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WHEN SCIENCE MEETS HUMAN JUDGMENT: COGNITIVE BIAS IN FORENSIC EXAMINATION AND ITS IMPLICATIONS FOR FAIR TRIALS IN INDIA

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ABSTRACT

Forensic science is frequently presented in criminal proceedings as an objective means of connecting a person, object, or event with a crime. Yet forensic examination is not always a mechanical process. In many disciplines, trained examiners must interpret ambiguous patterns, compare imperfect samples, assess the significance of findings, and decide whether the available material supports a conclusion. Those decisions can be influenced by contextual information, expectations, prior conclusions, workload, fatigue, institutional practices, and ordinary cognitive processes. The risk is not necessarily deliberate misconduct; it may arise when information that is not scientifically necessary for a particular examination changes the way evidence is perceived or interpreted.

This paper examines cognitive bias in forensic examination and its implications for fair criminal trials in India. It adopts a doctrinal and analytical methodology, drawing on the Bharatiya Sakshya Adhiniyam, 2023, constitutional principles, Indian judicial decisions on expert evidence, and published scientific literature. It does not conduct a questionnaire, interview, or original field survey. The paper explains confirmation bias, contextual bias, expectation effects, and tunnel vision; considers the relevance and limits of research in fingerprint examination, DNA interpretation, bloodstain-pattern analysis, and other forensic fields; and evaluates the Indian legal framework governing expert opinion. Decisions such as *State of H.P. v. Jai Lal* and *Ramesh Chandra Agrawal v. Regency Hospital Ltd.* establish general principles concerning expert evidence, but they do not create a specific, settled Indian doctrine on cognitive bias in forensic laboratories. That distinction is central to the analysis.

The paper argues that the legal admissibility of an expert opinion should not be confused with the scientific reliability of the method, the validity of its application to a particular case, or the strength of the conclusion expressed. Indian courts can address cognitive-bias risks through

reasoned scrutiny of methodology, disclosure of limitations, effective cross-examination, access to relevant underlying material, and cautious evaluation of conclusions that depend substantially on subjective interpretation. At the institutional level, context management, sequential unmasking, independent verification, documented decision-making, proficiency testing, and quality assurance can reduce avoidable risks. The paper concludes that fairness does not require courts to reject forensic science; it requires them to understand both its value and its human limits.

Keywords: forensic science; cognitive bias; confirmation bias; contextual information; expert evidence; fair trial; Bharatiya Sakshya Adhiniyam, 2023; forensic reliability.

1.INTRODUCTION

Scientific evidence has become a prominent feature of contemporary criminal investigation. Fingerprint comparisons, DNA profiling, questioned-document examination, ballistics, digital forensics, toxicology, forensic pathology, and crime-scene reconstruction may help investigators test competing accounts and identify links between people, places, and objects. Such evidence can be powerful because it may provide information that eyewitness memory or ordinary observation cannot reliably supply. It can also expose mistaken suspicions, exclude innocent persons, and corroborate an account independently of a witness.

Nevertheless, the label ‘scientific’ does not make every conclusion infallible. Some forensic methods depend on measurable quantities and well-characterised processes; others require an examiner to interpret patterns or decide whether two samples are sufficiently similar. Even where instruments generate measurements, a human being may select the sample, choose the method, determine whether the result is usable, interpret uncertainty, and prepare the final report. The process therefore contains both technical and human elements. The central concern of this paper is how ordinary cognitive processes can affect the interpretation of forensic material, and what legal safeguards are appropriate when that material is presented in court. Cognitive bias refers broadly to systematic influences on perception, interpretation, memory, or judgment. In forensic work, bias may arise when an examiner learns that a suspect has confessed, that another examiner has identified a match, that the police consider a person guilty, or that a crime was especially serious. Such information may be relevant to the investigation as a whole but unnecessary to the narrow scientific task being performed.

When the information is known before the examination, it can influence how ambiguous details

are noticed, weighted, or explained. This possibility does not mean every examiner is biased or that every forensic conclusion is unreliable. It means that a reliable system should not depend solely on the personal confidence or good faith of individual examiners.

The Indian context makes this question particularly important. Courts frequently receive expert opinions as part of the evidentiary record, and the Bharatiya Sakshya Adhiniyam, 2023 (BSA) continues to recognise expert opinion as relevant. Section 39 deals with opinions of experts on matters including science and other specialised fields. However, statutory recognition of expert opinion does not itself resolve how a court should assess the quality of the underlying method, the effect of potentially biasing context, or the degree of certainty that the expert may properly express.

The constitutional dimension arises from the right to a fair procedure and fair trial, read principally through Article 21 of the Constitution. A criminal trial must permit the accused to understand and challenge the evidence relied upon by the prosecution. If an expert's conclusion is treated as conclusive merely because it is described as scientific, the defence may face an unfair practical disadvantage. Conversely, an indiscriminate rejection of forensic evidence may deprive courts of valuable and sometimes exculpatory information. The appropriate approach is therefore critical evaluation rather than either unquestioning acceptance or blanket distrust. This paper studies the relationship between cognitive bias, forensic interpretation, expert evidence, and trial fairness. Its focus is on the legal and procedural safeguards that can make forensic conclusions more transparent and contestable in India. It does not assume that Indian courts have already adopted a comprehensive cognitive-bias framework. Instead, it identifies principles that can be drawn from existing expert-evidence jurisprudence and considers how published scientific research may inform future practice.

2. LITERATURE REVIEW

2.1 Scientific literature on cognitive bias

A key contribution to the field is Cooper and Meterko's systematic review of research on cognitive bias in forensic science. Their review identified 29 primary studies across forensic disciplines. The authors reported evidence that contextual information and confirmation bias could influence analysts' conclusions, particularly where examiners received case-specific information about a suspect or crime, were directed toward a particular exemplar, or knew a previous examiner's conclusion. The review also identified limitations in the research base, including differences in study design and a small number of studies in several disciplines. Its

value is therefore not that it proves every forensic technique is unreliable, but that it documents a credible and experimentally studied risk that forensic procedures should address.

Dror's work on cognitive neuroscience and forensic science emphasises that the human element is present throughout forensic work, not only at the moment of comparison. Human judgment may affect which evidence is selected, what information is considered relevant, how ambiguous results are interpreted, and how findings are communicated. Dror and other researchers have proposed context-management approaches, including Linear Sequential Unmasking (LSU), in which an examiner first evaluates the trace evidence before receiving comparison information or other context that could bias interpretation. The purpose is not to conceal scientifically necessary information permanently, but to control the timing and relevance of information.

The National Research Council's report, *Strengthening Forensic Science in the United States: A Path Forward* (2009), also questioned the uneven scientific foundations and quality controls across forensic disciplines. Although the report is American and cannot be treated as a statement of Indian law, its institutional recommendations remain relevant as comparative material: forensic conclusions should be supported by validated methods, transparent standards, appropriate proficiency testing, and clear communication of limitations. At the same time, the literature is not entirely one-sided. Researchers have cautioned that studies of contextual bias vary in ecological validity, and that not every item of case information necessarily causes error. The practical task is to distinguish information that is necessary for the scientific question from information that is irrelevant or potentially prejudicial. Camilleri and colleagues have advocated a risk-based approach, recognising that safeguards should be designed around the nature of the task and the likely consequences of error. A balanced review must therefore avoid two extremes: treating forensic examiners as immune to bias, and assuming that every subjective judgment is automatically defective.

2.2 Indian legal literature and expert evidence

Indian evidence law has long treated expert opinion as relevant where a court must form an opinion on a matter requiring specialised knowledge. The Supreme Court has repeatedly explained that an expert assists the court but does not replace the court's own responsibility to evaluate evidence. In *State of H.P. v. Jai Lal*, the Court stressed that expert evidence is advisory and that the expert should provide reasons supporting the opinion. The weight of an opinion depends on the quality of the reasoning, the data considered, and the court's assessment of the explanation.

In *Ramesh Chandra Agrawal v. Regency Hospital Ltd.*, the Supreme Court discussed the nature of expert evidence and the need for expertise grounded in specialised knowledge. Though the case arose in medical negligence rather than a forensic laboratory setting, its general discussion assists in understanding why credentials alone should not decide the weight given to an opinion. A court must consider the basis of the opinion and whether it assists the adjudication of the disputed issue.

Other decisions, including *Dayal Singh v. State of Uttaranchal*, demonstrate the broader importance of careful judicial evaluation of evidence and the consequences of investigative or evidentiary deficiencies. Such cases should not be represented as direct rulings on cognitive bias unless the judgment actually addresses that subject. The present paper uses Indian judgments for the principles they establish—expert assistance, judicial scrutiny, evidentiary reliability, and fair evaluation—and draws separately on scientific studies for the specific proposition that contextual information can influence forensic interpretation.

2.3 Literature gap

Much of the accessible Indian discussion of forensic evidence focuses on admissibility, the competence of experts, the weight of scientific reports, and investigative failures. There is comparatively less developed legal treatment of cognitive bias as a distinct issue in the forensic examination process. In particular, there is a need to connect general expert-evidence principles with practical safeguards such as controlled disclosure of case information, independent verification, documentation of interpretive decisions, and disclosure of uncertainty.

This paper addresses that gap through a doctrinal analysis supported by secondary scientific literature. It does not claim to measure the prevalence of bias among Indian examiners, because no original survey or interview data has been collected. Its contribution is analytical: to explain the risk, map it against existing legal principles, and propose safeguards suitable for consideration within Indian forensic and criminal procedure systems.

3. RESEARCH GAP

Three related gaps emerge from the literature. First, the Indian legal framework recognises expert opinion but does not expressly set out a detailed, generally applicable statutory procedure for identifying and managing cognitive bias during forensic examination. The BSA addresses the relevance of expert opinion, but relevance is not equivalent to a comprehensive guarantee of methodological reliability.

Second, cognitive bias is often discussed as a scientific or psychological issue rather than as a problem of evidence evaluation and procedural fairness. Yet the way a forensic conclusion is reached can affect the accused's ability to challenge it, the court's understanding of its limits, and the risk that an uncertain interpretation will be presented as a definitive identification.

Third, while international scientific literature proposes practical measures to reduce bias, their translation into Indian laboratory practice, expert reporting, and judicial reasoning requires careful examination. The challenge is not simply to import foreign procedures; it is to identify which safeguards are scientifically justified, legally compatible, proportionate to available resources, and capable of being implemented transparently.

Accordingly, the research gap is the limited integration of cognitive-bias research with Indian legal principles governing expert evidence and fair trial rights. This paper seeks to build that connection without claiming empirical findings that the methodology does not support.

4. RESEARCH OBJECTIVES

- To explain the meaning, forms, and operation of cognitive bias in forensic examination.
- To examine scientific research concerning contextual information, confirmation bias, and examiner judgment across selected forensic disciplines.
- To analyse the Indian legal framework governing expert opinion, with particular reference to Section 39 of the Bharatiya Sakshya Adhiniyam, 2023 and relevant judicial decisions.
- To assess how cognitive-bias risks may affect the reliability, presentation, and judicial evaluation of forensic evidence.
- To identify procedural and institutional safeguards capable of strengthening fairness, transparency, and scientific accountability in criminal trials.

5. RESEARCH QUESTIONS

- How can cognitive bias influence forensic examination and the interpretation of scientific evidence?
- To what extent do existing Indian statutory provisions and judicial principles address the risks associated with human judgment in expert evidence?
- What procedural safeguards can reduce avoidable cognitive bias while preserving the legitimate investigative value of forensic science?
- How should courts evaluate expert opinions where the method involves subjective

interpretation or where the basis and limitations of the conclusion are not fully disclosed?

6. RESEARCH HYPOTHESIS

The study proceeds on the hypothesis that, although forensic evidence can substantially assist criminal investigation, insufficient attention to contextual bias, examiner subjectivity, and the limits of scientific conclusions may weaken the reliability of forensic evidence and affect the fairness of criminal proceedings. The hypothesis is examined through legal doctrine and published scientific literature; it is not presented as an empirically proven finding about the frequency of bias in Indian laboratories.

7. RESEARCH METHODOLOGY

This paper adopts a doctrinal legal research methodology supplemented by a critical review of published scientific literature. It is qualitative and analytical in nature. No questionnaire, interview, survey, focus group, or original participant-based research has been conducted.

7.1 Doctrinal component

The doctrinal component examines statutory provisions and judicial decisions relevant to expert opinion and fair trial rights. The principal statutory source is the Bharatiya Sakshya Adhiniyam, 2023, particularly Section 39 on expert opinion, read with the broader constitutional framework. The analysis also considers relevant Supreme Court decisions on expert evidence, evidentiary evaluation, and investigative responsibility. Cases are discussed according to their actual holdings; decisions dealing with general expert evidence are not described as direct precedents on cognitive bias.

7.2 Secondary scientific literature

The scientific component draws on peer-reviewed studies and reviews concerning contextual bias, confirmation bias, human factors, and methods for managing information in forensic analysis. Materials from the National Institute of Standards and Technology and the National Research Council are used as comparative scientific and policy resources. These materials help explain the technical issue but do not have binding force in India.

7.3 Scope and limitations of the method

The paper focuses on cognitive bias in forensic examination rather than all forms of bias in policing, prosecution, or judicial decision-making. It considers examples from pattern-comparison and interpretive disciplines, while recognising that different forensic fields have different scientific foundations and error mechanisms. The analysis is limited by the relative scarcity of Indian judgments explicitly discussing cognitive bias as such, the diversity of forensic methods, and the fact that published international research cannot automatically be generalised to every Indian laboratory. These limits are addressed by distinguishing established legal propositions from scientific findings and policy recommendations.

8. DISCUSSION AND ANALYSIS

8.1 Understanding cognitive bias in forensic examination

Cognitive bias is not synonymous with dishonesty, corruption, or deliberate fabrication. It refers to influences on judgment that may operate without conscious intention. Human beings use expectations and prior experience to organise information, recognise patterns, and make decisions efficiently. These mechanisms are often useful in ordinary life, but they may become problematic where an examiner must make a high-stakes decision from ambiguous or incomplete material.

Forensic examinations frequently involve a comparison between questioned material and a known sample, or an interpretation of a pattern within a wider case. The examiner may be aware of the suspected offence, a confession, an eyewitness identification, the location where evidence was found, or the conclusions of other investigators. Some of this information may be necessary for the examination; other information may have no legitimate bearing on the technical question. The more ambiguous the material, the greater the concern that expectations may affect interpretation.

It is important to distinguish bias risk from error itself. A conclusion may be wrong because the sample is degraded, the method is not sufficiently validated, the instrument malfunctions, the examiner lacks training, or the evidence is contaminated. Cognitive bias is one possible contributor among several. A sound quality system should therefore address both human factors and technical sources of error rather than treating bias as the sole explanation for unreliable results.

8.2 Major forms of cognitive bias

A. Confirmation bias

Confirmation bias occurs when a person gives disproportionate attention or weight to information that supports an existing belief or expectation. In a forensic context, an examiner who is told that police have identified a particular suspect may be more likely to interpret ambiguous features as consistent with that suspect. This does not necessarily involve conscious favouritism. It may affect which details are noticed, how discrepancies are explained, or when the examiner decides that the available similarity is sufficient.

The risk is particularly important when the examiner receives a proposed conclusion before independently examining the evidence. If the first examiner has already declared a match, a second examiner may be influenced by that conclusion even where the second review is intended to be independent. Blind verification and independent analysis can reduce this risk by requiring the reviewing examiner to form an initial judgment without knowing the earlier result.

B. Contextual bias

Contextual bias refers to the influence of information surrounding the evidence rather than information necessary to analyse the evidence itself. Context may include a suspect's confession, the seriousness of the offence, a witness's account, a police theory, or the fact that a sample was recovered from a location associated with the accused. The same information can be relevant to the investigation as a whole while being irrelevant to a specific comparison task. The challenge is to identify which information is genuinely needed. For example, a DNA analyst may need to know the nature and condition of a sample and the question being asked, but may not need to know that a suspect has allegedly confessed. A fingerprint examiner may need the relevant comparison prints but may not need a narrative describing the accused as a repeat offender. Context management aims to provide the examiner with necessary information while reducing unnecessary exposure to potentially biasing details.

C. Expectation and anchoring effects

Anchoring occurs when an initial piece of information exerts disproportionate influence on later judgment. An examiner who sees a preliminary report, a suggested identification, or a particular interpretation before conducting an independent examination may find it difficult to evaluate the material as if that suggestion had never been seen. Later observations may be interpreted in a way that preserves the initial view. Expectations can also arise from routine laboratory practices. If an examiner repeatedly receives evidence from an investigative team that has already adopted a strong theory, the institutional setting may create a background expectation

about what the evidence is supposed to show. Standardised intake procedures and clear separation between investigative narratives and technical questions can help reduce this influence.

D. Tunnel vision and confirmation across the investigation

Tunnel vision describes a narrowing of attention around one suspect or theory, with insufficient consideration of alternative explanations. It can arise across the entire investigation, not only within the laboratory. Investigators may selectively submit samples that support their theory, fail to pursue exculpatory leads, or communicate a one-sided narrative to an examiner. The examiner's work may then appear to independently confirm the theory even though the information supplied to the laboratory has already been shaped by it. This demonstrates why cognitive-bias safeguards cannot be limited to the individual expert. The process by which evidence is selected, labelled, submitted, examined, interpreted, and reported can all influence the final result. Laboratory independence and transparent case records are therefore essential.

E. Hindsight bias and overconfidence

Hindsight bias occurs when, after learning the outcome of an event, a person sees that outcome as having been more predictable than it actually was. Once a suspect has been convicted or a theory accepted, earlier forensic findings may appear more decisive than they were at the time. Overconfidence may also arise when a report uses categorical language without adequately explaining uncertainty, limitations, or the possibility of alternative interpretations.

These risks are especially significant when expert evidence is communicated to a court through technical terminology that non-specialists may find difficult to evaluate. A report should distinguish observations from interpretations and conclusions. It should avoid expressing a degree of certainty that the method, data, and validation studies do not justify.

8.3 What the scientific literature shows—and what it does not show

Cooper and Meterko's 2019 systematic review found that the available studies supported the proposition that forensic practitioners and trainees can be susceptible to confirmation bias. In the studies they reviewed, case-specific information influenced conclusions in a number of the studies examining that question, while prior decisions and exemplar-related procedures also showed effects. The review is important because it draws on empirical studies rather than relying only on theoretical concerns. However, the review also identified methodological limitations and uneven coverage across disciplines. Some areas had several studies, while others had only one or a few. It is therefore not sound to conclude that all forensic methods are equally

subjective or equally susceptible to contextual influence. Nor does the evidence establish that every forensic report in India is biased. The proper conclusion is narrower: human judgment can be influenced by context, the risk is scientifically credible, and procedures should be designed to reduce avoidable influence.

The NIST human-factors programme similarly recognises that complex technical work is affected by human and organisational conditions. Fatigue, workload, communication practices, task design, training, and the structure of decision-making may contribute to errors. This broader perspective is valuable because bias reduction should not be framed as an accusation against individual examiners. It is a matter of designing systems that help skilled professionals make accurate, reproducible, and defensible decisions.

The literature also suggests that the best safeguards are practical and targeted. Linear Sequential Unmasking, for example, structures the order in which information is revealed so that an examiner can assess the trace evidence before receiving information that may shape the interpretation. Such an approach does not remove all human judgment, and it may need adaptation for different forensic disciplines. It nevertheless offers a procedural method for making the reasoning process more independent and transparent.

8.4 Cognitive bias across selected forensic disciplines

A. Fingerprint examination

Fingerprint comparison often involves trained visual judgment. Examiners compare friction-ridge details and assess whether the questioned impression and known print share sufficient features to support a conclusion. The quality of the impression, distortion, partial recording, smudging, and the examiner's decision threshold may all affect the task. If an examiner is told that a suspect has confessed or that another examiner has already identified a match, ambiguous ridge features may be interpreted in light of that information. Research discussed in the systematic literature review has examined the effects of contextual information in latent fingerprint analysis. Proposed safeguards include blind verification, access to multiple comparison samples rather than only a single suspect exemplar, and documentation of the basis for a conclusion. These measures do not imply that fingerprint evidence is inherently invalid. They recognise that visual comparison should be supported by a process that limits unnecessary influence and permits later scrutiny.

B. DNA analysis

DNA profiling is often regarded as highly scientific, but the interpretation of complex samples

may require judgment. Low-template DNA, mixtures from multiple contributors, degradation, contamination, and stochastic effects can make interpretation difficult. An analyst may have to assess whether a peak is meaningful, how many contributors are represented, or whether a result supports a particular proposition. In such cases, the scientific strength of DNA technology should not obscure the interpretive decisions made in a specific case. Contextual information may influence how ambiguous DNA mixtures are interpreted, especially if the analyst knows the suspect's identity or the prosecution theory. Information management can separate the scientific task from the investigative narrative. Reports should identify the analytical method, assumptions, limitations, and relevant propositions, and should not imply that a DNA association automatically establishes when, how, or why biological material was deposited.

C. Bloodstain-pattern analysis and crime-scene reconstruction

Bloodstain-pattern interpretation can involve assessing the shape, distribution, and location of stains to reconstruct possible events. The scene may be complex, and several explanations may fit the physical observations. If an examiner is told a detailed account of the alleged offence before inspecting the scene or analysing photographs, the account may influence which patterns are considered significant and which alternative explanations are explored.

A robust process should record the observations before settling on a reconstruction, identify assumptions, consider competing hypotheses, and disclose the limits of the available material. Where the conclusion depends on interpretation rather than a direct measurement, the expert should explain the reasoning in terms that can be tested in cross-examination.

D. Questioned documents, toolmarks, and other comparison evidence

Handwriting, questioned-document, toolmark, footwear, and firearm-related examinations may contain both measurable features and interpretive judgments. The susceptibility to bias will vary with the discipline, the quality of the samples, the method used, and the nature of the decision. A general rule that all such evidence is unreliable would be unjustified. Equally, an assumption that an examiner's training eliminates all cognitive influences would be scientifically unsound. The appropriate safeguard is discipline-specific validation and quality assurance, combined with procedures that limit exposure to irrelevant context. Examiners should be trained to distinguish the observations from the inference drawn from those observations. Where a method does not support a numerical probability or a categorical conclusion, the report should communicate that limitation rather than imply a level of certainty unsupported by the method.

8.5 Indian statutory framework: expert opinion under the BSA

Section 39 of the Bharatiya Sakshya Adhiniyam, 2023 provides that when a court must form an opinion on a point of foreign law, science or art, or another specialised field, or on identity of handwriting or finger impressions, the opinions of persons specially skilled in the relevant field are relevant facts. This provision continues the longstanding principle that courts may receive specialised assistance on questions outside ordinary knowledge. The provision establishes relevance, not automatic correctness. A person may be qualified to give an opinion while the particular opinion remains weak, insufficiently reasoned, or based on incomplete information. The court must still decide what weight the opinion deserves. Cognitive bias is relevant to this assessment where there is a reason to question whether the examiner received unnecessary contextual information, whether the examination was independently conducted, or whether the conclusion was expressed more strongly than the underlying method supports.

The BSA's treatment of expert opinion should be read with the general responsibility of the court to evaluate the entire evidence. The fact that an opinion is admissible does not make it conclusive, and the expert cannot determine the ultimate question of guilt. In practical terms, the court should ask what the expert observed, what method was used, whether that method is accepted and appropriate for the task, what limitations affected the sample, whether alternative explanations were considered, and whether the expert's reasoning can be followed.

A further distinction is necessary between admissibility and weight. Admissibility concerns whether the law permits the evidence to be received for consideration. Weight concerns how much reliance it deserves after considering its foundation, reliability, consistency, and relationship with the other evidence. A cognitive-bias concern may not automatically require exclusion in every case; it may instead affect the weight of the opinion, the need for further disclosure, the scope of cross-examination, or whether independent expert assistance is warranted. The proper response depends on the seriousness of the concern and its effect on the reliability of the particular conclusion.

8.6 Judicial approach to expert evidence in India

A. State of H.P. v. Jai Lal

In State of H.P. v. Jai Lal, (1999) 7 SCC 280, the Supreme Court explained the nature of expert evidence and the role of the court in evaluating it. An expert's opinion is advisory; the expert assists the court on a specialised question but does not decide the case. The opinion should be supported by reasons, and the court must assess the basis on which it has been reached. The

judgment is important for the present topic because it resists treating an expert's status as a substitute for analysis.

The case did not establish a specific doctrine of cognitive bias. Its relevance is indirect but significant: if the court must examine the reasons and materials supporting an expert opinion, it may also examine whether the opinion was formed through an independent process and whether irrelevant information could have influenced the analysis. A report that merely states a conclusion without explaining the underlying observations makes such scrutiny difficult.

B. Ramesh Chandra Agrawal v. Regency Hospital Ltd.

In *Ramesh Chandra Agrawal v. Regency Hospital Ltd.*, (2009) 9 SCC 709, the Supreme Court considered expert evidence in the context of medical negligence. The decision discusses the relevance of specialised knowledge and the need for the court to assess whether the evidence assists in resolving the issue. Although the case is not a forensic cognitive-bias decision, its principles reinforce the need to evaluate expertise in context rather than treating an expert opinion as self-proving.

Applied carefully, this principle suggests that courts should distinguish professional qualification from the reliability of a particular inference. A highly qualified expert may still be working with incomplete data or a method that permits more than one interpretation. The proper inquiry is not whether the expert is generally competent, but whether the reasoning in the case at hand is adequately supported.

C. Dayal Singh v. State of Uttaranchal

Dayal Singh v. State of Uttaranchal, (2012) 8 SCC 263, is relevant to the broader duty of courts to evaluate evidence carefully and to consider the consequences of deficiencies in investigation or presentation. It should not be cited as though it directly recognises contextual bias in forensic laboratories. Its contribution to this paper is the general insistence that criminal adjudication requires careful scrutiny of the evidentiary record and cannot be reduced to uncritical acceptance of the prosecution narrative.

The connection with cognitive bias is analytical: where an investigation is shaped by a single theory, the court should be attentive to whether evidence has been collected and interpreted fairly, whether contrary material has been considered, and whether the forensic conclusion is independently supported. These questions are consistent with careful evidentiary assessment, even where the judgment itself does not use the terminology of cognitive bias.

D. Tomaso Bruno v. State of Uttar Pradesh

In *Tomaso Bruno v. State of Uttar Pradesh*, (2015) 7 SCC 178, the Supreme Court emphasised

the importance of scientific and electronic evidence in criminal investigation and discussed the significance of best evidence, including CCTV footage, in the circumstances of the case. The decision is not a direct ruling on forensic examiner bias, but it illustrates a related principle: investigation should make appropriate use of available scientific material rather than rely only on conventional testimony where objective evidence may be available.

For the present study, the case also highlights that the presence or absence of forensic evidence is not the only issue. The selection, collection, preservation, and presentation of evidence affect the court's ability to test the prosecution theory. If an investigation selectively pursues evidence consistent with one explanation while neglecting available alternatives, the resulting evidentiary picture may be incomplete. This is a broader investigative risk, distinct from bias occurring inside the laboratory, but the two can interact.

E. Selvi v. State of Karnataka

In *Selvi v. State of Karnataka*, (2010) 7 SCC 1, the Supreme Court considered the constitutional implications of involuntary narco-analysis, polygraph examination, and brain electrical activation profile tests. The Court addressed the protection against testimonial compulsion under Article 20(3) and personal liberty under Article 21. The case is not primarily about cognitive bias in forensic examiners, but it demonstrates that scientific or investigative techniques remain subject to constitutional limitations. The broader lesson is that the use of science in criminal investigation does not displace constitutional scrutiny. Scientific methods must be assessed not only for claimed utility but also for their reliability, the conditions under which they are used, and their compatibility with individual rights. In relation to cognitive bias, this supports an approach in which forensic expertise is welcomed but remains subject to transparent procedures and fair-trial safeguards.

F. The limits of existing Indian precedent

The cases discussed above do not amount to a settled Indian judicial framework expressly addressing cognitive bias in forensic examination. They establish broader principles concerning the advisory character of expert opinion, the court's responsibility to evaluate evidence, the importance of scientific investigation, and constitutional limits on investigative methods. The absence of a direct doctrine does not make cognitive bias legally irrelevant. It means that arguments about bias must presently be framed through established principles of evidentiary weight, reliability, procedural fairness, and the right to challenge the prosecution case.

A cautious approach is therefore essential. Courts should not presume that a forensic report is biased simply because the examiner knew something about the case. Nor should they ignore a

demonstrated risk where the examiner was exposed to information capable of influencing a subjective interpretation. The issue should be examined on the facts, with attention to the method, the information disclosed, the examiner's process, and the practical consequences for the defense.

8.7 Fair-trial implications under Article 21

Article 21 protects life and personal liberty except according to procedure established by law, and its interpretation has developed to require fairness in criminal process. A fair trial includes a meaningful opportunity to challenge the evidence used against an accused. Forensic evidence can strengthen that opportunity when it is properly disclosed and explained; it can undermine fairness when its technical appearance prevents meaningful scrutiny.

The equality-of-arms concern arises when the prosecution relies on a technical conclusion while the accused lacks access to the underlying observations, images, notes, data, or methodological assumptions necessary to test it. Not every document in a laboratory file must necessarily be disclosed without qualification, and legitimate privacy or security concerns may arise. However, restrictions should be justified and proportionate, and they should not make a central forensic conclusion effectively unchallengeable. Cognitive bias also raises a problem of asymmetry. The expert may have received the full investigative narrative, including a confession or an asserted motive, while the defence sees only the final report. If the report does not disclose what information the examiner received, how the analysis was conducted, or whether the conclusion changed after exposure to contextual material, the defence may be unable to identify a meaningful line of cross-examination. Disclosure of the analytical process can therefore support both scientific accountability and procedural fairness.

At the same time, Article 21 should not be used to convert every methodological disagreement into a constitutional violation. A fair process requires proportionate safeguards and reasoned evaluation. The court should consider whether the alleged bias risk is real and material, whether it affects a central issue, whether the report's reasoning is transparent, and whether the defence has a meaningful opportunity to challenge it. Where the risk is minor or speculative, it may be addressed through ordinary evidentiary evaluation; where it materially undermines reliability, stronger measures may be required.

8.8 Practical safeguards to reduce cognitive bias

A. Context management and need-to-know disclosure

Laboratories should identify the information an examiner needs to perform the assigned task

and limit unnecessary disclosure of case details. Investigators can submit a focused technical question rather than a complete narrative containing allegations, confessions, or opinions about guilt. Where further context is genuinely necessary, it can be supplied in a documented and controlled manner. This is not an attempt to isolate science from reality; it is a method of ensuring that the scientific conclusion is based on scientifically relevant information.

B. Linear Sequential Unmasking

Linear Sequential Unmasking involves presenting information in a sequence designed to preserve an examiner's opportunity to evaluate the evidence independently. The examiner first records observations from the questioned material, then receives relevant comparison material or additional information at a later stage. Any change in the initial assessment can be documented and explained. The procedure should be adapted to the discipline and should not prevent access to information that is genuinely necessary to interpret the evidence.

C. Independent and blind verification

Where verification is required, the second examiner should, so far as practicable, reach an independent conclusion before learning the first examiner's result. If the second examiner is immediately told that the first has identified a match, the verification may be less independent than it appears. A documented blind review, followed by comparison of results and resolution of disagreements, can improve the value of verification.

D. Transparent reporting of reasoning and uncertainty

Forensic reports should separate observations, methods, interpretations, assumptions, and conclusions. They should identify the quality and limitations of the material, relevant uncertainty, possible alternative explanations, and the basis for any categorical language. Reports should not overstate what the evidence proves. For example, an association between a person and biological material does not, without more, establish the time or circumstances of deposition. Similarly, a pattern comparison may support a conclusion within a defined framework but should not be presented as an infallible identification unless the method and data justify that claim.

E. Audit trails and record preservation

Laboratories should preserve contemporaneous notes, images, measurements, instrument outputs, relevant communications, and records of changes in the examiner's assessment. Such records allow another expert to understand how the conclusion was reached. Audit trails can also help identify whether a report changed after the examiner received new contextual information. Documentation is especially important where the analysis involves judgment and

where the initial material is ambiguous.

F. Training, proficiency testing, and quality assurance

Training should explain cognitive bias as a normal human risk rather than as a personal accusation. Examiners should learn how context can affect interpretation, how to distinguish task-relevant from task-irrelevant information, and how to express uncertainty. Proficiency testing, peer review, validated methods, appropriate accreditation, manageable workloads, and periodic audits can complement context-management measures. No single safeguard is sufficient; reliability is best supported by a system of mutually reinforcing controls.

G. Judicial scrutiny and effective cross-examination

Courts should ask whether the expert's conclusion is based on a validated and appropriate method, whether the sample was adequate, what assumptions were made, whether alternative explanations were considered, and whether the report discloses the relevant limitations. Where the circumstances justify it, the court may permit questions about information received by the examiner, the sequence of examination, the existence of independent verification, and the records available for review. Cross-examination should not be treated as a substitute for proper laboratory practice. A defence lawyer may lack the technical knowledge or resources to discover a bias risk if the underlying process is not documented or disclosed. Judicial case management, access to relevant materials, and the possibility of independent expert assistance can make adversarial testing more meaningful.

H. Institutional independence and resource allocation

Forensic laboratories should have clear professional standards that protect analytical judgment from pressure to produce a result favourable to either side. Investigators may properly define the question and provide relevant case facts, but should not direct the conclusion. Workload, staffing, turnaround pressures, and inadequate equipment may contribute to mistakes and should be treated as quality-management issues. An institutional response is more effective than relying only on reminders to individual examiners to remain objective.

8.9 Balancing the value of forensic science with its limitations

The possibility of cognitive bias should not lead to the conclusion that forensic science is inherently untrustworthy. Properly collected and interpreted scientific evidence can exclude suspects, reveal inconsistencies, and provide reliable information that would otherwise be unavailable. In some cases, forensic evidence can protect an accused person from wrongful suspicion. The objective is to make the evidentiary process more dependable, not to undermine it.

The level of scrutiny should reflect the nature of the method and the issue in dispute. A well-validated instrumental measurement may raise different concerns from an interpretive comparison of a partial fingerprint or a complex DNA mixture. The court should not apply a single undifferentiated standard to every forensic discipline. Instead, it should consider the method's validation, known limitations, the quality of the sample, the role of human interpretation, and the extent to which the conclusion can be independently tested.

There is also a practical balance between safeguards and efficiency. Requiring extensive blind procedures for every low-risk routine task may consume resources without a proportionate gain. A risk-based model can prioritise cases in which the evidence is ambiguous, the consequences of error are grave, the examiner's judgment is central, or the method has known limitations. The objective is to apply the strongest safeguards where they are most likely to improve reliability.

8.10 Comparative perspectives and their relevance to India

International literature and institutional guidance provide useful models, but they should be adapted rather than copied mechanically. The United States National Research Council report highlighted the need for stronger scientific foundations, standards, and quality controls. NIST's human-factors work has considered how the design of tasks, information flow, and working conditions affect forensic decision-making. These materials do not bind Indian courts, but they offer a developed body of scientific and policy analysis that can inform Indian institutional reform.

The Linear Sequential Unmasking approach is particularly relevant because it provides a practical method for controlling the order in which information is disclosed. Its value lies in operationalising the abstract instruction to 'avoid bias'. Instead of expecting examiners to ignore information they have already received, the process reduces unnecessary exposure before the initial analysis. It can also improve transparency by recording what was known at each stage.

For India, implementation should consider the structure of State and Central Forensic Science Laboratories, staffing, training, case volume, and the need for uniform but discipline-sensitive procedures. National guidance could identify minimum safeguards while allowing laboratories to adapt them to the technical requirements of particular disciplines. Any reform should be accompanied by training, audit mechanisms, and periodic review to ensure that the procedure improves quality rather than becoming a paper-only formality.

9. CONCLUSION

Forensic science occupies an important position in modern criminal justice, but scientific evidence is not interpreted in a human vacuum. In many forensic disciplines, the examiner must make judgments about incomplete, ambiguous, or complex material. Cognitive bias can influence such judgments through confirmation, contextual information, anchoring, tunnel vision, and hindsight. The existence of this risk does not prove that a particular examiner is biased or that a particular forensic method is invalid. It demonstrates why reliability must be supported by sound procedures rather than assumed from the label 'scientific'. Indian evidence law recognizes expert opinion under Section 39 of the Bharatiya Sakshya Adhiniyam, 2023. Supreme Court decisions such as *State of H.P. v. Jai Lal and Ramesh Chandra Agrawal v. Regency Hospital Ltd.* reinforce that expert evidence assists the court and must be evaluated rather than accepted automatically. These judgments do not establish a distinct doctrine on cognitive bias, but their emphasis on reasoned evaluation provides a foundation for closer scrutiny of forensic methodology, assumptions, and limitations.

The central implication for fair trial rights is that the accused must have a meaningful opportunity to understand and challenge forensic evidence. This requires transparent reporting, appropriate disclosure, effective cross-examination, and judicial awareness of the difference between admissibility and reliability. At the laboratory level, context management, sequential unmasking, blind verification, audit trails, training, and quality assurance can reduce avoidable risks. At the judicial level, experts should explain not only what they conclude but how they reached that conclusion and what the evidence cannot establish.

Ultimately, the law should neither treat forensic science as infallible nor reject it because human judgment is involved. A fair and scientifically informed criminal process recognises the value of expertise while demanding transparency, methodological discipline, and proportionate safeguards. The objective is not certainty at any cost; it is a more reliable process in which scientific conclusions are tested with the same care that the criminal justice system owes to every person whose liberty is at stake.

10. RECOMMENDATIONS

- 1. Adopt written context-management protocols.** Forensic laboratories should define which categories of information are necessary for each examination and restrict access to irrelevant case narratives, suspect histories, confessions, and prior conclusions where these are not needed for the task.

2. **Introduce sequential disclosure where appropriate.** For suitable comparison and interpretive disciplines, laboratories should consider Linear Sequential Unmasking or an equivalent process so that the examiner can record initial observations before receiving potentially biasing information.
3. **Strengthen independent verification.** Where verification is required, the reviewing examiner should, as far as practicable, form an independent conclusion before being shown the first examiner's result. Disagreements should be documented and resolved through a transparent procedure.
4. **Improve the structure of forensic reports.** Reports should separate observations from interpretations and conclusions, identify the method and assumptions used, explain limitations, and avoid language that conveys greater certainty than the evidence supports.
5. **Preserve the analytical audit trail.** Laboratories should maintain examination notes, images, measurements, relevant communications, changes in conclusions, and the information supplied to the examiner. Appropriate disclosure should enable meaningful challenge without compromising legitimate confidentiality.
6. **Build cognitive-bias awareness into professional training.** Training should address confirmation bias, contextual effects, expectation, and overconfidence, and should teach examiners to recognise uncertainty without treating the issue as a personal accusation.
7. **Invest in validation, proficiency testing, and quality assurance.** Laboratories should regularly review methods, assess examiner performance, maintain suitable workloads, and implement quality systems that identify recurring sources of error.
8. **Develop judicial guidance on evaluating expert evidence.** Judicial training should address the difference between expertise, admissibility, reliability, and weight; the role of methodological limitations; and questions that may help evaluate a subjective forensic conclusion.
9. **Enable meaningful defence scrutiny.** Subject to lawful and proportionate limits, the defence should have access to relevant underlying observations, method descriptions, and records necessary to test a central forensic opinion. Where the technical complexity warrants it, courts should consider whether independent expert assistance is needed.
10. **Adopt a risk-based implementation strategy.** The strongest controls should be prioritised for ambiguous or high-consequence examinations and disciplines where human interpretation plays a substantial role, while maintaining proportionate

procedures for routine tasks.

1. SCOPE FOR FUTURE RESEARCH

- Future doctrinal research may examine how Indian courts evaluate forensic reports under the Bharatiya Sakshya Adhiniyam, 2023 as more decisions interpreting the new legislation become available.
- Discipline-specific studies could assess the feasibility of sequential unmasking and blind verification in Indian forensic laboratories, with appropriate ethical approval and laboratory cooperation.
- Further research may examine how forensic reports communicate uncertainty, whether courts distinguish observations from interpretations, and how cross-examination addresses methodological limitations.
- Comparative research could study context-management protocols used in selected jurisdictions and identify which elements are adaptable to Indian laboratory structures and resource conditions.
- Future research may examine how laboratory accreditation, proficiency testing, workload, and quality-assurance systems interact with cognitive-bias safeguards.

2. LIMITATIONS

- No questionnaire, interview, survey, or original field study was conducted. The paper therefore makes no claims about the prevalence of cognitive bias among Indian forensic examiners or about stakeholder perceptions.
- The scientific literature reviewed includes international studies. Their findings provide a basis for understanding plausible mechanisms and safeguards, but they cannot automatically be generalised to every forensic discipline or laboratory in India.
- Indian judicial decisions explicitly addressing cognitive bias in forensic examination appear limited. The paper therefore relies on general principles concerning expert evidence, judicial scrutiny, investigation, and fair trial rights, while clearly distinguishing those principles from direct rulings on cognitive bias.
- Different forensic disciplines vary in their methods, levels of subjectivity, validation, and known error mechanisms. The recommendations should be adapted to the relevant discipline rather than applied identically in every case.
- The paper is a legal and analytical study, not a technical validation of any particular

forensic method. Technical claims should be read in light of the scientific sources identified in the references.

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