

Forensic Science Regulator

Guidance

Cognitive Bias Effects

Relevant to Forensic Science Examinations

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Issue 2

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Contents

1.	Executive Summary	6
1.1	Introduction	6
1.2	Categories of Cognitive Bias	6
1.3	General Conditions Impacting on the Level of Cognitive Bias Risk	7
1.4	General Controls or Mitigation Impacting on the Level of Risk	9
2.	Introduction	10
2.1	General	10
2.2	Effective Date	10
2.3	Scope	10
2.4	Modification	10
3.	Terms and Definitions	12
4.	An Explanation and Brief Overview of Cognitive Bias	13
4.1	Overview	13
4.2	Categories of Cognitive Bias	14
4.3	Academic Research into Cognitive Bias in Forensic Science	16
4.4	Bias Countermeasures (Also Known as ‘Debiasing Techniques’)	17
5.	A Generic Process to Manage Cognitive Bias for a Range of Forensic Evidence Types	23
5.1	The Role of the Investigating Officer or Instructing Authority	23
5.2	The Role of the Scientist in the Analysis or Initial Evaluation Stage	24
5.3	The Role of a Forensic Expert	25
5.4	Process Outline	25
5.5	Mitigation Strategies to Reduce the Risk of Cognitive Bias	27
5.6	Recommended Good Practice	28

6.	Scenes of Crime	29
6.1	Introduction	29
6.2	Scene of Crime Process	30
6.3	Bias Countermeasures and Good Practice	33
7.	DNA Mixtures	35
7.1	Outline of the Forensic Process Involving DNA Mixture Interpretation	35
7.2	The Risk of Cognitive Bias in DNA Mixture Interpretation	36
7.3	Case Examples Where Cognitive Bias May Have Occurred	40
7.4	Mitigation Strategies Currently Deployed in the UK and Overseas	41
7.5	Further Recommendations for Good Practice	43
8.	Fingerprints	44
8.1	Brief Outline of the Forensic Process	44
8.2	Risks of Cognitive Bias	47
8.3	Examples Where Cognitive Risks Have Become an Issue	50
8.4	Examples of Mitigation Strategies	53
8.5	Recommended Good Practice	55
9.	Footwear, Tool Mark and Firearms Comparison, And Firearms	57
9.1	The Generic Marks' Comparison Process	57
9.2	Risks of Cognitive Bias	57
9.3	Examples Where Risks of Bias Have Become an Issue	61
9.4	Mitigation Strategies Currently Deployed in the UK and Overseas	61
10.	Particulate Trace Evidence (Including Hair and Fibre)	63
10.1	Outline of the Forensic Process for Particulate Trace Evidence Analysis	63
10.2	The Risk of Cognitive Bias in Particulate Trace Evidence Analysis	64
10.3	Case Examples Where Cognitive Bias May Contribute to Error	69

10.4	Mitigation Strategies Deployed Both Within the UK and Overseas	71
11.	Video and Audio	75
11.1	Introduction	75
11.2	Generic Video and Audio Process Outline	76
11.3	Risks of Cognitive Bias	77
11.4	Mitigation Strategies and Good Practice Guidance	78
12.	Review	82
13.	References	83
14.	Abbreviations and Acronyms	88
15.	Acknowledgements	89

1. Executive Summary

1.1 Introduction

1.1.1 Cognition is the mental process of knowing, including awareness, perception, reasoning and judgement, and is distinct from emotion and volition. Cognitive processes include mental shortcuts, which speed up decision making. However, cognitive bias occurs when the shortcut causes inferences about other people and/or situations to be drawn in an illogical fashion.

1.1.2 There is a tendency to display bias in judgements that are made in everyday life, indeed this is a natural element of the human psyche. Jumping to a conclusion, tunnel vision, only seeing what is expected/wanted, being influenced by the views of others, all are recognisable behaviours.

1.1.3 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; investigators may be influenced to follow a particular line of enquiry or interpretation of a finding that may be incomplete, or even wrong.

1.1.4 Simply because there is a risk of a cognitive bias does not imply that it occurs. The problem is that as it is a subconscious bias it is unlikely that an individual will know either way and therefore it is wise that all practitioners understand the issue and take proportionate steps to mitigate against it.

1.2 Categories of Cognitive Bias

1.2.1 There are a number of categories of cognitive bias described in more detail in the body of the text.

- a. Expectation bias, also known as experimenter's bias, where the expectation of what an individual will find affects what is actually found.
- b. Confirmation bias is closely related to expectation bias, whereby people test hypotheses by looking for confirming evidence rather than for potentially conflicting evidence.

- c. Anchoring effects or focalism are closely related to both of the above and occur when an individual relies too heavily on an initial piece of information when making subsequent judgements, which are then interpreted on the basis of the anchor.
- d. Contextual bias is where someone has other information aside from that being considered, which influences (either consciously or subconsciously) the outcome of the consideration.
- e. Role effects are where scientists identify themselves within adversarial judicial systems as part of either the prosecution or defence teams. This may introduce subconscious bias that can influence decisions, especially where some ambiguity exists.
- f. 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 that may support a less favoured outcome.
- g. Reconstructive effects can occur when people rely on memory rather than taking contemporaneous notes. In this case people tend subsequently to 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.

1.3 General Conditions Impacting on the Level of Cognitive Bias Risk

- 1.3.1 In many disciplines there is a spectrum of bias risk that is shaped by multiple factors including the following.
 - a. Risks of bias are lower 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 unresearched, ad hoc and personal to the practitioner.

- c. Risks are lower when practitioners and checkers are well trained, experienced and continuously meet acceptable standards of competence; they are greater when practitioners 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 independently and without influence from the reporting scientist. Risks are higher when checking is less rigorous and/or conducted collaboratively.

Table 1. Summary of conditions impacting on the risk of cognitive bias

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 unresearched, ad hoc and personal to the practitioner.
Practitioner competence	Practitioners are well trained, experienced and continuously meet acceptable standards of competence.	The practitioners are inexperienced, unmonitored and left to adopt their own approach.
Checking	Full independent reinterpretation.	Checking is conducted collaboratively, or not conducted at all.

1.4 General Controls or Mitigation Impacting on the Level of Risk

- 1.4.1 The most powerful means of safeguarding against the introduction of contextual bias is to ensure that the practitioner conducting the analysis only has information about the case that is relevant to the analysis. Often more information is required to ensure effective case assessment and examination strategy setting, and where this is required, then case management can be performed by a leading practitioner.
- 1.4.2 Controlling the flow of task-irrelevant information to analysts is sometimes referred to as sequential unmasking. [1] This guidance document advocates a structured approach where decisions on the suitability of the results and marks for later comparison are made prior to comparison with the reference samples.
- 1.4.3 Most structured approaches are not entirely linear. Initial analysis of the trace evidence may be revisited once the reference material is considered, provided that any changes to the findings are documented, with an explanation of the reasons. However, the policies adopted should be designed to avoid post-comparison rationalisation or circular reasoning where the decision maker begins with what they are trying to end with. The aim is to ensure that the decision process is transparent and, as it is recorded in the case file, it is of course disclosable.

2. Introduction

2.1 General

2.1.1 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 ...” (Code of Conduct: point 2).

2.1.2 However, many fields of forensic science include subjective assessment and comparison stages that are potentially susceptible to subconscious 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. It aims to show readers how to recognise cognitive bias and therefore help to safeguard against biasing effects, through adherence to good practice. This document also provides examples of good practice for specific subject areas. However, it is not possible to cover every subject area or discipline, although cognitive bias has the potential to impact in almost any area where decision making is required.

2.2 Effective Date

2.2.1 This guidance is available for use from 22 September 2020.

2.3 Scope

2.3.1 These guidelines are limited to the consideration of cognitive bias within processes associated with forensic science examinations at scenes and within the laboratory only. They do not cover the wider aspects of the Criminal Justice System of England and Wales (CJS) such as court processes, including activities of the judiciary/legal profession.

2.4 Modification

2.4.1 This is the second issue of this document.

- 2.4.2 Significant changes to the text have been highlighted in grey; deletions have not been marked.
- 2.4.3 The modifications made to create Issue 2 of this document were, in part, to ensure compliance with The Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018.¹ Text identified as out-of-date during this accessibility review has either been modified or deleted; however this document not been subject to a full practice review or new literature review.
- 2.4.4 The Regulator uses an identification system for all documents. In the normal sequence of documents this identifier is of the form 'FSR-#-####' where (a) the '#' indicates a letter to describe the type or document and (b) '####' indicates a numerical, or alphanumerical, code to identify the document. For example, the Codes are FSR-C-100. Combined with the issue number this ensures each document is uniquely identified.
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¹ To facilitate the operation of the Regulations the following significant changes to sections of the document are noted here. The following sections of the document have been amended: Contents page, 2.1.1, 2.2.1, 2.3.1, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.5, 2.4.6, 4.1.3, 4.4.8, 4.4.9, 4.4.16, 4.4.19, 5.1.3, 5.4.5, 7.2.5, 7.2.8, 7.4.1, 7.4.8, 7.5.1, 8.1.2, 8.1.3, 8.1.4, 8.1.5, 8.1.6, 8.1.7, 8.1.8, 8.2.4, 8.2.6, 8.2.9, 8.2.10, 8.2.15, 8.2.16, 8.3.9, 8.4.3, 8.5.1, 9.4.1, new sub-heading added in 10.1 to split list, 10.1.3 (pre-existing clauses from previous list not marked), 11.1.4, 13, 14. The following footnotes have been amended – 1, 8.

3. Terms and Definitions

Anchoring or Focalism

- 3.1.1 The tendency to rely too heavily on one piece of information when making decisions.

Blinding

- 3.1.2 Shielding the forensic examiner from information about the case that is not required in order to conduct the examination.

Cognitive Bias

- 3.1.3 A pattern of deviation in judgement whereby inferences about other people and situations may be drawn in an illogical fashion.

Confirmation Bias

- 3.1.4 The tendency to test hypotheses by looking for confirming evidence rather than potentially conflicting evidence.

Contextual Bias

- 3.1.5 The tendency for a consideration to be influenced by background information.

Debias

- 3.1.6 The reduction or elimination of the impact of bias in decision making and problem solving.

Expectation Bias

- 3.1.7 Also known as experimenter's bias, where the expectation of what will be found affects what is actually found.

Photogrammetry

- 3.1.8 The practice of obtaining reliable information about physical objects through the processes of recording measuring and interpreting photographic images.

Psychological Contamination

- 3.1.9 Exposure to other information that is irrelevant to the assessment but that introduces subconscious bias into the findings.

Reconstructive Effects

- 3.1.10 The tendency when people rely on memory to fill in gaps on recall with what they believe should have happened.

Role Effects

- 3.1.11 The tendency for individuals to identify themselves as part of a team with common goals, which may introduce subconscious bias.

4. An Explanation and Brief Overview of Cognitive Bias

4.1 Overview

- 4.1.1 Cognition is the mental process of knowing, including awareness, perception, reasoning and judgement, [2] and is distinct from emotion and volition [3]. 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 fashion. [4] People all tend to display bias in judgements that are made in everyday life, indeed this is a natural element of the human psyche. Jumping to a conclusion, tunnel vision, only seeing what is expected/wanted, being influenced by the views of others, all are recognisable behaviours. 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.
- 4.1.2 The consequences of cognitive bias may be far-reaching: decisions by the investigator to follow a particular line of enquiry, the Crown Prosecution Service to prosecute or not, and decisions in the CJS as to the 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 evidence and the conclusions drawn from its interpretation.
- 4.1.3 Cognitive bias has been identified as a potential issue within **various** criminal justice systems since the 1970s, [5] [6] [7] and in more recent years some high-profile cases including false positive fingerprint identifications [8] [9] 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 bias. [10]

4.2 Categories of Cognitive Bias

4.2.1 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 Itiel Dror. [11]

Expectation Bias

4.2.2 Expectation bias, also known as experimenter’s bias, where the expectation of what will be found affects what is actually found, 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 pre-existing expectations. This is also closely related to observer expectancy effects in which a researcher subconsciously manipulates an experiment or data interpretation in order to find a result consistent with expectations.

Confirmation Bias

4.2.3 Confirmation bias is closely related to expectation bias, whereby people test hypotheses by looking for confirming evidence rather than for potentially conflicting evidence. [12] [13] 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 the 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 (so-called conformity effects and institutional bias).

4.2.4 Examples such as a request to ‘quickly check this match’ demonstrate the potential for confirmation bias in verification processes.

Anchoring Effects

4.2.5 Anchoring effects or focalism are closely related to both the above and occur when an individual relies too heavily on an initial piece of information when making subsequent judgements, which are then interpreted on the basis of 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.

Contextual Bias

4.2.6 Contextual bias is where someone has other information aside from that being considered, which influences (either consciously or subconsciously) 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 the detectives believe that 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 the evaluation and that potentially influences this type of biasing has been termed ‘psychological contamination’ or ‘cognitive contamination’ [14], as opposed to the more widely understood issue within forensic science of ‘physical contamination’ [15].

Role Effects

4.2.7 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 that 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 that may support a less favoured outcome. [16] [17] An extreme example of this is where an individual wants one side 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 documented. [18]

Reconstructive Effects

4.2.8 Reconstructive effects [19] can occur when people rely on memory rather than taking contemporaneous notes. People tend to fill in gaps subsequently with what they believe should have happened and so may be influenced by protocol requirements when recalling events some time later from memory.

4.3 Academic Research into Cognitive Bias in Forensic Science

4.3.1 Academic research into cognitive bias in forensic science, conducted through both experimentation and identification of examples from past cases, has indicated effectively that any technique or process that includes subjective assessment and comparison is potentially susceptible to bias. A particularly useful overview of this topic has been published recently. [15] Other research papers have described studies on bias in DNA mixture interpretation [20], fingerprint comparison [21] [22], handwriting comparison [23], fire investigation [24], forensic odontology [25], bullet comparisons [26], hair comparison [27], and forensic anthropology [28]. 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 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.

4.4 Bias Countermeasures (Also Known as ‘Debiasing Techniques’)

Blinding Precautions

- 4.4.1 The most powerful means of safeguarding against the introduction of contextual bias is to ensure that the practitioner conducting the analysis only has information about the case that is relevant to the analysis. However, in controlling the risk of bias, it should be borne in mind that without relevant information, case assessment, targeting and interpretation may be hampered and therefore introduce a risk of its own.
- 4.4.2 With this in mind, most forensic science providers would be able take in the full picture and yet control and/or stage the flow of information to the individual conducting the actual analysis, thus ensuring both risks are managed (see section 5). If this is the mitigation strategy used, then careful records with dates and times need to be kept to ensure that there is no confusion about the order of disclosure and analysis. Also, the analyst needs to be aware that the information flow is likely to be staged and to avoid direct contact with the investigating officer prior to assessment.
- 4.4.3 Controlling the flow of information is also known as ‘sequential unmasking’, which as the name implies, requires trace evidence to be examined first and the findings documented before the examiner is exposed to further information such as known reference material.
- 4.4.4 Sequential unmasking does not restrict or limit the number of times that the examiner may revisit their initial analysis of the trace evidence once they have reviewed the reference material, provided that any changes to the findings are documented. [29] However, in 2015, Dror et al. [30] recommended that forensic science providers should impose some restrictions and controls on how this is conducted and proposed an extension to the process termed ‘linear sequential unmasking’. The simplest form of this approach is to restrict the number of changes that are allowed, but the approach favoured by the authors is to impose controls based on the confidence of the initial analysis. By flagging the confidence or limitations of the finding in the pre-assessment or first examination before the reference material is viewed means that modifications to

initial findings are transparent. In addition, if a high confidence finding is significantly modified it should alert the reviewer of the critical findings that this may be a riskier finding and additional quality assurance measures may be warranted, such as blind review by another examiner.

4.4.5 The importance of the demonstration of independence is particularly significant where the analysts are within the same organisation as the investigative unit. The same principles apply as in 4.4.1, but as well as case assessment and strategy the mechanisms that assist in maintaining independence include ensuring that the organisational structures and reporting lines are appropriate, to ensure that the information flow is as intended.

4.4.6 However, some forensic science practitioners are in sole practice, so the instructing agency needs to have a role in managing the information flow and therefore needs a working knowledge of the issues. In such situations, the practitioner may need to ensure that the officer in the case is aware of what appropriate information, images and disclosure is required at different stages of the investigation. Both the instructing agency and practitioner should keep careful records with dates and times to ensure that there is no confusion about the order of disclosure and analysis. The practitioner also ought to prompt the instructing agency if and when fuller disclosure is appropriate, but also to ensure that if a finding is subject to review this status is made clear. It could be damaging to the investigation if initial findings are acted on when viewing the reference material is considered essential; it could also be damaging to how an expert is perceived if a finding is changed in light of the reference material and the recipient of the preliminary report was not made aware of this possibility.

4.4.7 Access to background information is often required at specific stages, and varies from case to case. For instance, in investigative mode, the CCTV footage of the incident would be needed to target effectively for 'touch' DNA as well as perhaps requiring information from witness statements. However, the same information supplied to the analyst of the DNA is likely to be extraneous. In the evaluative mode sometimes very detailed versions of events from the parties involved are needed to address activity level propositions. The case strategy should include controls and require the recording of what and when information is seen by analysts in the case.

4.4.8 Good practice in forensic science requires that the independent checking of critical findings is undertaken (16.3.2 in Issue 5 of the Codes). Independent checking that minimises the risk of cognitive bias would entail assessment without knowing the outcome of the initial analysis or, where practicable, the identity of the original examiner in order to avoid confirmation bias.

Structured Approach

4.4.9 The 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 the USA. The sequence of working is:

- a. an examiner analyses a mark and makes notes on their observations;
- b. the examiner then compares the mark with a known print;
- c. having compared the images, the examiner evaluates what they have seen and reaches a decision; and
- d. the results are then subject to verification by one or more additional examiner(s).

4.4.10 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; it is important that no post hoc rationalisation is involved.

4.4.11 Another framework that has been applied to give structure to the evaluation of scientific findings is the case assessment and interpretation (CAI) model. [31] [32] [33] This helps scientists to design effective, efficient, and robust case-examination strategies. The CAI model is founded on Bayesian ² thinking and provides clarity on the role of forensic scientists within the criminal justice

² 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.

process. It also encourages consistency of approach, and helps to 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 evaluative assessment. Again, it is not entirely linear as iterations are included in the process only provided that no post hoc rationalisation is involved.

Method Development

- 4.4.12 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, this doesn't mean that it automatically manifests in affecting critical judgement.
- 4.4.13 Having a complete picture is often vital for constructing and testing relevant hypotheses and propositions. However, if knowing about certain aspects are assessed to work against the objective process in a particular method (i.e. assessment recommends that a blinding method is used), then the methodology right down to the 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.

Awareness, Training and Competence Assessment

- 4.4.14 In addition to well-defined evaluation procedures in place as outlined above, practitioners need to be aware of the risks and issues arising from cognitive bias. Practitioners need training in how the evaluation procedures assist in overcoming some of these risks in their respective roles, as well as what residual risk may remain. Ideally, this training should be practical in nature such that the practitioner experiences bias first hand, thus gaining an insight into subconscious bias as something that diligence alone cannot avoid, and that mitigation strategies are required. 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.

4.4.15 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 Charlton et al. [6] 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, utilising 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.

Avoidance of Reconstructive Effects

4.4.16 The taking of contemporaneous notes or technical records is another stipulation in the Forensic Science Regulator’s Codes (Issue 5: section 16.2.3). Adherence with this requirement wherever it is practicable to do so, and at all stages in the collection and processing of forensic evidence, provides the best safeguard against potential reconstructive effects.

Avoidance of Role Effects

4.4.17 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. These effects 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 a forensic science provider (FSP) is providing contracted services to the prosecuting side or to the defence, or in the case of police laboratories is providing services to an internal customer.

- 4.4.18 However, a wider customer is being served here, i.e. the CJS, not just the defence or prosecution sides paying for the services. The Forensic Science Regulator’s Codes 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.
- 4.4.19 This is reinforced in section 8 of the Codes (Issue 5) 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.
 - 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 pressurise examiners into biasing decisions.
- 4.4.20 Whilst point 4.4.19c 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 that might influence their technical judgement. In other words, organisational systems and safeguards are required to ensure that scientists are insulated from potential biasing pressures.
- 4.4.21 The Criminal Procedure Rules [34] state in part 19.2 that an expert’s duty to the court includes the following.
- “(1) An expert must help the court to achieve the overriding objective – by giving an opinion that is:
- a) objective and unbiased; and
 - b) within the expert’s area or areas of expertise.

(2) This duty overrides any obligation to the person from whom the expert receives instructions or by whom the expert is paid.”

- 4.4.22 The adoption of a structured approach such as the CAI principles as described in 4.4.11, which considers both prosecution and defence hypotheses, can help to ensure that evidence is evaluated and presented in a balanced manner, regardless of the defence or prosecution role. This requires the following.
- 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.
 - 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.

5. A Generic Process to Manage Cognitive Bias for a Range of Forensic Evidence Types

5.1 The Role of the Investigating Officer or Instructing Authority

- 5.1.1 The appropriate flow of information is very important in all cases; one limiting factor in the assistance that forensic science can give to an investigation is pertinent information not being passed on. Contextual or case information should be made available to the lead scientist for case-building purposes. The lead scientist can then ensure that analysts receive only the information appropriate for that stage, while still ensuring that proper case assessment can be made and that the most appropriate techniques are used.
- 5.1.2 However, when instructing experts in sole practice, the 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.
- 5.1.3 Anybody instructing experts should always **avoid** 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 does not automatically result in a biased decision, but it can have an influence and should be guarded against.³

- 5.1.4 The investigating officer or instructing authority should include information flow in their forensic strategy. This should be based on the nature of the evidence type, the phase of the analysis and the capability of the forensic science provider and the following should be considered.
- a. Is the provider able to apply any debiasing techniques themselves, i.e. a large provider will probably control the flow of information to the analyst?
 - b. Is this a small 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.

5.2 The Role of the Scientist in the Analysis or Initial Evaluation Stage

- 5.2.1 The analyst should know through their training that there are specific stages in which the mitigation strategy requires that they stay separate from the rest of the investigation and accept the fact that they should undertake the analysis 'blind'. During this stage they should not seek other information beyond what is required to conduct the analysis or evaluation, in order to protect their impartiality. The lead scientist can ensure that the case is properly prioritised, but if potentially biasing information is inadvertently disclosed to the individual conducting the analysis, for example, that someone is in custody or has confessed, the lead scientist should be informed that this has happened and they can assess how to manage any risk introduced.

³ In *R. v Rogers* [2013] EWCA Crim. 2406 the Court of Appeal (Criminal Division) rejected the argument that 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. [53]

5.3 The Role of a Forensic Expert

- 5.3.1 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 following criteria – that it is balanced, robust, logical and transparent. [31]
- a. Balanced – the expert has considered alternative propositions. At the simplest level it may be match or no match, but in other cases it may require that both the prosecution and defence propositions are constructed and/or considered in the evaluation.
 - b. Robust – it is based on data relevant to the proposition being considered and 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 taken. [33]
- 5.3.2 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.

5.4 Process Outline

- 5.4.1 A very brief outline of forensic process within the laboratory is as follows.
- a. Define the requirement.
 - b. Develop an examination strategy.
 - c. Agree the examination strategy with the client.
 - d. Lead scientist instructs analyst to carry out forensic examinations and analyses.
 - e. Review the 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. Second expert verifies the findings.
 - i. Communicate the scientific findings and analytical tests.

- 5.4.2 During this process it is the responsibility of the expert to record, retain and reveal their work including the following.
- a. Record all information received.
 - b. Record details of interpretation.

Risks of Cognitive Bias

- 5.4.3 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.
 - c. The evidence may be challenged.

- 5.4.4 The risks associated with relying on the scientific findings and analytical results as a way of assigning a weight of evidence include the following.
- a. It can be difficult to consider alternative hypotheses since the knowledge of the actual outcome provides a source of confirmation bias.
 - b. The limitations of the examination and tests performed can be overlooked when evaluating the findings.

- 5.4.5 Risk management in all disciplines usually starts with an assessment. A process map detailing the **contamination** control points as required in the Forensic Science Regulator's Codes (Issue 5: 20.2.2) for building in contamination controls **as well critical control points for data handling (Issue 5: 23.1.2)** during method development may be useful for this purpose. The idea being that information in the wrong place is potentially contaminating.

- 5.4.6 If adopted, applying the critical control point concept to a process map could identify the stages where the disclosure of case information could expose the individuals to the risk of bias. It also ought to identify the stages where a lack of information may make for an inadequate case assessment. This approach could inform the examination strategy as well as the 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. ⁴

5.5 Mitigation Strategies to Reduce the Risk of Cognitive Bias

5.5.1 When working in the evaluative mode, the expert goes through a formal process of pre-assessing the expected probabilities for a realistic range of possible outcomes, in as many or as few categories as is sensible for the examination, recording their opinions.

5.5.2 If considering source [35] level it may be that the possible outcomes could be simply the two hypotheses that the items being considered either match or do not match. At source level, and certainly at activity level, it may be that each category in the realistic 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. These are used to provide an expected outcome that may be either qualitative or quantitative with the latter expressed as a likelihood ratio (LR).

5.5.3 The mitigation strategy may further include consideration of the following.

- a. The background data and experience used for assessing the expected outcomes are documented and any gaps identified.
- b. A second expert carries out the same process independently, without viewing the decisions made by first expert, and the experts jointly agree the expected outcomes.
- c. Posterior probabilities ⁵ are not provided for the evaluation of findings.

⁴ The service information idea may be relevant in many areas, but may be particularly useful for sole traders or small teams where the evaluative role offered to the customer requires the customer to stage the information flow.

⁵ The posterior probability is the conditional probability assigned after the scientific evidence has been taken into account, and so considers the probability of the hypothesis given the evidence. This is an example of the prosecutor's fallacy or transposed conditional. The scientist should provide the probability of the evidence given the hypothesis.

5.6 Recommended Good Practice

5.6.1 The following stages are suggested good practice.

- a. Define requirement. ⁴⁵ [36]
 - i. Identify whether the scientist's role in the case is investigative (for example, intelligence) or evaluative (judicial).⁶
 - ii. Seek clarity on what are the issues, the purpose and how this fits into the hierarchy of sub-source (for example, touch DNA), source, activity and offence level propositions. [36] [37]
- b. Develop an evaluative examination strategy.
 - i. Formulate relevant prosecution and defence alternatives based on the case circumstances and information provided.
 - ii. Consider any agreed assumptions that are used in formulating these alternatives.
 - iii. Use assessment of possible outcomes to determine which tests are most informative and discriminating.
 - iv. Use this pre-assessment to assign a weight to an exhaustive list of possible outcomes, giving the expected outcome for each, expressed as a LR where these are quantitative.
 - v. 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.
- c. Carry out forensic examinations and analyses.
 - i. Review the 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.

⁶ When planning the approach it should always be remembered that intelligence produced can rapidly be expected to become evidence.

- ii. Compare the results with the reference samples and marks. The quality and suitability of the questioned result has already been assessed so this is not influenced by the reference result.
- d. Evaluate and interpret the scientific findings and analytical tests.
 - i. Mitigate the confirmation bias by using the LR or qualitative expectation that was assigned to each outcome before the examinations and tests were performed.
 - ii. Pre-assessment enables the scientist to explain how the weight of the evidence has been assigned.
 - iii. Provide details of the assumptions that have been made.
 - iv. Give the basis of the expert opinion and specify the propositions considered, with the reasoning for these, based on the case context.
 - v. Include any limitation of the opinion.
 - vi. Where there is a range of opinion on the matters dealt with in the report, the expert's report must summarise the range of opinion and give reasons for the expert's own opinion as required by the Criminal Procedure Rules part 19.4 f (i) and (ii).
- e. Verification by a second expert. Independent review at this stage in advance of communicating the result to the client.
- f. Communicate the scientific findings and analytical tests.

6. Scenes of Crime

6.1 Introduction

- 6.1.1 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, the speed of response including making most effective use of the 'golden hour', the 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.
- 6.1.2 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 that is obvious and readily to hand, but there will also be gaps. The latter may be filled by gathering 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 sources.

6.2 Scene of Crime Process

Serious Crime

6.2.1 In major or serious crime investigations, forensic science resources are called on 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 (for example, 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 the 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 evidence. [38]

Volume Crime

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

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

- b. 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.
- c. If a crime scene 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.
- d. Recovered evidence is packaged, labelled and transported back to police facilities, after which a decision is made on whether any evidence is subsequently processed. [38]

Crime Scene Activities and Risk of Bias

6.2.3 Whilst some crime scene studies have been published by criminology specialists, [39] [40] 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:

- a. it could result in failure to secure the required evidence if a crime scene investigation is closed prematurely, resulting in crucial evidence being lost;
- b. it could mislead an investigation by investigators focusing too early and incorrectly on a false lead, and other evidence is potentially overlooked; or
- c. if undertaken incorrectly activities could result in ‘psychological contamination’ of evidence downstream in the forensic analysis and interpretation processes.

6.2.4 Opportunities for cognitive bias can be usefully considered within the context of activities related to the crime scene. For example, serious crime examination could be categorised as follows (adapted from a conference presentation [41]).

- a. Gathering information prior to scene attendance.
 - i. 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 subconsciously 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.

- b. Controlling the forensic process at scenes.
 - i. 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. 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, and may not be reflective of typical scenes. However, other factors such as convenience may be more relevant and have more impact in real life. For example, establishing the boundary by taping from lamp post to lamp post is commonplace simply because they are already there.
- c. Creating a record of the scene.
 - i. This includes image capture and writing notes and statements. The cognitive processes include the selection of equipment and decisions on which images to capture, and entails an assessment of the current case needs plus some anticipation of future needs. Depending on police force requirements, these may allow a wide variation in how findings are documented and are therefore open to subjectivity. In addition, 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'.
- d. Undertaking forensic examinations at scenes.
 - i. This requires an understanding of the investigative needs of the case, plus to observe, discover and recover evidence to meet both 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 examiner's intuition and tacit knowledge, which in turn are susceptible to bias.

Packaging, Storing, Labelling and Transporting Recovered Items

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

6.3 Bias Countermeasures and Good Practice

6.3.1 It is impossible to undertake certain tasks effectively without being provided with a 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 the 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, for example, identifying evidence that a 'burglary' has been staged in order to make a false claim on insurance.

6.3.2 Serious crime investigations of necessity require much more latitude in terms of the 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 defence. [42]

6.3.3 Communication of the examiner’s 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 and is more transparent about the decision-making process.

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

6.3.5 The key points when building hypotheses identified in this guidance include the following.

- 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 that 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 can be tested by examination of the known material.
- f. Consulting colleagues and experts to formulate hypotheses.
- g. Ensuring that sufficient resources are available to develop or test the hypotheses.
- h. Ensuring that hypotheses-building is proportionate to the seriousness of the offence.

6.3.6 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.

6.3.7 In some circumstances where the collection and analysis of physical evidence is complex spanning several different evidence types, a coordination and integration role is required to be undertaken by experienced forensic practitioners, termed ‘crime scene coordinators’, or ‘Byford scientists’. [43] This role was introduced after an inquiry by Her Majesty’s Inspectorate of Constabulary into failings in the Yorkshire Ripper Inquiry due to important leads not being followed up while persisting with false leads, i.e. classic anchoring effects. These scientists 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 that appropriate inferences are drawn. [38] 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. It may be appropriate under certain circumstances for the coordinators to act as gatekeepers for contextual information and only impart to practitioners the information required to fulfil their tasks. [44]

7. DNA Mixtures

7.1 Outline of the Forensic Process Involving DNA Mixture Interpretation

7.1.1 The generic forensic process that encompasses the interpretation and reporting of DNA profiling results, including complex DNA results, can be briefly described as follows.

- 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. Findings are checked by a competent colleague/peer.
- f. A statement or report is issued.
- g. The scientist may be called to court to give oral testimony.

7.2 The Risk of Cognitive Bias in DNA Mixture Interpretation

General Considerations

- 7.2.1 Just like other areas of science, the interpretation of DNA profiles can potentially be affected by some form of subconscious and unintended bias. [20] 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 from any cognitive influences impacting on them at the time, both manifest and unperceived. Usually decisions are made, and opinions are formed, in the context of the information that the scientist has been given about the case.
- 7.2.2 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 high expectation of observing DNA profile matches simply because samples were submitted for analysis by police investigators.

General Conditions Impacting on the Level of Cognitive Bias Risk

7.2.3 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 the results are clear and unambiguous and greater when the results are complex or are of poor quality, and there is an increased reliance on subjective opinion.
- b. Risks are low when there is a methodical approach with defined standards built on principles that have been tested and validated, and greater when the approach is unresearched, ad hoc and personal to the operator.
- c. Risks are low 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 low 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.

7.2.4 These risks are also shown in table 2.

Table 2. Summary of conditions impacting on the risk of cognitive bias

Risk source	Low risk	High risk
Result quality	Results are clear and unambiguous.	Results are complex or are of poor quality, and there is an increased reliance on subjective opinion.
Interpretation approach	A methodical approach with defined standards built on principles that have been tested and validated.	The approach is unresearched, ad hoc and personal to the operator.
Operator competence	Operators are well trained, experienced	Operators are inexperienced,

Risk source	Low risk	High risk
	and continuously meet acceptable standards of competence.	unmonitored and left to adopt their own approach.
Checking	Full independent reinterpretation.	Checking is conducted collaboratively.

Advancing Technology

7.2.5 DNA testing technology continues to develop apace. Multiplexes frequently achieve results from low quantities of DNA. The incidence of complex mixtures and of low template profiles exhibiting stochastic effects has therefore increased. The availability of probabilistic software for interpreting DNA mixtures reduces the risk of bias during the mixture deconvolution and LR calculation, but risks remain in relation to decision-making about whether a DNA profile is suitable for comparison and any subjective decisions regarding input of data to the software.

Contemporaneous Case and Reference Sample Interpretation

7.2.6 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.

Potential Oversights in DNA Interpretation Induced by Cognitive Bias

7.2.7 Subconscious 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; with most, the risk is either reduced or eliminated if an assessment is made without knowledge of the reference sample result.

- a. Restricted assumptions about the number 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 artefacts.
- 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 emphasising the absence of non-matching alleles when it is not clear if contributors are fully represented.

Further Flaws Potentially Induced by Cognitive Bias

7.2.8

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, although effective case management can assist with identifying areas of disagreement. This can mean 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, including the following.

- a. A focus on strategies for DNA recovery and testing that are likely prove a case rather than disprove a case.
- b. A choice of propositions that maximise 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. A failure to express alternative explanations.
- e. A reluctance to express doubt, particularly during oral evidence at court.

7.3 Case Examples Where Cognitive Bias May Have Occurred

7.3.1 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 both to limit cognitive bias and/or demonstrate that it has not occurred.

Implying the Absence of Alleles is Due to Masking by a Major Component

7.3.2 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 a 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 19 out of a possible 20 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.

Only Addressing the Prosecution's Case When a Suspect Cannot be Excluded

7.3.3 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.

7.4 Mitigation Strategies Currently Deployed in the UK and Overseas

7.4.1 Below are examples of mitigation strategies that are variously used in current practice (as at 2020). All are experience-based examples of good practice in appropriate circumstances and should be applied as described.

7.4.2 Prior interpretation of the case sample result before the 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 the 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.

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

7.4.4 Full checking via repeat interpretation by an experienced and competent colleague including prior interpretation of the case sample result before the 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.

7.4.5 Case assessment and interpretation. The comparison of expected, pre-assessed outcomes with the actual results under appropriate hypotheses. Some documented indication of the expected outcome is recommended in all cases.

7.4.6 Careful selection of case stains/samples for testing to minimise the occurrence of mixtures and low template issues. The selection should be informed by case information and is good practice whenever case circumstances present a choice of DNA case stain targets.

7.4.7 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 on 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 the scope for conjecture and the risk of

misinterpretation; it improves the scientist's ability to gauge accurately whether or not the sample is suitable for any form of comparison or statistical evaluation.

7.4.8 Analysis and interpretation are carried out blind, in the complete absence of any information about the case. This approach is practised 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 case strategy would for instance need to define stages to prevent evaluative work on issues not pertinent to the case (for example, rarely would statistical analysis be useful if the victim's DNA profile is identified). The risk of missing identification of realistic alternative explanations for the evidence given the case circumstances may be greater using this approach.

7.4.9 Use of interpretation software for complex mixtures ⁷ such as LikeLTD, ⁸ STRmix™ (Institute of Environmental Science and Research) or TrueAllele® (Cybergenetics). Ideally these methods should be used whenever other objective numerical methods are not appropriate, naturally practitioners should be competent in their use should they be required.

7.4.10 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.

7.4.11 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.

7.5 Further Recommendations for Good Practice

7.5.1 In addition to more general guidance described in section 7.4 the following good practice should be considered.

⁷ Suitable validation of all such methods would be expected prior to their introduction in casework.

⁸ A software package developed by David Balding, Adrian Timpson, Christopher Steele, Mayeul d'Avezac and James Hetherington. Accessed 2 May 2020: <http://cran.r-project.org/web/packages/likeLTD/likeLTD.pdf>.

- a. Use a completely 'blind' checker who repeats the full interpretation described in section 7.4.2 but in the absence of any contextual information relating to the case. This may present practical challenges, particularly within small 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.
- b. **Qualitative evaluations should only be presented as investigative opinions for intelligence purposes, rather than as evaluative opinions.** 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.
- c. Training and education in relation to the risks of cognitive bias generally and specifically in relation to complex DNA interpretation.

8. Fingerprints

8.1 Brief Outline of the Forensic Process

- 8.1.1 A significant proportion of the surface of 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 the arrangements of ridge features and to report their opinion as to the common origin or otherwise of any two areas of friction ridge.

- 8.1.2 The fingerprint examination process consists of stages frequently referred to as Analysis, Comparison, Evaluation and Verification (ACE-V), terms that provide useful descriptors of the cognitive process undertaken by the examiner in arriving at their final opinion. Typically, the reference prints from a known donor are simply referred to as prints, and although the marks from an unknown donor recovered from incident scenes are sometimes called latent prints, in the UK they are usually referred to simply as marks.
- 8.1.3 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 the following.
- a. The surface on which the mark 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 mark.
- 8.1.4 During the comparison stage the examiner will systematically compare the ridge pattern and sequence of ridge characteristics in a mark from an unknown source with that of a known source print. They will establish their opinion of the level of agreement or disagreement between the unique sequence of ridge characteristics visible in each.
- 8.1.5 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 mark against a known reference print may allow examiners to observe further features within the mark by directing their attention to areas that require particular attention and further processing. This comparison activity may cause the examiner to reconsider their initial analysis of the mark and could require further documentation by way of technical notes; why the examiner came to this opinion needs to be recorded in sufficient detail to allow for appropriate audit by a similarly qualified examiner. The evaluation stage, however, remains a separate and distinct phase of the ACE-V process.

- 8.1.6 If the quality and/or quantity of detail visible within the mark(s) is lacking, the examiner will record the mark(s) as insufficient and generally no further examination will occur. If the examiner is satisfied that the level of agreement between the mark and print is sufficient to determine in their opinion 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 areas of friction ridge detail could not have been made by a common donor, then they will consider that particular individual excluded as a potential donor of the mark. The examiner may conclude that, although there may be some agreement evident between mark and print, the extent of disagreement and/or the quality and quantity of detail visible in both or either of them is such that it is not possible to come to a definitive conclusion at the time of the examination. In such a circumstance the examiner would consider the outcome of that examination to be inconclusive; as with the opinion-based findings of identified and excluded, why the examiner thought the outcome was inconclusive needs to be also be recorded in sufficient detail to allow for appropriate audit.
- 8.1.7 Although the process is often described sequentially, it is important to note that fingerprint examination is iterative in practice and the stages are not mutually exclusive throughout the process.
- 8.1.8 It is common practice across the fingerprint discipline globally that identifications are subject to verification by further examiner(s) who will conduct a second analysis, comparison and evaluation of the impressions under examination.
- 8.1.9 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.

8.2 Risks of Cognitive Bias

8.2.1 The subjective, iterative and interpretative elements inherent within the fingerprint examination process expose the fingerprint examiner to a range of cognitive influences that, if not properly managed, could impact on the reliability of examination outcomes and examiner opinion.

8.2.2 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 up to 2015 have established that fingerprint examiners may, on occasion, alter their original opinions and conclusions in circumstances when the original material is presented in a different context. [21] Further research has indicated that this influence is more prevalent when the impressions under examination are of poorer quality. [7]

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

Contextual Bias

8.2.4 Fingerprint examiners are exposed to a wealth of contextual information and other pressures, which will impact on their decision-making process, some of which are as follows.

- 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.

8.2.5 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 casework, have additional quality assurance measures in place, or have specialist teams dedicated to this type of casework.

8.2.6 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 a **mark** of borderline quality submitted as part of a serious crime than if the same **mark** was submitted as part of a low-level volume crime. Prior knowledge of the status of an arrested person can lead to a particular focus or emphasis on that individual to the exclusion of others.

Confirmation Bias

8.2.7 Within operational fingerprint bureaux, the majority of examination requests are received from police officers or prosecution services, with both hoping that the examination outcomes will help to '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.

8.2.8 Combined with a personal moral code to 'do the right thing', this emphasis on 'identification' as the most favoured hypothesis will exert a powerful cognitive influence on examiner decision making.

8.2.9 **During the verification process**, having prior knowledge of the previous examiner's findings and conclusions may also expose fingerprint examiners to the risk of confirmation bias.

8.2.10 At a technical level, examiners can be unduly influenced by confirmation bias when, having found a number of features from a **mark** to agree with features in a **print** from a known source, the examiner will then begin to reason backwards, finding features in the **mark** that are suggested by those in the known print rather than being visible without reference to **that known print**.

8.2.11 Itiel Dror's paper 'Practical Solutions to Cognitive and Human Factor Challenges in Forensic Science' [45] 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 a heightened expectation of an identification being at the 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.

Cultural Bias

- 8.2.12 Individual perceptions are influenced by the environment in which they operate. Prior to the publication of The Fingerprint Inquiry Report [9] 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.
- 8.2.13 Historically, investigating officers and courts have accepted fingerprint evidence without challenge, which further contributed to the perception that fingerprint examination enjoyed ‘practical infallibility’.
- 8.2.14 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 findings or the findings of others.
- 8.2.15 Further examples of cultural influence that 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;
 - c. lack of interaction with peers or exposure to alternative methods of working; and
 - d. lack of acceptance of the potential for errors or effective root cause analysis of errors.
- 8.2.16 The Fingerprint Inquiry Report called for the profession:
- a. to move away from any presentation of fingerprint evidence with 100 per cent certainty;

- b. to explore fully the cogency of explanations offered for any evident differences between impressions; and most importantly; and
- c. to recognise that fingerprint evidence is opinion evidence and as such is inherently subjective.

8.2.17 Any process that 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 a subconscious 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.

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

8.3 Examples Where Cognitive Risks Have Become an Issue

Brandon Mayfield Case, 2006

8.3.1 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.

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

8.3.3 The US 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 ten features that they believed to be in agreement with Mayfield's prints. The OIG report [8] 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 that 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” (Ibid.). It would appear that the examiners applied a lower level of scrutiny to the information that supported their favoured hypothesis of identification.

- 8.3.4 The OIG found that the examiner’s interpretation was also influenced by circular reasoning, working backwards from the known source material: “Having found as many as ten 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.” (Ibid.). Again, the examiners would seem to be subconsciously 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.” (Ibid.).

Shirley McKie Case, 1999

- 8.3.5 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.
- 8.3.6 Ms McKie was subsequently charged with perjury in 1999 and at her trial the SCRO identification was challenged and refuted by two American fingerprint experts, Mr Pat Wertheim and Mr David Grieve. These experts also challenged the identification of an impression that had been presented as part of the prosecution case against Mr Asbury.
- 8.3.7 The jury 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.

8.3.8 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 risk factors and in the case of Y7 and Q12 Ross it is likely that these risks crystallised into the misidentification.” [9]

8.3.9 Amongst the risk factors identified in the SCRO methodology listed below are those that are relevant to the cognitive bias issues under discussion in this paper.

- a. Practitioners being taught that 100 per cent certainty is possible or that that fingerprint evidence is infallible.
- b. Establishing an inner conviction that can lead to a circular argument discounting differences that must be capable of explanation, even if the examiner is not sure what that explanation is.
- c. Diminishing 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.
- d. Diminishing the usefulness of asking an examiner to reconsider their findings – if they have already reached a conclusion with 100 per cent certainty then it is not surprising that a re-examination would typically lead to a confirmation of the initial findings.
- e. 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 identification (this topic is discussed in some detail in [6]).
- f. An inappropriate hierarchical philosophy, where examiners could be influenced to make identifications or confirm identifications of senior

officers when the quality and volume of information did not properly support this identification.

- g. 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.
- h. Contextual information from the police, which may subconsciously influence the conclusions of fingerprint examiners.

8.4 Examples of Mitigation Strategies

Federal Bureau of Investigation, Latent Print Unit

8.4.1 Following the procedure review instigated as a result of the Brandon Mayfield case, the FBI introduced a system of blind verification. It 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”. [46] The FBI further stated that blind verification should “eliminate confirmation bias and limit contextual bias in the examination process”.

8.4.2 Blind verifications take place in the following cases.

- a. Those with a single mark conclusion.
- b. Circumstances where there are conflicts between examiners.
- c. Circumstances where there are conflicts on decisions of ‘value’ or ‘no value’.

8.4.3 The FBI is clear that blind verifications cannot be performed by any examiner who has **the following**.

- a. Previously been consulted by the primary examiner.
- b. Knowledge of the previous examiner’s conclusions.
- c. Any knowledge of the information used by the primary examiner or specific background case details.

8.4.4 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.

Scottish Police Authority Forensic Services, Fingerprint Units

- 8.4.5 In anticipation of the publication of The Fingerprint Inquiry Report in 2011, the Scottish Police Authority (SPA) 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.
- 8.4.6 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, the SPA recognised that it was not essential for subsequent examiners to have access to this information on every occasion.
- 8.4.7 A proportionate risk management approach was adopted to mitigate the risks of cognitive influence without impacting on service delivery. A range of measures included the following.
- a. Improved note taking, including a 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 circumstances.
 - e. Regular dip-sampling of all completed casework.

- f. Training programmes for examiners exploring cognitive bias and its impact on the human decision-making process.

8.5 Recommended Good Practice

8.5.1 The Forensic Science Regulator’s Codes (Issue 5: 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 searches. [14]

8.5.2 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.” [47] 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 the following.

- a. Name of risk.
- b. Scope of risk.
- c. Nature of risk.
- d. Stakeholders.
- e. Quantification of risk.
- f. Risk tolerance.
- g. Risk treatment and control mechanisms.
- h. Potential action for improvement.

8.5.3 Suitable risk treatment and control mechanisms for consideration with regard to fingerprint examination are as follows.

- a. Survey and breakdown the extent of current contextual information available to examiners and assess the added value that each piece of information brings to the examination process.
- b. Remove or limit contextual information that 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 casework assessed as this is 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 that are considered complex or cause a variance in opinion between examiners.
- f. 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.

9. Footwear, Tool Mark and Firearms Comparison, And Firearms

9.1 The Generic Marks' Comparison Process

9.1.1 The generic forensic process that is outlined below encompasses the interpretation and reporting of comparison of 'marks' 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.

Process Outline

9.1.2 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.

9.1.3 Items are received along with case information and questions to be addressed by the scientific work.

9.1.4 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.

- a. Examine the item/mark recovered from the crime scene.
- b. Use recovery and enhancement techniques as required.
- c. Generate/examine the 'control' item.
- d. Make test marks if required in the appropriate manner.
- e. Undertake a comparison using appropriate methods and equipment.
- f. Interpret and evaluate findings.
- g. Verify the result.
- h. Describe findings in a statement or report.
- i. The scientist may be called to court to give oral testimony.

9.2 Risks of Cognitive Bias

9.2.1 A mark's 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, for example, a revolver that 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 on 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. [46] 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. For instance, in tool mark/firearms comparisons there are the following two methods, which are by nature subjective.

- a. Traditional pattern recognition where the examiner's opinion is based on the relative extent of detailed agreement with a best-known non-match.
- b. Consecutive matching striae (CMS) where the examiner applies a conservative criteria of runs of aligned striae to establish a possible match.

9.2.2 The interpretation and evaluation of a 'mark's 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.

9.2.3 Usually the opinions are formed in the context of supplied case information, introducing the possibility of contextual bias. Within the interpretation of marks, it is considered that there is a spectrum of bias risk (Table 3).

Table 3: Spectrum of bias risk in the interpretation of marks

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. [26]	When the approach is unresearched, ad hoc and personal to the operator. When the expectation of an open case file (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.

9.2.4 The risks in table 3 can be summarised as follows.

- a. Risks are low when results are clear and unambiguous and greater when results are complex or are of poor quality, and there is an increased reliance on subjective opinion.

- b. Risks are low when there is a methodical approach with defined standards built on principles that have been tested and validated and greater when the approach is unresearched, ad hoc and personal to the operator. Risks are low when equipment is well maintained and functioning to the required standard.
- c. Risks are low 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.
- d. Contextual and confirmation bias risk is low when the contextual information is minimised, particularly at the comparison review stage where the reviewer is unaware of the examiner's opinion, or of other evidence that relates to the mark's examination.
- e. Expectation bias manifesting in missing an open case file (OCF) hit is low when there is an expectation of success. [48]

9.2.5 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 on Home Office Guidance, [49] which is not explicitly reflected in the legislation.
- c. Reluctance to express doubt particularly during oral evidence at court.
- d. Reluctance to understand and express clearly the limitations of a comparison after a time delay between the offence and the recovery of a suspect item.
 - i. The comparison of 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 details 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 the overseas location of a manufacturing plant or time and cost considerations.

9.3 Examples Where Risks of Bias Have Become an Issue

9.3.1 Following are examples where some form of cognitive bias may have been a factor.

- a. The identification of a tool being responsible for cutting a wire fence, where detail was clearly visible that excluded the suspect tool.
- b. A 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 a similar modus operandi, and a similar calibre, make and model of gun. Possibly due to confirmation and contextual bias compounded by a lack of awareness of differences between sub-class and individual characteristics.

9.4 Mitigation Strategies Currently Deployed in the UK and Overseas

9.4.1 Examples of mitigation strategies that are variously in current (as at 2020) 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 of appropriate hypotheses with actual results.
- 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 the 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, 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.

9.4.2 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 ongoing 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 ongoing monitoring of the 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.

10. Particulate Trace Evidence (Including Hair and Fibre)

10.1 Outline of the Forensic Process for Particulate Trace Evidence Analysis

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

- a. 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.
- b. 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.

Recovery of Particulate Trace Materials Using Appropriate Techniques

10.1.2 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 that potentially contains some of the target material. Where there is a limited amount of target material of interest that can be immediately identified, for example, 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 that 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.

Evaluation and Reporting

10.1.3 This process can briefly be described as follows.

- a. The scientific findings are evaluated and interpreted within the context of the case-specific information available (may be at source and/or activity level as appropriate).
- b. A report or statement describing the findings and providing an opinion on their significance is then provided.
- c. Oral testimony - the scientist may be called to court to give evidence.

10.2 The Risk of Cognitive Bias in Particulate Trace Evidence Analysis

10.2.1 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 interpretation and opinions are required. Trace particulate evidence examinations can broadly be divided into two groups.

- a. 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.

- b. 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).

10.2.2 Additionally, opinions are formed in the context of the information supplied about the case and the samples submitted, for example, 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. This may introduce contextual bias. [27]

10.2.3 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 target effectively those fibre transfers that 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.

10.2.4 Within trace evidence examinations, there is a spectrum of bias risk as follows, and as shown in Table 4.

- a. Bias 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 that shows little intra-sample variation). Risks are 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. 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 low when there is a methodical approach with defined standards built on principles that have been tested and validated and greater when the approach is unresearched, ad hoc and personal to the operator.
- f. Risks are low 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 low 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 low 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.

Table 4: Spectrum of Bias Risk- Particulate Trace Evidence Examinations

Risk source	Low risk	High risk
Case assessment	Full case assessment considering potential outcomes, preferably with	No case assessment; only one hypothesis considered.

Risk source	Low risk	High risk
	at least two competing hypotheses.	
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 unresearched, ad hoc and personal to the operator.
Operator competence	Operators are well trained, experienced and 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.

10.2.5 For some trace evidence there are data in the published literature to support the practitioner.

- a. 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.

b. For fibres, there is considerable empirical data to support interpretations, such as population studies, transfer and persistence studies, colour block studies and target fibre studies. There is currently no database that provides any guidance with respect to how common a particular fibre might be in the general population. Microspectrophotometry spectral databases used by the former Forensic Science Service Limited went some way to providing this, but changing fashions and fibre technology mean that the maintenance of a completely representative data set is probably unachievable. Therefore, any assessment regarding how common (or otherwise) a fibre is will involve the expertise and experience of the witness and thus be essentially subjective, unless specific industrial enquiries can be made for a particular case. This will affect the assessment of the evidence and means that there is a degree of subjectivity in the evidence.

10.2.6 Fibre, hair and trace evidence analyses 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.

10.2.7 It may not be 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; where a range of instrumental and analytical techniques are employed that 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.

10.2.8 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 potentially be an alternative, legitimate source of matching fibres.

10.3 Case Examples Where Cognitive Bias May Contribute to Error

10.3.1 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 the subsequent analytical testing of the material has been an issue in casework 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. In specific cases, there may be legitimate differences in opinion that are not due to bias.

- a. Absence of matching glass fragments concluded as being inconclusive.
 - i. 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 clothing of a person involved in breaking the window (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 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.

- b. Absence of matching fibres concluded as being neutral.
 - i. 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 example, the defendant might have 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.
- c. Difference in treatment of crime and reference material post transfer.
 - i. 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 time of the offence, and then having to interpret a population of fibres on a suspect's garment that does not match the control, but perhaps did at the time of the offence.

10.3.2 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 that contain optical brighteners causing them to fluoresce, demonstrated that this was possible. But the issue that the experiment does not address is how the examiner can 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 to pursue experiments to assess this, 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.

10.4 Mitigation Strategies Deployed Both Within the UK and Overseas

- 10.4.1 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.
- 10.4.2 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.
- 10.4.3 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 (for example, microspectrophotometry results 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.

- 10.4.4 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.
- 10.4.5 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 outcomes 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.
- 10.4.6 Training – appropriate training of practitioners in the methods employed can demonstrate initial and ongoing competence.
- 10.4.7 Quality assurance trials – participation in internal and external quality assurance trials. Members of the European Network of Forensic Science Institutes (ENFSI) ETHG participate in an annual collaborative exercise that 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 (FSPs) in the UK also participate in Collaborative Testing Services Inc. (CTS) 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 two 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.

Further Recommendations for Good Practice

- 10.4.8 In addition to the good practice previously described, the following may also be considered.
- a. Use of a completely independent ('blind') checker who repeats the examination/interpretations but in the absence of any contextual information relating to the case. This may present practical challenges, particularly within small 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 small organisations. Clear documentation of case assessment, interpretation and a report/statement that clearly states the limits of the examinations used (i.e. where appropriate their subjective nature, limitations of small amounts of reference material, for example, 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 FSP 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.

11. Video and Audio

11.1 Introduction

- 11.1.1 A video or audio comparison often seeks to establish whether 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 one that has been generated under identical conditions to the original item.
- 11.1.2 Any examination is dependent on the visual quality and clarity of the detail that is observed by the examiner, as well as 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. 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, for example, registration number, intentional alteration such as cosmetic modifications, wear and tear such as scratches or other damage features. [50]
- 11.1.3 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 scientist's, relevant experience, depth of knowledge and skill as well as their disposition at the time.
- 11.1.4 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 case assessment and interpretation (CAI) approach is adopted.

- a. With regards to video this section should be read in conjunction with the Forensic Science Regulator’s Codes – Video analysis appendix.
- b. With regards to audio-related comparisons this section should be read in conjunction with the appendix to the Codes - FSR-C-134 Speech and audio forensic services.

11.2 Generic Video and Audio Process Outline

11.2.1 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, and audio recordings associated with a suspected criminal act under investigation. The process includes the following.

- a. Recovery of video, photo or audio material related to the crime scene.
- b. Items are received by the analyst along with relevant case information and the 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. Undertaking a comparison using appropriate methods and equipment.
- g. Interpreting and evaluating findings.
- h. Verification of the result.
- i. Findings are described in a statement or report.
- j. The scientist may be called to court to give oral testimony.

11.3 Risks of Cognitive Bias

11.3.1 Within video and audio comparison, there is a spectrum of bias risk (table 5).

Table 5: Spectrum of Bias Risk in Video and Audio Comparison

Risk factor	Low risk	High risk
Detail and 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 characterised prior to exposure to reference image.	When the approach is unresearched, ad hoc and personal to the operator. Item is characterised 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.

Risk factor	Low risk	High risk
Verification of results	Independent review of critical findings.	There is no independent review, or the reviewer knows the findings and conclusions drawn from the original assessment.

11.4 Mitigation Strategies and Good Practice Guidance

Avoiding Psychological Contamination in the Processing of Material

- 11.4.1 One of the greatest risks of introducing cognitive bias is in the way that 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 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 to safeguard against contextual bias. For the same reason it is better for the analyst to receive a written briefing regarding the comparison to be made rather than being in direct verbal contact with the investigator, so that the opportunity for the transfer of non-relevant and potentially biasing information (both contextual and confirmatory) can be avoided.
- 11.4.2 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.

Independent assessment of critical findings is also crucial. Independent checking that minimises 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.

Use of Validated Processes

- 11.4.3 All forensic processes should be validated prior to use in casework. Section 20 of the Codes provides guidance on validation with more detailed explanations given in associated validation guidance issued by the Regulator. [51] 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.
- 11.4.4 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, the 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 the full characterisation of the processes applied including the 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-processed. [52] When using colour as a comparator, the limitations of the approach should be fully evaluated and understood: under certain lighting conditions (for example, sodium lamp), two 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.
- 11.4.5 Techniques deployed to aid in the side by side comparison of images must be validated to ensure that 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. Where this is not possible, the resultant limitations in making a comparison should be declared in any statement.

Proficiency Testing/Quality Control Measures

- 11.4.6 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. However, these measures should be both strengthened by and demonstrated to be effective through the use of effective quality assurance/quality control (QA/QC) measures. These measures include the following.
- a. Initial competency assessment of an individual prior to commencing forensic casework. The individual is subjected to proficiency testing using characterised test material of known provenance to demonstrate that they, in combination with validated working practices, generate reliable unbiased outcomes.
 - b. Ongoing competency assessment through the 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.
 - c. 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 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 scene. [15] A further refinement is

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

12. Review

12.1.1 This document is subject to review at regular intervals.

12.1.2 If you have any comments, please send them to the address or e-mail set out on the Regulator’s Internet site at:

www.gov.uk/government/organisations/forensic-science-regulator

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14. Abbreviations and Acronyms

ACE-V	Analysis, comparison, evaluation and verification
ACPO	Association of Chief Police Officers of England, Wales and Northern Ireland
AFIS	Automated Fingerprint Identification System
CAI	Case assessment and interpretation model
CCTV	Closed-circuit television
CJS	Criminal Justice System of England and Wales
CMS	Consecutive matching straie
CPS	Crown Prosecution Service
DNA	Deoxyribonucleic acid
ENFSI	European Network of Forensic Science Institutes
ETHG	European Textile and Hair Group
EWCA Crim	England and Wales Court of Appeal, Criminal Division
FBI	Federal Bureau of Investigation
FSP	Forensic science provider
Hd	Defence hypothesis

HM	Her Majesty's
Hp	Prosecution hypothesis
IRM	Institute of Risk Management
IPOL	International Police Intelligence Department (Netherlands Police Service)
ISO	International Organization for Standardization
LR	Likelihood ratio
OCF	Open case file
OIG	Office of the Inspector General (US Department of Justice)
QA	Quality assurance
QC	Quality control
SCRO	Scottish Criminal Records Office
SNP	Spanish National Police
SPA	Scottish Police Authority
UK	United Kingdom of Great Britain and Northern Ireland
US	United States (of America)
USA	United States of America
UV	Ultraviolet

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