances and should be applied as described:

9.4.2 Prior-interpretation of case sample result before reference result is revealed. Formally noting the following from the DNA result, prior to comparison with the reference profile:

- a. suitability to include or exclude;
- b. assessment of number of contributors;
- c. level of representation of contributors;
- d. potential for stochastic effects;
- e. identification of likely/unlikely genotype combinations that might explain the mixture.

9.4.3 This is a critical step and is recommended for DNA profile interpretation in all circumstances.

- 9.4.4 Full checking via repeat interpretation by an experienced and competent colleague including prior-interpretation of case sample result before reference result is known. The check should be conducted independent of, and uninfluenced by, the reporting scientist, and should use original unmodified hard copy or electronic results that are free from annotation. This is a critical step and is recommended for DNA profile interpretation in all circumstances.
- 9.4.5 Case Assessment and Interpretation. Comparison of expected, pre-assessed outcomes with actual results under appropriate hypotheses. Some documented indication of expected outcome is recommended in all cases.
- 9.4.6 Careful selection of case stains/samples for testing to minimise the occurrence of mixtures and low template issues. Selection should be informed by case information and is good practice whenever case circumstances present a choice of DNA case stain targets.
- 9.4.7 Duplicate (or multiple) analyses to assess stochastic effects in low template samples. Replication is often used in conjunction with interpretation in a consensus framework, but can also be used prior to probabilistic evaluation of the results separately. Replication should be applied whenever a poor quality profile is to be relied upon to progress an investigation or provide evidence against a suspect. It assists in evaluating reproducibility, identifying spurious peaks and informing conclusions relating to the likelihood of allelic drop-out and the number of contributors. Replication allows a fuller understanding of the nature of the sample and reduces scope for conjecture and the risk of misinterpretation; it improves the scientist's ability to accurately gauge whether or not the sample is suitable for any form of comparison or statistical evaluation.
- 9.4.8 Analysis and interpretation is carried out blind, in the complete absence of any information about the case. This approach is practiced in some jurisdictions and eliminates the risk of some types of bias. It does present the practical challenge of separating case strategy, hypotheses testing, stain selection etc. from result interpretation and reporting in the context of the case. The risk of missing identification of realistic alternative explanations for the evidence given the case circumstances may be greater using this approach.
- 9.4.9 Use of recently developed interpretation software for complex mixtures⁵³ such as LikeLTD⁵⁴, STRmix™ (Institute of Environmental Science and Research (ESR) or TrueAllele® (Cybergenetics). Ideally should be used with all suitable results whenever other objective numerical methods are not appropriate. Efforts should be made to ensure practitioners are able to use them reliably whenever required.

⁵³ Suitable validation of all such methods would be expected prior to introduction in casework.

⁵⁴ A software package developed by David Balding, Adrian Timpson, Christopher Steele, Mayeul d'Avezac and James Hetherington. Further details available from: <http://cran.r-project.org/web/packages/likeLTD/likeLTD.pdf> [Accessed 27/08/2014]

- 9.4.10 Appropriate training of practitioners in the method employed, who can demonstrate initial and ongoing competency. This is a critical step and is recommended for DNA profile interpretation in all circumstances.
- 9.4.11 Transparency and disclosure of appropriate experimental data used to support conclusions and opinions. Research work should ideally be published in a peer reviewed scientific journal.

9.5 Further recommendations for good practice

9.5.1 In addition to the good practice described in 7.4 we also recommend the following:

- 9.5.1.1 When a numerical evaluation is not possible, it remains of crucial importance that qualitative and subjective judgments of pertinent profile features and their combined likelihood are assessed under the hypotheses framed by both the prosecution hypothesis (Hp) and defence hypothesis (Hd) separately. The final opinion of evidential weight must be based on how much, if any, comparison of separate assessments favours one hypothesis over the other, as with a likelihood ratio. For example, consider a complex mixture that cannot be conditioned on the presence of a known profile: If it is not possible to form a properly reasoned and reliable view about the probability that the mixture could arise if it came from a combination of unknown individuals (Hd), then the result can be of little, if any, probative value because half of the LR is unknown. If this approach is always adopted, it helps practitioners to identify when an observation favours neither prosecution nor the defence and is likely to prevent issues like those described in case examples 7.3.2 and 7.3.5.
- 9.5.1.2 Use a completely “blind” checker who repeats the full interpretation described in 7.4.2 but in the absence of any contextual information relating to the case. This may present practical challenges, particularly within smaller organisations. However, it will assist in a continuous learning and improvement cycle, where Reporting Officers can identify instances where they may have been affected by bias. Further, it provides assurance for the courts that the interpretation is free from contextual bias.
- 9.5. If there is no suitable option for objective evaluation, only employ qualitative and subjective based approaches that have been validated and therefore have demonstrated the robustness of resultant conclusions and opinions. Such procedures should include system performance data indicating when the approach breaks down and is no longer valid. The approach should be quality managed with defined standards and safeguards using trained staff who demonstrate initial and ongoing competence. It is also recognised that some scientists perform better than others under cognitive pressures and if a suitable measure can be adopted by providers this would help to mitigate the risks through improved staff selection, training and self-awareness.
- 9.5.1.4 Training and education in relation to the risks of cognitive bias generally and specifically in relation to complex DNA interpretation.

9.6 Further Research

- 9.6.1 The wider use of software packages (see note 50) capable of numerical evaluation of complex DNA results is likely to reduce the frequency with which

issues relating to subjectivity are encountered. However, such software does not yet offer a complete solution and there will continue to be a gap filled by non-numeric interpretation. Whilst best practice will minimise the inherent issues it is likely that there will continue to be a risk of cognitive bias and general disagreement between experts. We recommend continued research into objective methodology that will increase the power of DNA technology and improve the reliability and robustness of the evaluative processes for the benefit of criminal justice.

10. FINGERPRINTS GUIDANCE

10.1 Brief Outline of the Forensic Process

- 10.1.1 Every finger, palm or sole of foot comprises an intricate system of ridges and furrows, known as friction ridge skin. The arrangement and appearance of features within friction ridge skin are unique to each individual, persist throughout life and are accepted as a reliable means of human identification. Fingerprint Examiners are trained to interpret arrangements of ridge features and to report their opinion as to the common origin or otherwise of any two areas of friction ridge.
- 10.1.2 The fingerprint examination process consists of stages frequently referred to as Analysis, Comparison, Evaluation and Verification (ACE-V), terms which provide useful descriptors of the cognitive process undertaken by the examiner in arriving at their final opinion.
- 10.1.3 Each mark is analysed to establish the quality of detail visible within the mark and to determine its suitability for further examination taking account of variables such as:
- a. The surface on which the impression was left
 - b. Any distortion arising from pressure applied when the impression was deposited
 - c. The clarity, quality and quantity of detail visible in the print.
- 10.1.4 During the comparison stage the examiner will systematically compare the ridge pattern and sequence of ridge characteristics in an impression from an unknown source with that of a known source impression. They will establish their opinion of the level of agreement or disagreement between the unique sequence of ridge characteristics visible in both impressions.
- 10.1.5 During the evaluation stage of the process the examiner will review all of their previous observations and come to their final opinion and conclusions about the outcome of the examination process. The ACE-V process is iterative in application with the analysis and comparison stages overlapping on occasion. The examination of a latent print against a known reference print may allow examiners to observe further features within the mark by directing their attention to areas, which require particular attention and further processing. This comparison activity may cause the examiner to reconsider their initial analysis of the mark and which could require further documentation by way of technical notes. The evaluation stage however remains a separate and distinct phase of the ACE-V process.

- 10.1.6 If the quality and/or quantity of detail visible within either or both impression is lacking, the examiner will record the impression(s) as **insufficient** and generally no further examination will occur. If the examiner is satisfied that the level of agreement between both impressions is sufficient to determine that they were made by a common donor, then they will consider the unknown impression **identified** to a particular individual. If the examiner feels that the level of disagreement between the two impressions is so significant that they are able to determine that both impressions could not have been made by the known donor, then they will consider that particular individual **excluded** as a potential donor of the unknown print. The examiner may conclude that, although there may be some agreement evident, the extent of disagreement and/or the quality and quantity of detail visible in both or either impression is such that it is not possible to come to a definitive conclusion at this time. In such a circumstance the examiner would consider the outcome of that examination to be **inconclusive**⁵⁵.
- 10.1.7 Although the process is often described sequentially, it is important to note that fingerprint examination is iterative in practice and each stage is not mutually exclusive throughout the process.
- 10.1.8 It is common practice across the fingerprint discipline globally that identifications are subject to verification by further examiner(s) who will conduct a personal analysis, comparison and evaluation of the impressions under examination.
- 10.1.9 Due to the subjective nature of the interpretative cognitive process undertaken by the examiner in arriving at their final opinion, it is accepted that the information used to come to conclusions may vary between examiners. For example, individual examiners may approach their examination from different starting points or consider the visible features in differing sequences; however, the original conclusions are shown to be reliable through demonstrating consistent end results from all subsequent examiners.
- 10.2 Risks of Cognitive Bias**
- 10.2.1 The subjective, iterative and interpretative elements inherent within the fingerprint examination process expose the fingerprint examiner to a range of cognitive influences which, if not properly managed, could impact on the reliability of examination outcomes and examiner opinion.
- 10.2.2 Significant research has already been undertaken across the fingerprint discipline to explore the impact of cognitive influence and human factors on the examination process and the examiners personal decision-making behaviours. Studies undertaken to date have established that fingerprint examiners will, on occasion, alter their original opinions and conclusions in circumstances when

⁵⁵ Not every UK bureau use the same toolbox terminology at this time and 'inconclusive' may not be an option for some to use. This places a cognitive burden on the examiner to side with decisions that may lead to stronger biasing implication. To this extent 'inconclusive' could be a valuable tool to the decision-making armoury.

the original material is presented in a different context⁵⁶. Further research has indicated that this influence is more prevalent when the impressions under examination are of poorer quality⁵⁷.

10.2.3 The risks of cognitive bias inherent in the fingerprint examination process can be categorised as contextual, confirmation and cultural.

10.2.4 **Contextual bias**

10.2.4.1 Fingerprint examiners are exposed to a wealth of contextual information which will impact on their decision making process such as;

- a. Nature and details of the crime including background information
- b. Association with or personal knowledge of the victim or their circumstances
- c. Status of suspects or person(s) already in custody for the crime
- d. Previous criminal activity of suspects or persons of interest
- e. Location of the crime (an area close to their home)
- f. Media or public interest associated with the crime
- g. Personal moral codes or behaviours
- h. Time pressure from investigating officers or office managers

10.2.4.2 For many organisations, contextual influence relating to crime type is in fact imbedded within their standard operating procedures. Crimes of a serious nature such as murder, rape and sexual assault are often given priority over other case work, have additional quality assurance measures in place or have specialist teams dedicated to this type of case work.

10.2.4.3 Prior knowledge of contextual information can influence the decision making process of a fingerprint examiner. For example, during an analysis an examiner may be more likely to retain an impression of borderline quality submitted as part of a serious crime than if the same impression was submitted as part of a low level volume crime. Prior knowledge of the status of an arrested person can lead to particular focus or emphasis on that individual to the exclusion of others.

10.2.5 **Confirmation Bias**

10.2.5.1 Within operational fingerprint bureaus, the majority of examination requests are received from police officers or prosecution services, with both hoping that the examination outcomes will help “solve the case” or “secure a conviction”. Contributing to the detection of crime is considered a fundamental aspect of fingerprint bureau service delivery. Also, personal identification or “hit” rates are used as key performance indicators at both organisational and individual level.

⁵⁶ Dror, I. et al (2006 check) Contextual Information Renders Experts Vulnerable to Making Erroneous Identifications: *Forensic Science International* 156 74-78

⁵⁷ Dror, I. et al (2005) When Emotions Get the Better of Us: The effect of Contextual Top-down Processing On Matching Fingerprints, *Applied Cognitive Psychology*, Wiley InterScience DOI:10.1002/acp 1130

- 10.2.5.2 Combined with a personal moral code to “do the right thing,” this emphasis on “identification” as the most favoured hypothesis will exert powerful cognitive influence on examiner decision making.
- 10.2.5.3 Having prior knowledge of the previous examiner’s findings and conclusions may also expose fingerprint examiners to the risk of confirmation bias and this will have a particular importance during the verification process.
- 10.2.5.4 At a technical level, examiners can be unduly influenced by confirmation bias when, having found a number of features from an unknown impression to agree with features in an impression from a known source, the examiner will then begin to reason backward, finding features in the unknown impression which are suggested by those in the known print rather than being visible without reference to the known source material.
- 10.2.5.5 Dror’s paper “Practical Solutions to Cognitive and Human Factor Challenges in Forensic Science”⁵⁸ discusses the issue of base rate regularities and the impact of new technology into the fingerprint examination process. Within the context of automated fingerprint identification systems (AFIS) examiners become accustomed to having positive hits positioned at or near the respondent list. AFIS systems are designed to return those candidates most similar to the mark under search. The combination of heightened expectation of an identification being at top of the list along with the most similar candidates being returned at the top of the list carries with it an increased risk of cognitive influence on the decision making of fingerprint examiners.
- 10.2.6 **Cultural Bias**
- 10.2.6.1 Individual perception is influenced by the environment in which they are operating. Prior to the publication of The Fingerprint Inquiry Report in 2011, there was a tendency to represent the findings of fingerprint examiners as statements of objective fact rather than expressions of informed technical yet subjective opinion, albeit an opinion based on sound training and experience.
- 10.2.6.2 Historically, investigating officers and courts have accepted fingerprint evidence without challenge, which further contributed to the perception that fingerprint examination enjoyed “practical infallibility”.
- 10.2.6.3 Operating in environments where differences of opinions are perceived as disputes with a “right” or “wrong” answer can also exert a powerful cognitive influence on examiners, leaving them reluctant to challenge their own or the findings of others.
- 10.2.6.4 Further examples of cultural influence which can impact on the decision making process include;
- a. Strict hierarchical structures based on time served rather than competence.
 - b. Over confidence in individual or organisational competence.

⁵⁸ Dror, I.E. (2013) Practical solutions to cognitive and human factor challenges in forensic science. Forensic Science Policy & management 4 p1-9.

- c. Lack of interaction with peers or exposure to alternative methods of working.
- d. Lack of acceptance of the potential for errors or effective root cause analysis of errors.

10.2.6.5 The Fingerprint Inquiry report called for the profession to move away from any presentation of fingerprint evidence with 100% certainty, to fully explore the cogency of explanations offered for any evident differences between impressions and most importantly to recognise that fingerprint evidence is opinion evidence and as such is inherently subjective.

10.2.6.6 Any process which relies on the subjective personal interpretation of data as part of the decision making process is at risk from the influence of cognitive bias. This influence is typically exerted at an unconscious level and examiners often believe that their personal strategies are sufficient to mitigate any associated risk of cognitive bias. However experience has shown this not to be the case.

10.2.6.7 The challenge for the fingerprint profession is to adopt effective risk management strategies at individual and organisational level but without impacting on service delivery.

10.3 Examples where cognitive risks have become an issue

10.3.1 Brandon Mayfield Case 2006

10.3.1.1 In May 2004 Brandon Mayfield, an Oregon attorney, was arrested by the Federal Bureau of Investigation (FBI) as a material witness in an investigation of terrorist attacks on commuter trains in Madrid, Spain. In March 2004, the FBI fingerprint department had conducted a computer database search of an impression found on a bag of detonators and identified the impression to Brandon Mayfield. Two weeks after Mayfield's arrest, the Spanish National Police (SNP) informed the FBI that they had in fact identified the print to an Algerian national called Daoud.

10.3.1.2 The FBI compared Daoud's prints with the impression on the bag of detonators and agreed the findings of the SNP. They subsequently withdrew their previous identification of Brandon Mayfield.

10.3.1.3 The U.S. Department of Justice, Office of the Inspector General (OIG) launched a review into the FBI's handling of the case and provided an assessment of the causes of the misidentification. FBI examiners initially found 10 features they believed to be in agreement with Mayfield's prints. The OIG report [E] concludes; "...the unusual similarity in position and ridge counts was a critical factor that misled four examiners and contributed to their overlooking other important differences between LFP 17 and Mayfield's fingerprint" (Executive Summary). This conclusion implies that due to the unusual level of similarity, examiners were less focused on information which would negate the hypothesis of identification. The report further states; "There were also other subtle but important differences between the prints in the positioning of the features. But the unusual similarity in position and ridge counts was a critical factor that.....contributed to their overlooking other important differences" (Executive

Summary). It would appear that the examiners applied a lower level of scrutiny to the information which supported their favoured hypothesis of identification.

10.3.1.4 The OIG found that the examiner’s interpretation was also influenced by circular reasoning, working backward from the known source material; “Having found as many as 10 points of unusual similarity, the FBI examiners began to ‘find’ additional features that were not really there, but rather were suggested to the examiners in the Mayfield prints” (Executive Summary). Again the examiners would seem to be unconsciously seeking out information to confirm their favoured hypothesis of identification and this is a consistent theme throughout the assessment of the causes of the errors, particularly with regard to the explanation offered by the examiners for observed differences between the prints. “This explanation required the examiners to accept an extraordinary set of coincidences. The OIG found that the support for this explanation was, at best, contradictory” (Executive Summary).

10.3.2 **Shirley McKie Case 1999**

10.3.2.1 During the 1997 trial of Mr. David Asbury for the murder of Miss Marion Ross, Ms. McKie, one of the investigating officers, did not accept that an impression from the crime scene, identified to her by experts from the then Scottish Criminal Records Office (SCRO) could have been made by her.

10.3.2.2 Ms. McKie was subsequently charged with perjury in 1999 and at her trial the SCRO identification was challenged and refuted by American Fingerprint Experts, Mr. Pat Wertheim and Mr. David Grieve. These experts also challenged the identification of an impression which had been presented as part of the prosecution case against Mr. Asbury.

10.3.2.3 The jury unanimously found Ms. McKie not guilty; however the fingerprint evidence remained a matter of dispute and controversy across the national and international fingerprint community for the next decade and was subject to a Scottish Government Justice Committee Inquiry in 2006. In March 2008 Sir Anthony Campbell was appointed to hold a public inquiry into the identification and verification of the fingerprints associated with HM Advocate v McKie 1999. The Fingerprint Inquiry Report was published in December 2011 stating that two misidentifications had occurred and also presented an in-depth scrutiny of fingerprint examination methodology and associated issues.

10.3.2.4 On discussing the causes of the errors Sir Anthony Campbell stated; “The method of work described by the four SCRO officers displays a number of recognised risks factors and in the case of Y7 and Q12 Ross it is likely that these risks crystallised into the misidentification”⁵⁹.

10.3.2.5 Amongst risk factors identified in the SCRO methodology listed below are those which are relevant to the cognitive bias issues under discussion in this paper:

⁵⁹Campbell, A. (2011). The fingerprint inquiry report. Available at: <http://www.thefingerprintinquiryscotland.org.uk/inquiry/3127-2.html>

- 10.3.2.6 Practitioners being taught 100% certainty which could be attained prematurely in the examination process on the basis of relatively few characteristics.
 - 10.3.3 Establishes an inner conviction which can lead to a circular argument discounting differences which must be capable of explanation even if the examiner is not sure what that explanation is.
 - 10.3.4 Diminishes the independence of the verification process because a verifying examiner might tend towards confirming the view of the first examiner particularly if the examiner is senior in experience or rank.
 - 10.3.5 Diminishes the usefulness of asking an examiner to reconsider their findings – if they have already reached a conclusion with 100% certainty then unsurprising that a re-examination would typically lead to a confirmation of the initial findings
 - 10.3.6 The ethos in the SCRO fingerprint bureau where pride was taken in an ability, particularly on the part of more experienced officers, to identify marks that other bureaus might not consider sufficient for identification⁶⁰.
 - 10.3.7 **An inappropriate hierarchical philosophy**
 - 10.3.8 Examiners could be influenced to make identifications or confirm identifications of senior officers, where the quality and volume of information did not properly support identification.
 - 10.3.9 The application of inappropriate tolerances in the observation and interpretation of detail in marks and prints, reverse reasoning and the influence of repeated viewing of known prints.
 - 10.3.10 Contextual information from the police, which may subconsciously influence the conclusions of fingerprint examiners.
- 10.4 Examples of mitigation strategies.**
- 10.4.1 **IPOL Unit, Netherlands Police Service, Zotermeer**
 - 10.4.1.1 The IPOL unit has introduced a structure and workflow process specifically designed to mitigate the risks associated with cognitive bias.
 - 10.4.1.2 The fingerprint unit is established around regional centres and a central hub. Latent images are input by staff at the regional centres, sent for search on the automated fingerprint recognition system and then processed by examiners at the central hub. These examiners receive only the on-screen image, with all lifts and case information retained at the regional centres.
 - 10.4.1.3 This structure effectively removes any risk of contextual influence affecting the examiner's technical decision making.

⁶⁰ This topic is discussed in some detail in: Charlton, D., Fraser-Mackenzie, P.A.F. & Dror I.E. (2010). Emotional experiences and motivating factors associated with fingerprint analysis. *Journal of Forensic Sciences*, 55, p385-393

10.4.1.4 Prior to processing the search, the examiner must conduct an onscreen analysis without reference to any comparison print. They are required to demonstrate a minimum of 12 unique features in the print before proceeding with the features graded for suitability for use in the initial findings. Any further features identified at comparison phase are highlighted as such and appropriate tolerances applied. This type of workflow mitigates the risks of cognitive influence associated with the application of inappropriate tolerances in the observation and interpretation of detail in impressions.

10.4.2 **Federal Bureau of Investigation (FBI) Latent Print Unit**

10.4.2.1 Following the procedure review instigated as a result of the Brandon Mayfield Case, the FBI introduced a system of blind verification. They have defined blind verification as “the independent application of Analysis, Comparison, and Evaluation (ACE) to a friction ridge print by another qualified examiner who does not know the conclusions of the primary examiner”⁶¹. The FBI further state that blind verification should; “eliminate confirmation bias and limit contextual bias in the examination process”.

10.4.2.2 Blind verifications take place in cases with a single mark conclusion, circumstances where there are conflicts between examiners and also on decisions of “value” or “no value”. The FBI are clear that blind verifications cannot be performed by any examiner who has previously been consulted by the primary examiner, who has knowledge of the previous examiner’s conclusions, any knowledge of the information used by the primary examiner or and specific background case details.

10.4.2.3 The FBI accepts that some consultation is necessary for the sharing of expertise and that not every consultation between examiners is indicative of a complex analysis. However an analysis is considered complex when dissimilarities or factors influencing the quality of the print could interfere with the proper interpretation of the impression. When a complex analysis or conclusion results in an identification, examiners are required to document any explanation for differences caused by apparent distortion and identify the supporting data for their explanation in the case record.

10.4. **Scottish Police Authority Forensic Services (SPA FS), Fingerprint Units**

10.4.3.1 In anticipation of the publication of The Fingerprint Inquiry Report 2011 SPA FS established a series of work streams to consider good practice in relation to the cognitive influence issues raised as a result of the McKie case.

10.4.3.2 It was accepted that a certain amount of case context is required to allow the initial examiner to develop an effective case assessment strategy, however SPA FS recognised that it was not essential for subsequent examiners to have access to this information on every occasion.

⁶¹ Dror, I.E., & Cole, S.A., (2010). The vision in “blind” justice: Expert perception, judgment, and visual cognition in forensic pattern recognition. *Psychonomic Bulletin & Review* **17(2)**, 161-167

10.4.3.3 A proportionate risk management approach was adopted to mitigate risks of cognitive influence without impacting on service delivery. A range of measures was developed;

- a. Improved note taking, including demonstration of features used in lead identifications.
- b. A complex marks process to manage variance in opinion between examiners. This process includes a blind technical review process, where examiners are required to prepare technical reports and supporting visuals following a completely independent review of the relevant impressions. Those involved in the technical review process have no prior knowledge or access to case-related information or the technical findings of any other examiners.
- c. A blind verification process for lead identifications in which verifying examiners have no knowledge of the technical findings of any previous examiners.
- d. The removal of any case context information or related communication documentation from the verification process in any circumstance.
- e. Regular dip-sampling of all completed case work.
- f. Training programmes for examiners exploring cognitive bias and its impact on the human decision making process.

10.4.4 **Surrey and Sussex Forensic Identification Services Unit (FISU)**

10.4.4.1 Surrey and Sussex Forensic Identification Services Unit have followed similar processes to SPA, and have also introduced cognitive profiling recruitment tests which have proven very effective at predicting cognitive skills of new staff, thus improving effectiveness and efficiency in managing cognitive influence.

10.4.4.2 Other parameters under consideration by FISU are longitudinal studies to underpin cognitive issues with overall accuracy and performance, and embedding cognitive processes to mitigate risks in using new technologies (remote transmission and on screen annotation tools).

10.5 **Recommended good practice**

10.5 The Codes (section 20.4) states that once a method has been designed or determined, there should be an assessment to identify any risks including; “identifying areas where the operation of the method, or interpretation of the results, requires specialist skills or knowledge to prevent ambiguous or misleading outputs or outcomes”. An organisation should therefore adopt a risk management approach to the fingerprint methodology as applied within their organisation to identify, assess and evaluate the threats and consequences posed by the issue of cognitive bias. Practical solutions could include the introduction of a blind element to the verification process or randomising the respondent lists delivered through AFIS searches⁶².

⁶² Dror, I.E. (2013) Practical solutions to cognitive and human factor challenges in forensic science. Forensic Science Policy & management 4 p1-9.

10.5.2 Further generic guidance from The Institute of Risk Management states that; “Risk Identification should be approached in a methodical way to ensure that all activities within the organisation (or method) have been identified and all the risks flowing from these activities defined”⁶³. Once identified, the risks should be displayed in a structured format, which can then be used to evaluate the consequences of the risk including the probability of occurrence. Risk assessment in this manner allows the organisation to break down each stage of the process and consider how best the impact can be mitigated. Areas to be considered can include:

- a. Name of Risk
- b. Scope of Risk
- c. Nature of Risk
- d. Stakeholders
- e. Quantification of Risk
- f. Risk Tolerance
- g. Risk Treatment & Control Mechanisms
- h. Potential Action for Improvement.

10.5.3 Suitable Risk Treatment and Control Mechanisms for consideration with regard to fingerprint examination are listed below:

- a. Survey and breakdown extent of current contextual information available to examiners & assess added value each piece of information brings to the examination process.
- b. Remove or limit contextual information which adds no tangible value to the fingerprint examination process.
- c. Remove or limit contextual information made available to verifying or subsequent examiners.
- d. Introduce a blind verification process for identified case work assessed as at greatest risk from contextual, confirmation and/or cultural bias.
- e. Introduce a blind element to a technical review process for analyses, comparisons and/or evaluations which are considered complex or cause a variance in opinion between examiners.
- f. As part of a technical review process for complex marks or circumstances where examiners have a variance in opinion, introduce an appropriate and proportionate note-taking strategy which requires examiners to provide written and visual accounts of their reasoning and findings.
- g. Develop bespoke training programmes to raise awareness of the cognitive issues involved in human perception, judgement and decision making.
- h. As part of an established quality management system, instigate an effective review and monitoring process to provide assurance that the risk treatment and control measures continue to provide effective risk management.

⁶³ Institute of Risk Management (2002) “A Risk Management Standard” IRM

11. FOOTWEAR, TOOL MARK AND FIREARMS COMPARISON AND FIREARMS CLASSIFICATION GUIDANCE

11.1 The generic marks comparison process

11.1.1 Introduction

- 11.1.1.1 The generic forensic process that is outlined below encompasses the interpretation and reporting of 'marks' comparison cases. It is applicable to a wide range of evidence types such as firearms, footwear, and tool marks and outlines a practical strategy that can be used to counter potential cognitive bias when carrying out 'marks' comparison cases:
- 11.1.1.2 With regards to tool mark comparison this section should be read in conjunction with Regulator Codes of Practice and Conduct – Draft Appendices Toolmarks – HOS/12/027
- 11.1.1.3 With regards to footwear marks related comparisons this section should be read in conjunction with Regulator Codes of Practice and Conduct – Draft Appendices Footwear – (HOS/11/059)
- 11.1.1.4 With regards to firearms related comparisons this section should be read in conjunction with the Regulator Codes of Practice and Conduct – Draft Appendices Firearms – HOS/12/026, Microscopy and Firing Marks.
- 11.1.1.5 The strategy also addresses the possible low expectation of a 'hit' when screening through a firearms Open Case File (OCF)⁶⁴
- 11.1.1.6 Confirmation bias in firearms classification examinations is also addressed. In this context this section should be read in conjunction with Forensic Science Regulator Codes of Practice and Conduct – Draft Appendices Firearms – HOS/12/026, Classification of Firearms and Ammunition.
- #### 11.1.2 Process outline
- 11.1.2.1 Items are recovered from the crime scene and may consist of the original item or a 'true' copy of the mark generated by other methods.
- 11.1.2.2 Items are received along with case information and questions to be addressed by the scientific work.
- 11.1.2.3 The case information, supplied by the customer, is used to direct the item examination recovery and analysis strategy, ideally within a framework of appropriate propositions.
- Examination of the item/mark recovered from the crime scene.
 - Use of recovery and enhancement techniques as required.
 - Generation/Examination of the 'control' item
 - Make test marks if required in the appropriate manner.
 - Undertake a comparison using appropriate methods and equipment

⁶⁴ An OCF is defined as an organised collection of ammunition components derived from crime scenes that is intended to be compared against test fired and crime scene ammunition samples in order to establish whether or not a single gun has been used at one or more scenes.

- f. Interpret and evaluate findings
- g. Verification of result
- h. Findings are described in a statement or report.
- i. The scientist may be called to court to give oral testimony.

11.2 Risks of cognitive bias

11.2.1 A marks comparison seeks to establish if a 'mark' (the unknown) has been made by the submitted exhibit (the known) or has been made by the same item e.g. a revolver which has not been recovered could be responsible for discharging multiple bullets recovered from multiple scenes. It is based on the comparison of detail and is therefore observational. The scientist is looking to determine if the detail present in the mark matches characteristic detail on the item or in a test mark or is significantly different. An assessment of what the detail is and how it has been produced must consider general characteristics common to a set of items (CLASS), unintentional manufacturing marks present on a sub-set of items (SUB-CLASS) through to random damage/wear and tool mark characteristics (INDIVIDUAL). Any examination is therefore dependent upon the visual quality and clarity of the detail that is observed by the examiner. The process is one of pattern recognition aided by the use of equipment such as photographic/imaging, low power microscopy and comparison microscopes. The final assessor of the level of significance of any agreement between the marks is the human operator; there is no significant instrumental analysis [W]. In footwear mark comparisons, the methods employed by footwear practitioners are normally side-by-side comparisons or overlay. In this way the footwear expert assesses the level of agreement in terms of the pattern, pattern configuration, mould/moulding detail, wear and damage. The assessment is subjective, although reference material and data can be used to support the evaluation of the findings. In tool mark/firearms comparisons there are currently two methods; traditional pattern recognition where the examiner's opinion is based on the relative extent of detailed agreement with a best known-non-match and Consecutive Matching Straie (CMS) where the examiner applies a conservative criteria of runs of aligned strai to establish a possible match. Both techniques use subjectivity.

11.2.2 The interpretation and evaluation of a 'marks comparison' may potentially be affected by some form of unintended bias. In the interpretation process there are no results produced by a 'black box'; opinions and decisions are based on the individual's, relevant experience, depth of knowledge and skill as well as their disposition at the time. Every effort must be made to make it logical, transparent, balanced and robust. Usually the opinions are formed in the context of supplied case information, introducing the possibility of contextual bias.

11.2.3 Within marks interpretation it is considered that there is a spectrum of bias risk (table 2).

Risk factor	Low risk	High risk
Detail	The detail in the mark(s) is clear, well defined and unambiguous	Marks are confused and complex, of poor quality and the detail present is poorly defined.
Equipment	Optimum visualisation of the detail in a mark using appropriate equipment/imaging and enhancement techniques.	Poor or inappropriate equipment/imaging and enhancement techniques.
Approach/Examiner	There is a methodical approach with defined standards built on principles that have been tested and validated. Possible confirmation bias may reduce as a consequence of the comparison reviewer having less contextual information ⁶⁵	When the approach is un-researched, ad hoc and personal to the operator. When the expectation of an OCF hit is very low.
Scientist/Examiner	Scientist/examiners are well trained, experienced and continuously meet acceptable standards of competence	Scientist/examiners are inexperienced, unmonitored and left to adopt their own approach.

Table 2: Spectrum of bias risk in marks interpretation

- a. Risks are low when results are clear and unambiguous and greater when results are complex, of poor quality and there is an increased reliance on subjective opinion.
- b. Risks are lower when there is a methodical approach with defined standards built on principles that have been tested and validated and greater when the approach is un-researched, ad hoc and personal to the operator.
- c. Risks are lower when equipment is well maintained and functioning to the required standard.
- d. Risks are lower when operators are well-trained, experienced and continuously meet acceptable standards of competence and results are peer reviewed, and greater when operators are inexperienced, unmonitored and left to adopt their own approach.
- e. Contextual and confirmation bias risk is lower when the contextual information is minimised, particularly at the comparison review stage and the reviewer is unaware of the examiner’s opinion, or other evidence that relates to the ‘marks’ examination.

⁶⁵ Kerstholt, J., Eikelboom, A., Dijkman, T., Stoel, R., Hermsen, R., van Leuven, B., Does suggestive information cause a confirmation bias in bullet comparisons? (2010) *Forensic Science International* **198** 138–142

- f. Expectation bias manifesting in the missing of an OCF hit is lower when there is an expectation of success⁶⁶.

11.2.4 Other more general bias risks within “Marks” and firearms examination and classifications:

- a. Observations that support the defence case are less rigorously considered or evaluated and are not given their true weight.
- b. Interpreting the Firearms Act 1968 when classifying potential component parts or antiques. Confirmation bias on the status of firearms should be avoided; this is particularly pertinent where the prosecution expert relies upon Home Office Guidance, which is not explicitly reflected in the legislation.
- c. Reluctance to express doubt particularly during oral evidence at court.
- d. Reluctance to clearly understand and express the limitations of a comparison after a time delay between the offence and the recovery of a suspect item.
 - i. The comparison of footwear a footwear mark recovered at a crime scene to footwear recovered months later.
 - ii. The assessment of the significance when there is matching and non-matching characteristic detail in the mark.
- e. Failure to express alternative explanations, such as possible sub-class origins and arguments for alternative firearms legal classifications.
- f. A failure to assess detail correctly due to a lack of knowledge and the inability to investigate due to location of manufacturing plant or time and cost considerations.

11.3 Examples where risks of bias have become an issue

- a. The identification of a tool being responsible for cutting a wire fence, where detail was clearly visible that excluded the suspect tool.
- b. Situation where critical findings checks were being undertaken on a basis of ‘I will check yours if you check mine’. An independent approach was not maintained.
- c. The association of two crime scenes in the same geographic area, involving crimes of similar *modus operandi*, calibre, make and model of gun. Possibly due to confirmation and contextual bias compounded by lack of awareness of differences between sub-class and individual characteristics.
- d. The automatic classification of vintage firearms as not being subject to the section 58(2) exemption provided for antique firearms, due to the prosecution expert relying on “official” guidance as opposed to statute, possibly as a result of confirmation bias.

⁶⁶ Nennstiel R., (2010). The Human Factor in Detecting Cold Hits, Association of Firearms and Toolmarks Examiners Annual Training Seminar. Henderson, Nevada, USA, 2nd – 7th May 2010.

- e. Classification of possible component parts of a firearm as being subject to the 1968 Act without consideration of any alternative hypothesis most probably due to confirmation bias.

11.4 Mitigation strategies currently deployed in the UK and overseas

11.4.1 Examples of mitigation strategies that are variously in current practice are listed below. These are considered to be good practice in appropriate circumstances:

- a. Case Assessment and Interpretation. Comparison of expected, pre-assessed outcomes with actual results under appropriate hypotheses.
- b. Full disclosure of all data used in the evaluation.
- c. In all firearms classification cases, the reviewer should clearly set out what is official guidance and what is statute, ensuring that alternative classification hypotheses are addressed to counter any confirmation bias.
- d. Use a completely “blind” checker who repeats the full interpretation, but in the absence of any contextual information relating to the case. Initially, the checker should not be aware of the opinion of the reporting scientist.
- e. An acceptable alternative is that result will be subject to a critical findings check by a second authorised examiner. The initial practitioner completes the comparison and records what items they have examined, their findings together with their conclusion. The checker then undertakes a detailed independent review wherever possible without knowledge of the previous practitioner’s conclusion. The aim of the check is as follows:
 - i. The examiner has followed the appropriate documented examination process and applied the appropriate relevant scientific methodology and techniques.
 - ii. The work and findings of the examination are reflected in the conclusion of the report. The results must support the conclusion and clearly there should be an understanding or statement of the findings.
 - iii. The maximum evidence has been obtained, that nothing has been overlooked and there are no other marks that may change the outcome.
 - iv. The submitting authority’s question has been fully addressed.

11.4.2 In addition to the good practice described above the following are also recommended:

- a. Validation testing of qualitative and subjective based approaches to demonstrate the robustness of conclusions and opinions.
- b. Development of standards and quality managed procedures for qualitative and subjective based methods, including system performance data indicating when the approach breaks down and is no longer valid.
- c. Practitioner training in the specific method used, together with initial and on-going competency assessment.
- d. Training and education in relation to the risks of cognitive bias in firearms classification and marks comparison generally.
- e. An approach to quality that includes the assessment and monitor of on-going competence of practitioners including the use of proficiency tests, declared and undeclared trials.

- f. Providers should ensure that a validated form of Context Management is applied.
- g. The use of blind trials should be introduced to increase the “success” rate of cold OCF hits.

12. TRACE EVIDENCE (INCLUDING HAIR AND FIBRE) GUIDANCE

12.1 Outline of the Forensic Process for Trace Evidence analysis

12.1.1 The examination of trace evidence covers a wide range of materials including particulate material such as glass, paint, hairs and fibres. However whilst the range of trace materials is wide, the analysis of such material essentially follows the same process which involves comparison of crime (unknown/recovered) material with one or more known/reference samples. This process can briefly be described as follows:

12.1.2 Item receipt: items are received along with case information and questions to be addressed by the scientific work. When dealing with contact traces, taking and submitting the right reference samples (from the crime scene or individuals) is critical as it can have a fundamental impact on the subsequent comparison.

12.1.3 Case assessment: case information is used to direct the strategy for item examination and trace evidence recovery and analysis. Ideally case assessment should be carried out within a framework of appropriate propositions. By its nature trace evidence examination is time consuming, so practicality and cost have to be considered. Case assessment can assist with targeting the exhibits most likely to yield probative evidence.

12.1.4 Recovery of trace materials using appropriate techniques

12.1.5 Identification of target material and comparison with reference sample(s):

- a. Whichever recovery technique is used, the examiner is often presented with a large amount of debris which may potentially contain some of the target material. Where there is a limited amount of target material of interest which can be immediately identified, e.g. glass fragments, paint fragments, this material can be recovered in its entirety or a sample taken. The material can then be compared with the relevant reference sample(s) using the appropriate microscopy and instrumental/analytical techniques.
- b. With other evidence types, for example fibres and hairs, there will often be a large amount of material collected which is of no relevance to the case. For this reason it is necessary to review the reference sample(s) and use features to enable an initial search of the recovered material to locate that which is of potential interest. For example, for hairs and fibres a search of tapings under a low power microscope would be conducted to locate hairs/fibres with similar macroscopic features (colour, length etc.) to the recovered hairs/fibres. This material can then be recovered for more detailed comparison with the reference samples using the appropriate microscopy and instrumental/analytical techniques.

- c. Evaluation of the scientific findings and interpretation within the context of the case specific information available (may be at source or activity level as appropriate).
- d. Provision of report or statement describing the findings and providing opinion on their significance.
- e. Oral testimony - the scientist may be called to court to give evidence.

12.2 The Risk of Cognitive Bias in Trace Evidence analysis

- 12.2.1 As in other areas of forensic science, trace evidence analysis can potentially be affected by some form of subconscious and unintended bias and will be a particular risk where subjective interpretations are required. Trace evidence examinations can broadly be divided into two groups:
- 12.2.2 Those that are entirely subjective and based on mainly observational skills, for example, the microscopic comparison of hairs or the comparison of the layers of paints in a microscopic fragment, which relies exclusively on a subjective assessment of whether the crime and reference samples match.
- 12.2.3 Those that may include an initial subjective element, followed by the use of objective instrumental techniques to confirm or eliminate matches. For example, analysis of paint after a visual comparison and fibre comparisons where the subjective microscopic examinations can usually be followed by the use of a range of instrumental/analytical techniques including Microspectrophotometry, Fourier Transform Infrared, Raman spectroscopy and Thin Layer Chromatography. Hair comparisons have no similar follow up tests (unless dyed), other than DNA analysis (nuclear or mitochondrial DNA) which, because of the cost and the destructive nature of the testing, is often not an option.
- 12.2.4 Additionally, opinions are formed in the context of the information supplied about the case and the samples submitted e.g., where and how the glass was broken, how close the person was to the breaking glass, how long after the incident/alleged contact clothing was recovered etc. This may introduce contextual bias⁶⁷. Regardless of contextual case information, practitioners may have a higher expectation of observing matching hairs, fibres, glass etc., simply because the samples have been submitted by the police investigators.
- 12.2.5 Due to the nature of trace evidence, the recovery and comparison is time consuming and requires a high level of skill, knowledge and often patience. In all cases involving contact traces, there is a requirement for relevant case information to be available to the practitioner to allow effective case assessment. Where fibre evidence is being considered, without information it would be impossible in all but the simplest cases to effectively target those fibre transfers which are viable and would be most probative, thus keeping the time expenditure at a level commensurate with the requirements of the case. This will also apply to hair examinations, where the population of hairs potentially of interest is large.

⁶⁷ Miller, L. (1987) Procedural Bias in Forensic Science Examinations of Human Hair, Law and Human Behaviour 11(2) p157-163

12.2.6 Within trace evidence examinations, there is a spectrum of bias risk:

Risk Source	Low risk	High risk
Case Assessment	Full case assessment considering potential outcomes, preferably considering at least two competing hypotheses	No case assessment; only one hypothesis considered.
Examination process	Empirical analysis using instrumental techniques	Subjective microscopic analysis only
Result Quality	Results are clear and unambiguous	Results show wide intra-sample variation, are of poor quality and there is an increased reliance on subjective opinion.
Interpretation Approach	There is a methodical approach with defined standards built on principles that have been tested and validated	The approach is un-researched, ad hoc and personal to the operator.
Operator Competence	Operators are well trained, experienced and continuously meet acceptable standards of competence	Operators are inexperienced, unmonitored and left to adopt their own approach.
Checking	Independent confirmation of critical observations. Full independent reinterpretation	No checking or checking is conducted collaboratively

Table 3: Spectrum of bias risk within trace evidence examinations

- a. Risks are high where no case assessment is carried out with respect to the potential outcomes of the examinations and the expectations of the examiner, preferably considering at least two competing hypotheses. Risks are reduced significantly where a documented assessment is carried out, the potential outcomes of the examinations are considered in the light of the relevant contextual information available, and the expectations of the examiner are recorded.
- b. Risks are low when empirical analysis forms part of the examination processes, and greater where there is an increased reliance on subjective observational analysis.
- c. Risks are low where results are clear and unambiguous (for example with a strongly coloured manmade fibre sample which shows little intra-sample variation) and is higher where there is wide intra-sample variation

(for example with a shoddy mix of fibres where it may not be possible to use instrumental techniques to confirm microscopic matches).

- d. Risks are low if there are sufficient reference samples showing all possible variations for example within a painted surface, hair from different parts of the head, all broken windows have been sampled etc. Risks are higher if only a limited reference sample is available and may result in the practitioner making a subjective assessment of the match.
- e. Risks are lower when there is a methodical approach with defined standards built on principles that have been tested and validated and greater when the approach is un-researched, ad hoc and personal to the operator.
- f. Risks are lower when operators/checkers are well trained, experienced and continuously meet acceptable standards of competence; they are greater when operators/checkers are inexperienced, unmonitored and left to adopt their own approach.
- g. Risks are lower when critical observations, such as paint layer colours and sequence, are checked independently by another competent practitioner and higher where no critical observation checks are carried out.
- h. Risks are lower when interpretation is checked by a competent peer who conducts a separate interpretation, fully independent and without influence from the reporting scientist. Risks are higher when checking is less rigorous and/or conducted collaboratively.

12.2.7 For some trace evidence there are data to support the practitioner. Studies of glass have been undertaken over many years and provide a great deal of data regarding background population, persistence on clothing, breaking windows and the transfer of glass fragments; refractive index information and analytical data for different types of glass are also available. For fibres, there is considerable empirical data to support interpretations, such as population studies and target fibre studies but there is currently no fibre database which provides any guidance with respect to how common a particular fibre might be in the general fibre population. Previous databases (Forensic Science Service) went some way to providing this, but constantly changing fashions and fibre technology changes mean that any database is almost impossible to keep up to date. Therefore, any assessment regarding how common (or otherwise) a fibre might be is essentially subjective and based on the scientist's experience, unless specific industrial enquiries can be made for a particular case.

12.2.8 Fibre, hair and trace evidence analysis generally are becoming less used, and therefore the risk that the examinations are not carried out by practitioners who are dealing with the evidence on a routine basis is increasing. The lack of work in this field has serious implications for the maintenance of scientists' experience and competence and a reduction in the number of practising scientists may ultimately result in there being no one suitable to undertake peer-review.

12.2.9 It is not operationally practical to carry out a full independent check of microscopic fibre matches where large numbers of fibres have been recovered from tapings and individually examined; but where a range of instrumental and analytical techniques are employed which back-up the subjective microscopic

matches this is not necessary. However, where subjective observational methods are the only option, for example in hair comparisons, a full independent check is vital.

- 12.2.10 With budgetary constraints a certain amount of 'pre-assessment' is often carried out by police forces before selected items are submitted to a forensic provider for examination. There is a bias risk inherent in this process, particularly where the practitioner is not fully informed. For example, other items seized but not submitted for examination may be potentially be an alternative, legitimate source of matching fibres.

12.3 Case Examples where Cognitive Bias May Contribute to Error

- 12.3.1 The analytical processes for trace evidence have largely remained the same for several decades. As a result methods have been validated and well-tested in forensic casework. The authors are unaware of any specific examples where the results of the microscopic comparison of trace evidence, or subsequent analytical testing of the material has been an issue in case work in the UK. The area of high risk with respect to bias in trace evidence analysis is that of the case evaluation and interpretation where contextual bias might be introduced. Whilst no specific casework examples can be provided where cognitive bias may have contributed to interpretational error, the following hypothetical examples involving glass and fibre examinations are offered where bias might be observed:

12.3.2 Absence of matching glass fragments concluded as being inconclusive

- 12.3.2.1 Clothing is submitted from a suspect who is believed to have been seen breaking a glass window and who was arrested shortly after the incident. The practitioner would have a high expectation of finding glass fragments on the persons clothing (choice of clothing to examine would depend on the height of the window). If the relevant clothing was examined and no glass is found then what should the practitioner conclude? As a simple observation then it could be said that no glass was recovered, however this provides no evaluation of the significance of the evidence. Often it is concluded that the findings are inconclusive as it is not possible to comment as no glass was found. If the practitioner evaluates the evidence using a structure of alternative propositions, one reflecting the prosecution view and one the defence view (or a hypothetical defence view if appropriate) the lack of any glass fragments may well support the view that the suspect was not involved in breaking the window as alleged. Therefore reporting the findings as inconclusive might be considered biased.

12.3.3 Absence of matching fibres concluded as being neutral

- 12.3.3.1 The examination of car seat tapings for a transfer of fibres from the clothing of an individual who is alleged to have stolen and driven the car for some hours results in no matching fibres being found. The defendant has made no comment. In this situation, it is tempting to conclude that the absence of matching fibres is neutral and does not assist in addressing whether or not the individual had been in the car. However, if the information available provides no explanation for the absence of matching fibres (for e.g., the defendant might have had had time to change clothing before arrest) and the scientist had a high expectation of finding matching fibres if the contact had occurred as alleged, the

absence of matching fibres may well support the view that the defendant had not been in the car. Even where a 'no comment' interview has been offered by the defendant, a good case assessment at the outset requiring consideration of the full range of outcomes and potential defence scenarios, including the absence of any matching fibres, would be likely to result in this type of bias being eliminated.

12.3.4 **Difference in treatment of crime and reference material post transfer**

12.3.4.1 A fibre examiner faces considerable difficulty in dealing with cases where clothing has been altered at a chemical level in the period between the offence and seizure of the clothing, for example where the body of a victim has been submerged in a river or at sea for some time, causing the dye in the clothing to fade. In this situation, the challenge for a fibre examiner is firstly searching for fibres without a reference sample that is representative of the fabric at the type of the offence, and then having to interpret a population of fibres on a suspect's garment which does not match the control, but perhaps did at the time of the offence.

12.3.4.2 A European Textile and Hair Group (ETHG) collaborative exercise in 2004 involved a hypothetical scenario involving blue pigmented viscose fibres found on the victim's clothing, which appeared the same as those from the putative source when compared under transmitted light, but differed markedly under UV light. Clearly these fibres did not match. Subsequent experimentation to test a theory that when the T-shirt had become wet, the fibres had 'taken up' washing detergent residues on T-shirt which contain optical brighteners causing them to fluoresce, demonstrated that this was possible. But the issue that the experiment does not address is how we tell whether the fibres on the T-shirt fluoresced the same as those from the mattress prior to the absorption of detergent. It is entirely possible that the fluorescent behaviour observed under the microscope is exactly what the fibres were like at the point of transfer. Whilst it is fair to explore the possibility that fibres have been changed at a chemical level and pursuing experiments to assess that, it would be biased for a laboratory to state that on the basis of such experiments more support is provided for the view that the fibres recovered from the T-shirt came from the mattress rather than from another source.

12.4 **Mitigation strategies deployed both within the UK and overseas**

12.4.1 The following are examples of mitigation strategies that are variously used in current practice. All are examples of good practice in appropriate circumstances and should be applied as described.

12.4.2 Independent checking – where only subjective observational assessments of a match are possible (for example hair comparisons, paint layer colours and sequences), full independent checking should be carried out and clearly documented. The check should be carried out independently of the original examiner.

12.4.3 Independent checking of analytical results – where instrumental techniques are used, either alone or to back up subjective microscopic matches, and the results are subject to interpretation by the operator (e.g., Microspectrophotometry result for analysis of colour of fibres, refractive index

measurements for glass, chemical analysis of glass fragments and paint layers), the interpretation of the results should, where possible, be carried out by two competent and experienced scientists, (operator plus one other) independently of each other.

- 12.4.4 Use of statistical approach to evaluation – to assess whether the refractive index of suspect glass fragments match that of reference glass sample(s) a statistical approach can be applied rather than relying on the experience of the practitioner.
- 12.4.5 Case Assessment and Interpretation – a robust and documented comparison of expected, pre-assessed outcomes with actual results under appropriate competing hypotheses. Some documented indication of expected outcome is recommended in all cases. Where results are at the least likely end of the expected outcomes, for example the absence of matching fibres where the most likely outcome was to find lots of matches, an independent review of the tapings would be advisable.
- 12.4.6 Training – appropriate training of practitioners in the methods employed who can demonstrate initial and ongoing competence.
- 12.4.7 Quality assurance trials – participation in internal and external quality assurance trials. Members of the ENFSI European Textile and Hair Group (ETHG) participate in an annual collaborative exercise which seeks to test various parts of the process of fibre examination. Membership of the ETHG is limited, and participation is only available to members. Forensic Science Providers (FSP) in the UK also participate in CTS (Collaborative Testing Services Inc.) trials which are available by subscription and cover fibre, paint and glass analysis. These trials are considered to be fairly basic and test the microscopic and analytical procedures employed, but do not assess the approach to evaluating the significance of the findings. At least one of the UK FSPs carrying out fibre work also carries out internal quality assurance testing with each of their scientists undertaking a mock case every 2 years to test their competency. Only some of these trials will be relevant with respect to assurance that bias is being avoided, however all provide some level of assurance of the ongoing competence of the scientists involved. There is a gap in the current system with respect to ‘blind’ trials – small organisations do not have the resources to conduct such testing.
- 12.4.8 **Further recommendations for good practice**
- 12.4.9 In addition to the good practice described in 11.4, also following may be considered:
- a. Use of a completely independent (“blind”) checker who repeats the examination/interpretations described in 11.4.1 and .2 but in the absence of any contextual information relating to the case. This may present practical challenges, particularly within smaller organisations. However, it will assist in a continuous learning and improvement cycle, where reporting scientists can identify instances where they may have been affected by bias. Further, it provides assurance for the courts that the interpretation is free from contextual bias.
 - b. Documented case assessment and interpretation in all cases involving trace evidence analysis, preferably carried out independently by a

second scientist, but at the very least to be peer reviewed. Elements of the interpretation should also be included in the scientist's statement to explain to the court how their conclusion has been reached.

- c. With a reduction in the use of trace evidence analysis in casework in the UK, maintaining competency and having sufficient trained and competent staff to allow independent checks and peer reviews will be a challenge, particularly for smaller organisations. Clear documentation of case assessment, interpretation and a report/statement which clearly states the limits of the examinations used (i.e. where appropriate their subjective nature, limitations of small amounts of reference material (hairs) and whether findings and interpretation have been reviewed) should be a requirement. Such transparency and disclosure provides the opportunity for scrutiny and the identification of potential bias.
- d. Where items submitted to a forensic provider for examination have been the subject of 'pre-assessment' by the submitting force, ideally a list of other items seized should be made available to the scientist on request to allow consideration of potential alternative sources of transferred material.
- e. Training and education in relation to the risks of cognitive bias in trace evidence examination generally and specifically in relation to highly subjective examinations.
- f. A program of 'blind' or undeclared quality assurance trials in the UK submitted to all FSPs could address the issue of bias thus providing assurance to the courts that procedures are robust and areas of potential bias are identified and managed.

13. VIDEO AND AUDIO

13.1 Introduction

13.1.1

A video or audio comparison often seeks to establish if the image or signal associated with a suspected crime (the "item") is of a specific article or person (the "target"). This may be for example a person's face captured on CCTV, an item of clothing being worn by the perpetrator, a vehicle or indeed any other object that may be relevant to the crime scene. This is undertaken by comparison against a reference image or signal from the target, ideally which has been generated under identical conditions to the original item. The comparison may be subjective and may utilise either purely visual side by side comparisons, or may include use of tools to aid comparison, such as overlaying of the images and switching between the two to highlight any potential differences. Alternatively comparison may be aided by objective measurements of the images (photogrammetry) for example in facial comparison in which spatial proportions of facial features are compared using measurements of distances and angles between facial landmarks in order to quantify any differences or similarities observed. Elimination should be the fundamental aim in any comparison and presence of a single difference for which there is no viable explanation should be sufficient for an exclusion. Conversely where a number of features are seen to be in common and no differences are observed, then this can provide corroboration to other evidence of inclusion.

13.1.2 Any examination is therefore dependent upon the visual quality and clarity of the detail that is observed by the examiner plus how inherently discriminable the object is from other objects of the same type. In combination these ultimately impact on the strength of the conclusions that may be drawn. For example with a good quality image of a motor vehicle it may be possible to identify the make and model with confidence by observing a combination of class characteristic features such as the shape of the windows, lights, bumpers, doors, overall shape etc. However, narrowing the identification to a single specific car would require much more detail in the images in order to observe individual characteristics or features that differentiate one individual car of the same make/model from another e.g. registration number, intentional alteration such as cosmetic modifications, wear and tear such as scratches or other damage features⁶⁸.

13.1.3 The basis for opinions and conclusions reached lies in the detection of correspondence or discordance of features determined to be reliable. These in turn rely on the individual's, relevant experience, depth of knowledge and skill as well as their disposition at the time. Every effort must be made to ensure that opinions and conclusions are logical, transparent, balanced and robust. In some cases a statistical model may be applied to provide a formal probabilistic basis for a conclusion. In other cases a statistical model may not be feasible but this does not necessarily preclude reaching a sound conclusion where for example a CAI approach is adopted.

13.2 Generic video and audio process outline

13.2.1 The generic forensic process that is outlined below encompasses the interpretation and reporting of video and audio comparison cases. It is applicable to a wide range of evidence types including photographic evidence with motion and still images, plus audio recordings associated with a suspected criminal act under investigation:

- a. Recovery of video, photo or audio material related to the crime scene consisting
- b. Items are received by the analyst along with relevant case information and questions to be addressed by the scientific work.
- c. Generation of an exact copy of the original then use of techniques as required to clarify or clean up the copy of the image or audio signal
- d. Examination of the copied material recovered from the crime scene and notation of features determined to be reliable
- e. Examination of the 'control' item
- f. Undertake a comparison using appropriate methods and equipment
- g. Interpret and evaluate findings
- h. Verification of result
- i. Findings are described in a statement or report.
- j. The scientist may be called to court to give oral testimony.

⁶⁸ Scientific Working Group Imaging Technology (SWGIT) (2013) Best practices for forensic photographic comparison V1.1 Section 16

13.3 Risks of cognitive bias

13.3.1 Within video and audio comparison, there is a spectrum of bias risk:

Risk factor	Low risk	High risk
Detail & Presentation	The images/signals are clear detailed and unambiguous with item and reference images generated under identical conditions	The images are of poor quality and the detail present is poorly defined, and the images being compared have been generated under very different conditions
Equipment	Optimum visualisation of the detail in an image using appropriate equipment/imaging and enhancement techniques.	Poor or inappropriate equipment/imaging and enhancement techniques.
Approach	There is a methodical approach with defined standards built on principles that have been tested and validated. Item is characterized prior to exposure to reference image	When the approach is un-researched, ad hoc and personal to the operator. Item is characterized after exposure to reference image
Scientist/Examiner	Scientist/examiners are well trained, experienced and continuously meet acceptable standards of competence	Scientist/examiners are inexperienced, unmonitored and left to adopt their own approach.
Verification of results	Independent review of critical findings	There is no independent review, or reviewer knows findings and conclusions drawn from original assessment

Table 4: Spectrum of bias risk in video and audio comparison

13.4 Mitigation strategies and good practice guidance

13.4.1 Avoiding psychological contamination in the processing of material

13.4.2 One of the greatest risks of introducing cognitive bias is in the way the material is provided for assessment. Examiners should only be provided with the information relevant to the examination of the item image, and in the first instance and they should only be asked to describe what they see. The latter guards against confirmation bias, which is almost inevitable if the question asked is along the lines of “do you agree that this is item/individual x?”, or the examiner asks to be told what the item is so that they can consider whether or not they agree. Not being provided with the case notes and other extraneous information prior to the examination and comparison task at hand helps safeguard against contextual bias. For the same reason it is better for the

analyst to receive written briefing regarding the comparison to be made rather than being in direct verbal contact with the investigator, so that opportunity for transfer of non-relevant and potentially biasing information (both contextual and confirmatory) can be avoided.

- 13.4.3 Wherever possible, the item should be assessed prior to observing the reference image or signal, again so that confirmation bias can be guarded against. If a series of images are submitted of what is believed to be the same item, these should be assessed in sequence starting with the worst image first, so that the potential for confirmation bias between these images is avoided. Where a discriminatory feature is identified in the item only after comparison with the reference, this should be fully explained in the examination records, so that transparency of the assessment is maintained at all times.
- 13.4.4 Independent assessment of critical findings is also crucial. Independent checking that minimizes the risk of cognitive bias entails assessment without knowing the outcome of the initial analysis, or even where possible the identity of the original examiner in order to avoid confirmation bias.
- 13.4.5 **Use of validated processes**
- 13.4.5.1 All forensic processes should be validated prior to use in casework. Section 20 of the FSR Codes provides guidance on validation with more detailed explanations given in validation appendix currently due for publication by the FSR in September 2014 plus guidance on how to approach validation of digital forensic techniques in an currently being drafted for consultation by the FSR. Scientific validation is the process by which a new method or technique is assessed to ensure that it is fit for purpose and that once implemented will continue to function as such. This principle applies whether a system provides objective highly automated analysis and comparison of materials, or at the other extreme where the process relies almost entirely on subjective comparison and assessment by an analyst.
- 13.4.5.2 Bias is less likely when images are clear and well defined, whilst the risk of bias increases as images become less defined and ambiguity regarding interpretation increases. Therefore use of appropriate and validated methods to clarify images/signals may help reduce risk of bias. However certain techniques for image manipulation are “lossy” and can result in the loss of potentially discriminable detail (increasing the risk of false inclusion) whilst other enhancement techniques can create artefacts, thereby increasing the risk of false exclusion. It is crucial therefore that any manipulation processes are validated. This should include full characterization of the processes applied including determination of the limits within which the application can be reliably used and demonstration through experimentation not to increase the risk of false inclusion or exclusion. Likewise during application to casework, and especially in the enhancement of audio signals the analyst should frequently check back during processing against the original to ensure that the signal has

not become over-processed⁶⁹. Likewise, when using colour as a comparator, the limitations of the approach should be fully evaluated and understood: under certain lighting conditions (e.g. sodium lamp), 2 items that are different in colour under natural illumination may appear to be the same, whilst the same item under different lighting conditions may appear to be markedly different in colour.

13.4.5.3 Techniques deployed to aid in the side by side comparison of images must be validated to ensure they do not introduce bias. For example overlaying techniques for comparison can highlight differences between images by rapid flicking between images. However a gradual transition between two overlaid images may cognitively mask any differences from the observer. Wherever possible the same context should be used to generate reference images for comparison against the original crime scene image by for example re-constructing the scene and capturing the reference image using the same equipment, lighting conditions, camera angles, environmental conditions etc. Where this is not possible, the resultant limitations in making a comparison should be declared in any statement.

13.4.6 Proficiency testing/ QC measures

13.4.6.1 The fact that the police have asked for a comparison to be made between two images or an image and an item can in itself create a bias towards confirmation. The use of appropriate procedures, plus the training, experience and competence of the examiner should in combination ensure that in this is being safeguarded against in practice, but these measures should be both strengthened by and demonstrated to be effective through the use of effective QA/QC measures. These measures include the following:

13.4.6.2 Initial competency assessment of an individual prior to commencing forensic casework: the individual is subjected to proficiency testing using characterized test material of known provenance to demonstrate that they, in combination with validated working practices, generate reliable unbiased outcomes.

13.4.6.3 Ongoing competency assessment through use of declared and undeclared trials. Undeclared or blind trials are of particular value as these are more likely to give a truer indication of typical performance and behaviours, unlike a declared trial where the individual knows that they are being observed, and may consequently behave differently to normal by for example being more cautious in their evaluation.

13.4.6.4 Provision of an image line up using “fillers”. This is akin to an identity parade in which for example the analyst may be presented with a number of images comprising that of the target plus a number of other broadly similar “innocent” items, and asked to determine which if any constitutes a match to the image corresponding to the crime scene⁷⁰. A further refinement is to split this

⁶⁹ Manchester, P. (2010) An introduction to forensic audio. Sound on Sound. January 2010 <http://soundonsound.com/sos/jan10/articles/forensics.html>

⁷⁰ Kassin, et al (2013). The forensic confirmation bias: Problems, perspectives, and proposed solutions. Journal of Applied Research in Memory and Cognition. 2, p42-52

comparison into two sets so that the examiner does not know whether an individual set contains the target image.

14. ABBREVIATIONS

ACE-V	Analysis, Comparison, Evaluation and Verification
FBI	Federal Bureau of Investigation
ENFSI	European Network of forensic Science Providers
ETHG	European Textile and Hair Group
FSP	Forensic science provider
Hd	Defence hypothesis
Hp	Prosecution hypothesis
LR	Likelihood Ratio
OCF	Open Case File

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