THE EMERGENCE OF COGNITIVE BIAS IN FORENSIC SCIENCE AND CRIMINAL INVESTIGATIONS

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ABSTRACT

The emergence of cognitive bias within forensic science and criminal investigations is being increasingly discussed and described as an issue and concern in relation to the admissibility of evidence and expert witness testimony. A review of standards and processes within the forensic science disciplines has highlighted the role of subjective interpretations and empirical research has identified and demonstrated the potential impact of unconscious cognitive bias in data collection, analysis, and decision-making. Therefore, it is imperative that the forensic science and legal communities addresses implications relating to both the presence, and potential effects of cognitive bias, and how to mitigate its manifestations. This article highlights the vulnerabilities to cognitive issues within forensic science, and discusses the importance of recognizing biases that may impact interpretation during analysis. The key issues are presented with reference to previous and new studies within the field of cognitive forensics. Furthermore, the consequences of these issues are highlighted in relation to their impact on how evidence is presented in courts of law. The possible solutions that may minimize, control, and alleviate the effects of cognitive bias to secure the creditability of the forensic examiner and the forensic science disciplines are discussed.

CONTENTS

I. INTRODUCTION

The use of forensic evidence in criminal procedures has been applied for over a century. In contrast to most other types of evidence, scientific experts are considered to provide impartial scientific evidence.[1] As such, their evidence is highly valued by the courts and can carry weight in criminal proceedings. Over time, expansion and recognition of forensic evidence in criminal settings has increased the role of forensic scientists in both the detection and examination of criminal events.[2] The value of forensic evidence in crime scene investigations has created opportunities to establish and apply contemporary methods and techniques of

[1] Saul M. Kassin et al., *The Forensic Confirmation Bias: Problems, Perspectives, and Proposed Solutions*, 2 J. APPLIED RES. MEMORY COGNITION 42 (2013).
[2] Ruth M. Morgan & Peter A. Bull, *The Philosophy, Nature and Practice of Forensic Sediment Analysis*, 31 PROGRESS PHYSICAL GEOGRAPHY 43 (2007).

the highest standard, particularly when addressing crime scene evidence collection, analysis, and the interpretation of evidence presented in court.[3]

For the most part, for decades the courts have accepted forensic evidence as scientific, objective, and impartial, as well as highly reliable and validated. The remarkable success of forensic investigations portrayed in the media and television programmes, such as CSI, further reflects the idea that forensic evidence is very rarely inaccurate, contradictory or wrong.[4]

In reality, however, there has recently been an increase in the critique of some of the methods and techniques used in forensic science. One area of critique has been identified in regard to evidence admissibility and error rates in methods applied by forensic scientists and expert evidence presented in court.[5] The National Academy of Sciences[6] in the United States, and the Fingerprint Inquiry[7] as well as the Forensic Science Regulator in the United Kingdom,[8] have underlined the potential for subjective interpretations and bias within disciplines undertaking forensic science.[9] New research within the field of forensic science has addressed some of the issues that have been identified, including the presence of cognitive biases.

Empirical research has been carried out across numerous forensic domains and has highlighted cognitive biases and its effect in forensic examinations. The impact of cognitive biases has begun to be evaluated at all stages of the forensic science process including data collection, analysis, evidence interpretation and final presentation in court.[10] Studies within decision-making and human cognition have repeatedly and consistently demonstrated that the active nature of human information processing systematically holds a set of cognitive biases, resulting in the human mind being subjected to error.[11] It has been demonstrated that these vulnerabilities are not limited to a specific field, with similar cognitive biasing issues being established across law enforcements and numerous forensic science disciplines.[12]

The growing concerns over expert decision-making being influenced by cognitive processes have created heated controversy within the literature. Many have questioned the role of the forensic scientist at crime scenes and the exposure to

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[3] Brian Caddy & Peter Cobb, *Forensic Science in* CRIME SCENE TO COURT: THE ESSENTIALS OF FORENSIC SCIENCE (Peter C. White ed., 2d ed. 2009).
[4] Morgan & Bull, *supra* note 2.
[5] Jehuda Hiss et al., *The Forensic Expert Witness - An Issue of Competency*, 168 FORENSIC SCI. INT'L 89 (2007).
[6] NATIONAL RESEARCH COUNCIL, STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD (2009).
[7] FINGERPRINT INQUIRY, THE FINGERPRINT INQUIRY SCOTLAND (2011).
[8] HOUSE OF COMMONS: SCIENCE AND TECHNOLOGY COMMITTEE, THE FORENSIC SCIENCE SERVICE-SEVENTH REPORT OF SESSION 2010-12 (2011).
[9] Itiel E. Dror & Simon A. Cole, *The Vision in "Blind" Justice: Expert Perception, Judgment, and Visual Cognition in Forensic Pattern Recognition*, 17 PSYCHONOMIC BULL. & REV. 161 (2010).
[10] *See* Kassin et al., *supra* note 1.
[11] JOHN R. ANDERSON, COGNITIVE PSYCHOLOGY AND ITS IMPLICATIONS (5th ed. 2000).
[12] Bryan Found, *Deciphering The Human Condition: The Rise of Cognitive Forensics*, AUSTL. J. FORENSIC SCI. 1 (2014).

domain irrelevant information; potentially being one of the sources to constitute bias in forensic settings.[13] Greater involvement of the forensic scientist in criminal procedure has resulted in decisions and interpretation regarding the source of evidence to be made on a much more regular basis.[14] Therefore, understanding the underlying process of such judgments within forensic science is fundamental.

This paper will highlight the vulnerabilities to cognitive interpretation issues within the forensic science process, and discuss the significance of recognizing biases that may impact criminal investigations and forensic analysis. The paper will discuss the role of the forensic scientist, and in addition, examine how such a role could be affected by cognitive errors during different stages of the forensic conceptual framework. Furthermore, the key issues and possible consequences of cognitive biases will be highlighted and presented with reference to new and previous studies within the field of forensic science and criminal procedures with a main focus on the United States and United Kingdom. Even though organizations such as the National Institute of Standards and Technology (NIST) in the United States and the Forensic Science Regulator in the United Kingdom, have started to support the general recommendation of the National Academy of Sciences report, and recognize the effect of cognitive biases, the forensic science community have yet to fully implement the proposed solutions on how to alleviate its effect. This paper will therefore also review the possible solutions highlighted in the recent body of literature within both law, and forensic domains, to assist on how to mitigate and control the effect of cognitive bias in all stages of a criminal investigation.

Part II of this article begins with analyzing the role of forensic science in the criminal process, and continues with Part III evaluating the responsibilities of expert witness testimonies in court proceedings. Part IV explores the role of human cognition in decision-making and highlights some contemporary studies in cognitive biases in the field of psychology and social sciences, Part V summarizes how human cognition and cognitive biases could affect the legal system. Part VI then seeks to explore how these cognitive phenomena might unfavorably affect the judgment of forensic scientists, with reference to empirical research within cognitive bias in different forensic domains. Part VII introduces some proposed solutions on how to address cognitive biases in forensic science and criminal procedures, with the final Part VIII discussing possible reforms and recommended future direction to better develop our understanding of cognitive bias and minimize its impact in the practice of the forensic sciences.

II. The Role of Forensic Science in the Criminal Process

Forensic science concerns the implementation of science for the purpose of law.[15] In general terms, forensic science is applied in the investigation of crime,

[13] D. Michael Risinger et al., *The Daubert/Kumho Implications of Observer Effects in Forensic Science: Hidden Problems of Expectation and Suggestion,* 90 Calif. L. Rev. 3 (2002).
[14] William C. Thompson, *What Role Should Investigative Facts Play in the Evaluation of Scientific Evidence*, 43 Austl. J. Forensic Sci. 123 (2011).
[15] *See* Caddy & Cobb, *supra* note 3.

and has become increasingly important in the detection of criminal events, and crime reduction.[16] The domain of forensic science is varied and includes a multitude of disciplines. Forensic scientists possess knowledge and skills that allow them to collect, analyze and interpret trace materials and evidence associated with, and found at crime scenes. Very often forensic scientists are required by law to communicate their findings to assist courts,[17] and therefore, maintaining the integrity and security of evidence from its initial discovery to final presentation is crucial.[18] The conceptual framework outlined by Morgan and Bull[19] (2007) presents six fundamental stages of physical trace evidence within forensic investigations; division and transfer of matter, persistence and tenacity, collection, analysis/identification, interpretation and presentation. Each stage is dependent upon the previous stage being fulfilled, and the framework illustrates the importance of effectively addressing each stage to achieve accurate results and evidence in criminal investigations.[20]

However, whilst there may be similarities between forensic investigations, the context of an individual crime scene will be specific to that particular event. This context must be incorporated into the appraisal of each crime scene and the complexity of the multiple variables and their relationship to one another acknowledged. This is vital in order to establish the best approach for the collection and analysis of physical evidence and its interpretation in a specific case. [21]

The value of forensic analysis is well recognized, and the ability of analytical techniques to provide ever more accurate and detailed empirical analysis of forensic samples has been identified.[22] However, the interpretation of that evidence in specific forensic contexts is essential. There has been much debate in the literature concerning the methods and approaches that should be taken to offer robust and accurate interpretations of evidence to investigators and to the courts.[23] Indeed, a number of cases where the validity of different approaches has been questioned[24] (such as the case of *R. v T*[25] in the United Kingdom). More recently

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[16] Julie Mennell & Ian Shaw, *The Future of Forensic and Crime Scene Science. Part I. A UK Forensic Science User and Provider Perspective*, 157 FORENSIC SCI. INT'L S7 (2006).
[17] *See* Caddy & Cobb, *supra* note 3.
[18] Anastasia Holobinko, *Forensic Human Identification in the United States and Canada: A Review of the Law, Admissible Techniques, and the Legal Implications of Their Application in Forensic Cases*, 222 FORENSIC SCI. INT'L 394.e1 (2012).
[19] Ruth M. Morgan & Peter A. Bull, *Forensic Geoscience and Crime Detection, Identification, Interpretation and Presentation in Forensic Geoscience*, 127 MINERVA MEDIOLEGALE 73 (2007).
[20] *Id. See also* Ruth M. Morgan et al., *The Relevance of the Evolution of Experimental Studies for the Interpretation and Evaluation of Some Trace Physical Evidence*, 49 SCI. JUST. 277 (2009).
[21] Kirstie R. Scott et al., *The Transferability of Diatoms to Clothing and the Methods Appropriate for Their Collection and Analysis in Forensic Geoscience*, 241 FORENSIC SCI. INT'L 127 (2014).
[22] *See* Morgan et al., *supra* note 20.
[23] Norman Fenton, Martin Neil & David A. Lagnado, *A General Structure for Legal Arguments About Evidence Using Bayesian Networks*, 37 COGNITIVE SCI. 61 (2012).
[24] Mike Redmayne et al., *Forensic Science Evidence in Question*, CRIM. L. REV. 347 (2011).
[25] R v. T, [2010] EWCA (Crim) 2439 *available at* http://www.bailii.org/ew/cases/EWCA/Crim/2010/2439.pdf. In the case of R. v. T, The Court of Appeal for England and Wales rejected the testimony of an expert whom had applied likelihood ratios to evaluate the probative value of a shoe-print evidence. The Court of Appeal, Criminal

there has been an augmented awareness of the complexity and uncertainties surrounding the dynamics of evidence that may be recovered from crime scenes. Caution has been called for in the interpretation of physical evidence, with a focus on developing approaches that take into account an empirical evidence base that also incorporates the context specific nature of a particular scene.[26] The necessity for further empirical research within context specific cases has been highlighted where experimental studies, which imitate the forensic reality, are of fundamental importance in order for a measure of the significance of pertinent physical and trace evidence to be identified.[27]

III. Forensic Science and Expert Evidence

As a result of the complexity of data analysis and interpretation of evidence in the forensic sciences, the issue of admissibility of evidence and expert witness testimonial accounts has been raised.[28] Issues regarding validation and error rates of techniques used by forensic scientists and the professional standards of experts have been articulated in addition to the role of expert witness testimony in court proceedings.[29]

In the British and American systems, where trial by jury is the normal state of affairs, the role of the expert witness and the evidence that they provide in a courtroom is not only considered as a methodological question, but also an ethical one. It is not the role of a forensic scientist to determine the truthfulness of a variety of propositions related to crime. The role of the forensic scientist is to provide input to the legal process, where the accuracy of the source of various premises pertinent to the evidence presented is made generally by a judge or jury.[30] However, it has been documented that experts are often over confident in their abilities, and it has been observed that much of the forensic science evidence presented in court has arguably been accepted without a sufficient degree of scrutiny.[31]

Division, determined that; no attempt could credibly be made in the generalization of cases to use a formula to calculate probability estimation in the area of footwear evidence. It was also indicated that Bayes theorem and likelihood ratios should not be used outside the field of DNA. Due to the fact that likelihood ratios are used in forensic domains the decision from the court received severe criticism from leaders in the field and the forensic science community, where some of the criticism was with regards to the courts ruling being based on the misunderstandings of likelihood ratio frameworks and statistics.

[26] *See* Morgan & Bull, *supra* note 2.

[27] *See* Morgan et al., *supra* note 20.

[28] Angi M. Christensen & Christian M. Crowder, *Evidentiary Standards for Forensic Anthropology*, 54 J. Forensic Sci. 1211 (2009).

[29] Law Commission, Expert Evidence in Criminal Proceedings in England and Wales The House of Commons 1–206 (2011).

[30] *See* Thompson, *supra* note 14.

[31] Jennifer L. Mnookin et al., *The Need for a Research Culture in the Forensic Sciences*, 58 UCLA L. Rev. 725 (2011).

A. EXPERT EVIDENCE STANDARDS IN THE UNITED STATES.

In the majority of American states, the admissibility criteria applied for expert evidence follows the ruling of the United States Supreme Court in the 1993 case of *Daubert v. Merrell Dow Pharmaceuticals, Inc*.[32] The admissibility criteria set out in *Daubert* is widely known as the *Daubert* standard.[33] Other American states continue to use the "general acceptance" test established in *Frye v. United States*.[34] The purpose of the *Daubert* standard has been to ensure the dependability and significance of scientific or technical expert testimonies admitted in court.[35] The *Daubert* guidelines allow judges to act as gatekeeper in keeping "junk science" out of the courtroom, and aid judges to evaluate the reliability and relevance of scientific testimonies.[36] The *Daubert* standard requires evidence presented in court by an expert witness to be testable, subjected to peer review, have established standards, have a known or potential error rate, and be widely accepted by the relevant scientific community.[37] The Federal Rule of Evidence (FRE) 702 was appended in 2001 to highlight the connection between the methods and data used, and aimed to focus on the acceptability of the conclusion, rather than the qualification of the expert.[38]

The discussion of error and expert evidence intensified in the forensic science community with the publication of the National Academy of Sciences Report (2009).[39] The report reviewed the standards of process within disciplines undertaking forensic science. The National Academy of Science concluded that there are issues regarding reliability and errors within some forensic disciplines.[40] Furthermore, the report emphasized the potential for subjective interpretation and cognitive bias.[41] However, it has been asserted that the concept of error in this context is often misunderstood by the forensic community as well as the court. Christensen et al. (2014)[42] discuss the difference between scientific error and statistical error rates which have been confused with practitioner errors and also highlight the importance for forensic practitioners to ensure that the potential

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[32] Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579 (1993).

[33] Angi M. Christensen, *The Impact of* Daubert*: Implications for Testimony and Research in Forensic Anthropology (and the Use of Frontal Sinuses in Personal Identification)*, 49 J. FORENSIC SCI. 427 (2004).

[34] Frye v. United States, 293 F. 1013 (D.C. Cir 1923). According to the *Frye* standard scientific evidence, procedures, techniques and principles presented to the court must be generally accepted by a meaningful portion of the associated scientific community, meaning that expert testimonies must be based on scientific methods that are adequately established and acknowledged.

[35] Morgan et al., *supra* note 20..

[36] Christopher R. Grivas & Debra A. Komar, Kumho, Daubert, *and the Nature of Scientific Inquiry: Implications for Forensic Anthropology*, 53 J. FORENSIC SCI. 771 (2008).

[37] *See* Christensen, *supra* note 35.

[38] Dennis C. Dirkmaat et al., *New Perspectives in Forensic Anthropology*, 47 AM. J. PHYSICAL ANTHROPOLOGY 33 (2008).

[39] *See* NATIONAL RESEARCH COUNCIL, *supra* note 6.

[40] *See* Found, *supra* note 12.

[41] *See* Kassin et al., *supra* note 1.

[42] Angi M. Christensen et al., *Error and its Meaning in Forensic Science*, 59 J. FORENSIC SCI. 123 (2014).

sources or error and limitations within methods used by forensic scientists are not only understood, but also communicated correctly to the legal community. This was also an issue raised by the National Academy of Science report, which highlighted the importance of acknowledging and addressing all possible sources of error, including cognitive biases, by the forensic science domains.[43]

B. *Expert Evidence Standards in the United Kingdom*

In England and Wales, the Law Commission highlighted the issues regarding expert evidence in criminal proceedings in their 2011 report 'Expert Evidence in Criminal Proceedings in England and Wales' where they stated that the judicial approach to the admissibility of expert evidence in England and Wales was passive.[44] In the Criminal Procedure Rules, Rule 33.2 sets out the duty of the expert to the court, with the main objective to provide unbiased objective opinions based within his or her expertise.[45] The Law Commission report however acknowledges that too much expert opinion is admitted without adequate scrutiny, where no test is applied to determine the reliability of the evidence presented.[46] The report proposed that expert evidence in criminal trials should be subjected to a "reliability based admissibility test" before being presented to a jury to exclude unreliable expert evidence.[47] These recommendations were aimed at establishing a framework in criminal proceedings for controlling expert evidence at the admissibility stage, where possible sources of error and bias must be made clear.[48] As a result of the concerns raised by both reports, there has been a call for the development of a research agenda, with the suggested mechanism to enable this being closer collaboration between the professionals within the industry and academic research institutions.[49] Whilst this is an admirable aim, there has to date been limited funding made available for primary research within the forensic sciences to address each part of the forensic science process (crime scene investigation, sampling and analysis, interpretation of that analysis and the presentation of evidence in court).

IV. Human Cognition and Cognitive Bias

In order to understand how judgments and interpretations in forensic science and criminal investigations can be affected by cognitive mechanisms, it is important to recognize the strengths and weakness of human cognition in decision-making.[50]

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[43] *See* National Research Council, *supra* note 6.
[44] *See* Law Commission, *supra* note 29.
[45] Ministry of Justice, The Criminal Procedure Rules, Part 33 Expert Evidence (2013).
[46] *See* Law Commission, *supra* note 29.
[47] *Id.*
[48] *Id.*
[49] Bernard Silverman, Research and Development in Forensic Science: A Review 24 (2011).
[50] Jean-Paul Caverni et al., *Cognitive Biases: Their Contribution for Understanding Human Cognitive Processes*, 68 Advanced Psychol. 7 (1990).

The information processing approach is known as human cognition, and defines the acquisition, organization and the use of knowledge.[51] The study of human cognition addresses human perception, judgment and decision-making, which are all influenced by a variety of cognitive processes.[52] However, in order for the brain to organize information and new perceptions the human mind will use *schemata* to comprehend the data derived. The power of schemata plays a vital role in judgment and decision-making, which could be defined as "scripts" that help the brain analyze the perception and judgment of an individual based on their prior beliefs.[53] The human mind does encode passively the information coming in, which is known as 'bottom up' and is considered to be purely raw data derived from the environment. The processing and interpretation of incoming data (bottom-up information) is mediated by a variety of 'top down' cognitive mechanisms such as knowledge, experience, motivations expectations and emotional states.[54] Top-down processing makes the processing of information much more efficient[55] however, in some cases top-down components interfere with and distort the processing of the bottom-up component.[56] For example, research within psychology and social science has demonstrated that the emotional state of individuals can have a significant impact upon the way information is processed and interpreted as perceptions and understandings are highly related to emotional conditions.[57] Mock juror studies that have addressed the issue of emotional state and decision-making have demonstrated that emotional state can influence verdict outcomes. Results have shown that presenting emotionally disturbing evidence influences the verdict of mock jurors.[58] Within forensic science, it is now acknowledged that forensic evidence can also potentially be influenced by a variety of top-down processing, with much forensic analysis arguably occurring in highly emotional contexts where evidence is associated with specific crimes against a victim(s).[59]

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[51] Itiel E. Dror & Peter A.F. Fraser-Mackenzie, *Cognitive Biases in Human Perception, Judgment and Decision-making: Bridging Theory and the Real World* in CRIMINAL INVESTIGATIVE FAILURES 53 (Kim Rossmo ed., 2008).

[52] Laura Hoppitt et al., *Cognitive Mechanisms Underlying the Emotional Effects of Bias Modification*, 24 APPLIED COGNITIVE PSYCHOL. 312 (2010).

[53] NEISSER ULRIC, COGNITION AND REALITY: PRINCIPLES AND IMPLICATIONS OF COGNITIVE PSYCHOLOGY (1976).

[54] *See* Kassin et al., *supra* note 1.

[55] Itiel E. Dror & Stephen M. Kosslyn, *Age Degradation in Top-Down Processing: Identifying Objects from Canonical and Noncanonical Viewpoints*, 24 EXPERIMENTAL AGING RES. 203 (1998).

[56] Peter A.F. Fraser-Mackenzie, Rebecca E. Bucht & Itiel E. Dror, *Forensic Judgment and Decision-making in* COMPARATIVE DECISION MAKING 385 (Philip H. Crowley & Thomas R. Zentall eds., 2013).

[57] Angela Byrne & Michael W. Eysenck, *Individual Differences in Positive and Negative Interpretive Biases*, 14 PERSONALITY & INDIVIDUAL DIFFERENCES 849 (1993).

[58] David A. Bright & Jane Goodman-Delahunty, *Gruesome Evidence and Emotion: Anger, Blame, and Jury Decision-Making*, 11 PSYCHIATRY PSYCHOL. L. 154 (2006).

[59] Itiel E. Dror et al., *When Emotions Get the Better of Us: The Effect of Contextual Top-Down Processing on Matching Fingerprints*, 19 APPLIED COGNITIVE PSYCHOL. 799 (2005).

Therefore, relying exclusively on top down cognitive mechanisms and operative information processing is liable to cause weakness in the interpretation of evidence.[60] This type of information may affect the analytical methods and influence the decision-making procedure when generating the final conclusion and thereby cause a biasing effect.[61] These types of errors could be referred to as cognitive biases, potentially defined as the psychological and cognitive factors that unconsciously manipulate and interfere with the data processing, causing judgment and decision-making to be unreliable.[62] This issue is also part of a concept commonly known as heuristics.

Heuristics are strategies that use mental shortcuts in decision-making, including ignoring part of the information to make decisions quicker, more prudent and accurate.[63] For enhanced and frugal cognition, heuristics trade off some loss in accuracy, which could lead to faulty reasoning.[64] There are differing methods where cognitive heuristics can operate, such as through anchoring and adjustments, whereby the tendency is to rely on the first piece of information presented when making a decision.[65] For example studies regarding sentencing guidelines have demonstrated that judges use different judgmental anchors when making sentencing decisions.[66] It has been demonstrated that judges were influenced by sentencing demands which resulted in people who had committed very similar crimes receiving different sentences.[67] Tversky and Khaneman (1974)[68] demonstrated in their study that people tend to rely on various cognitive heuristics, and whilst this is considered generally to be beneficial,[69] it could also create systematic errors in judgment and decision-making. This has been specifically demonstrated when it comes to prior expectations which could provide a sufficient and unconscious tendency to perceive and interpret evidence that would confirm pre-existing beliefs, otherwise known as confirmation bias.[70]

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[60] Itiel E. Dror, *The Paradox of Human Expertise: Why Experts Get It Wrong, in* THE PARADOXICAL BRAIN 177 (Naridner Kapur ed., 2011).

[61] Vittorio Girotto & Guy Politzer, *Conversational and World Knowledge Constraints on Deductive Reasoning*, 68 ADVANCES PSYCHOL. 87 (1990).

[62] Jonathan St. B.T. Evans & Paul Pollard, *Belief Bias and Problem Complexity in Deductive Reasoning*, 68 ADVANCES PSYCHOL. 131 (1990).

[63] Gerd Gigerenzer & Wolfgang Gaissmaier, *Heuristic Decision-Making*, 62 ANN. REV. PSYCHOL. 451 (2011).

[64] Arthur S. Elstein, *Heuristics and Biases:Selected Errors in Clinical Reasoning*, 74 ACAD. MED. 791 (1999).

[65] Oscar Bergman et al., *Anchoring and Cognitive Ability*, 107 ECON. LETTERS 66 (2010).

[66] Thomas Musseweiler & Birte Englich, *Subliminal Anchoring: Judgmental Consequences and Underlying Mechanisms*, 98 ORG. BEHAV. & HUM. DECISION PROCESSES 133 (2005).

[67] Birte Englich & Thomas Musseweiler, *Sentencing Under Uncertainty: Anchoring Effects in the Courtroom*, 31 J. APPLIED SOC. PSYCHOL. 1535 (2001).

[68] Amos Tversky & Daniel Kahneman, *Judgment under Uncertainty: Heuristics and Biases*, 185 SCI. 1124 (1974).

[69] *See* Gigerenzer & Gaissmaier, *supra* note 63.

[70] Daniel Khaneman & Shane Frederick, *Representativeness Revisited:Attribute Substitution in Intuitive Judgment, in* HEURISTICS AND BIASES: THE PSYCHOLOGY OF INTUITIVE JUDGMENT 49 (Thomas Gilovich, Dale Griffin, & Daniel Khaneman eds., 2002).

Confirmation bias is the tendency to selectively gather and process information to confirm a hypothesis or preconception[71] by looking for evidence that would validate existing beliefs and expectations, in terms of rejecting, excusing or ignoring evidence that could contradict the current assumption.[72] Studies within reasoning have demonstrated that people attempt to find evidence, which confirms to a rule rather than finding evidence that would disconfirm it.[73] The fundamental mechanisms upon which confirmation bias operates are *selective information search* and *biased interpretation* of available information.[74] Selective information search within legal perspectives occurs when an individual examines information or evidence to incriminate a suspect based on a personal hypothesis, and ignores the search for evidence that could exonerate or lead to an alternative hypothesis.[75] Biased interpretations occur when experts only interpret evidence that supports, and will be in favor of their own hypotheses. This inhibits the expert from observing the evidence from multiple angles, often resulting in a subjective conclusion.[76] For example, the majority of criminal investigations are driven by a theory, which leads investigators in their search for evidence guided by their initial hypothesis regarding when, why, how and by whom a crime was committed.[77] These working hypotheses could arguably be affected by preconceptions and expectations of the investigators due to the way the brain processes and stores information, especially when dealing with ambiguous and complex evidence.[78] Thus, a variety of influences that have nothing to do with the case drive and guide the investigation, and can affect its outcome. As described earlier, a preference for confirmation over falsification, could arguably result in investigators searching for and finding confirmatory evidence against a suspect in contrast to find disconfirming and exonerating information.[79]

An article by Kassin et al. (2013) "*The Forensic Confirmation Bias: Problems, Perspectives and Proposed Solutions*"[80] outlined both some of the earliest and the most contemporary work on confirmation biases. The authors traced the concept of confirmation bias back to the philosopher Francis Bacon who

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[71] Itiel E. Dror & David Charlton, *Why Experts Make Errors,* 56 J. FORENSIC IDENTIFICATION 600 (2006).
[72] Paul C. Gianelli, *Confirmation Bias,* 22 CRIM. JUST. 60 (2007).
[73] Patricia W. Cheng et al., *Pragmatic Versus Syntactic Approaches to Training Deductive Reasoning,* 18 COGNITIVE PSYCHOL. 293 (1986).
[74] Karl Ask & Pär Anders Granhag, *Motivational Sources of Confirmation Bias in Criminal Investigations: The Need for Cognitive Closure,* 2 J. INVESTIGATIVE PSYCHOL. & OFFENDER PROFILING 43 (2005).
[75] *Id.*
[76] Barbara O'Brian, *Prime Suspect: An Examination of Factors That Aggravate and Counteract Confirmation Bias in Criminal Investigations,* 15 PSYCHOL. PUB. POL'Y & L. 315 (2009).
[77] *See* Ask & Granhag, *supra* note 74.
[78] Alafair S. Burke, *Improving Prosecutorial Decision Making: Some Lessons of Cognitive Science,* 47 WM. & MARY L. REV. 1587 (2005).
[79] *See* O'Brian, *supra* note 76.
[80] *See* Kassin et al., *supra* note 1.

acknowledged the impact of it in his work of 1620, by recognizing various obstacles that influence the human mind.[81] The body of literature within psychology has over the years recognized different sources and fuels of cognitive bias, and confirmation bias in particular, such as time pressure,[82] expectations,[83] pre-existing beliefs,[84] and motivation.[85] Empirical research has demonstrated that the beliefs held by people are resistant to change. Once people form a hypothesis they fail to adjust the tenacity of their beliefs in the light of evidence that will challenge the accuracy of those beliefs.[86] This is also known as belief perseverance, which is the tendency to continue to confirm a theory even though the evidence underlying the theory is confounded.[87] One of the earliest studies in belief perseverance was to study the effect of what is known as the *debriefing paradigm*. In a study conducted by Anderson et al. (1980)[88] subjects were presented with allegedly authentic reports of fire-fighters. After reading the reports subjects were asked to write an explanation of the relationship between fire fighting abilities and risk preference observed in the case histories given. This was done to investigate whether fictitious information about the relationship between the personality trait such as risk taking and fire fighter ability could produce a perseverant social theory. The case histories reports given to the subjects were manipulated whereby participants were led to perceive that there was either a positive or negative correlation between risk preference and fire fighting abilities. The results demonstrated that even after participants were debriefed concerning the fiction of the case reports, they persisted in the theories that they had formed from those case histories. Participants led to believe that risk taking makes better fire-fighters and those initially led to believe that risk taking makes poorer fire-fighters persevered their initial beliefs, even after being debriefed about the fictional nature of the initial information.[89] The study demonstrated that the participants adhered to their conclusions even though the evidence fundamental to the conclusions were confounded. Similarly, mock juror studies have found that jurors tend to be unable to disregard evidence that has been ruled inadmissible.[90] Equally, in a crim-

[81] Itiel E. Dror, *How Can Francis Bacon Help Forensic Science? The Four Idols of Human Biases*, 50 JURIMETRICS J. L. SCI. TECH. 93 (2009).
[82] Ian Evett, *Evaluation and Professionalism*, 49 SCI. JUST. 159 (2009).
[83] Paola Bressan & Maria F. Dal Martello, *Talis Pater, Talis Filius: Perceived Resemblance and the Belief in Genetic Relatedness*, 13 PSYCHOL. SCI. 213 (2002).
[84] David L. Hamilton & Mark P. Zanna, *Context Effects in Impression Formation: Changes in Connotative Meaning*, 29 J. PERSONALITY & SOC. PSYCHOL. 649 (1974).
[85] Ziva Kunda, *The Case for Motivated Reasoning*, 108 PSYCHOL. BULL. 480 (1990).
[86] Burke, *supra* note 78.
[87] Craig A. Anderson & Kathryn L. Kellam, *Belief Perseverance, Biased Assimilation, and Covariation Detection: The Effect of Hypothetical Social Theories and New Data*, 18 PERSONALITY & SOC. PSYCHOL. BULL. 555 (1992).
[88] Craig A. Anderson et al., *Perseverance of Social Theories: The Role of Explanation in the Persistence of Discredited Information*, J. PERSONALITY & SOC. PSYCHOL. 1037 (1980).
[89] *Id.*
[90] Scott A. Hawkins & Reid Hastie, *Hindsight: Biased Judgments of Past Events After the Outcomes are Known.*, 107 PSYCHOL. BULL. 311 (1990).

inal investigation, the act of considering someone "accountable" (which is a condition necessary for turning a person into a suspect) is in itself likely to increase the belief of the investigator in the culpability of the suspect(s).[91]

The fact that people can be unaware of pre-existing beliefs has potential consequences in forensic settings. This is also known as the observer effect, which in general terms could be described as when the result of an observation in a particularly set of circumstances is affected by the observer.[92] In forensic science the term observer effect is used when the motives or preconceptions of the observer are thought to influence the perception and interpretation of evidence, resulting in examiner bias.[93] Context effect is highly related to observer effect and is used in the forensic sciences to describe situations in which forensic analysis are affected by the context of the crime or by the contextual information available to the analyst prior to their assessment.[94]

Studies have demonstrated that it is difficult for people to evaluate the strength of evidence independent of pre-existing beliefs and that there is a tendency to devalue disconfirming evidence.[95] This is because evidence is weighed to support prior beliefs to a greater degree than evidence that contradicts those beliefs.[96] The psychology and social science literature suggests that people not only demonstrate confirmation bias when seeking new information but also in the memory of stored information;[97] meaning that people search their memories in biased ways. The product of various cognitive biases that could obstruct accuracy in what is perceived, how it is perceived, and how it is interpreted is also known in criminal cases as tunnel vision. Tunnel vision has been shown to have an effect in the initial stages of criminal investigations and this is a significant issue because all subsequent stages of the investigation will potentially be impacted by the information generated at this initial stage.[98]

V. COGNITIVE BIAS AND THE LEGAL SYSTEM

Research regarding cognitive biases and decision-making has also been applied within the legal system.[99] Studies conducted by Phillips et al. (1999)[100] in

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[91] *See* Ask & Granhag, *supra* note 76.

[92] William. C. Thompson, *Painting the Target Around the Matching Profile: The Texas Sharpshooter Fallacy in Forensic DNA Interpretation*, 8 LAW PROBABABALITY & RISK 257 (2009).

[93] *See* Risinger et al., *supra* note 13.

[94] *See* Thompson, *supra* note 92.

[95] Charles G. Lord et al., *Biased Assimilation and Attitude Polarization: The Effects of Prior Theories on Subsequently Considered Evidence*, 37 J. PERSONALITY & SOC. PSYCHOL. 2098 (1979).

[96] Keith A. Findley & Michael S. Scott, *The Multiple Dimensions of Tunnel Vision in Criminal Cases*, 2 WIS. L. REV. 292 (2006).

[97] *See* Burke, *supra* note 78.

[98] *See* Findley & Scott, *supra* note 96.

[99] *See* Kassin et al., *supra* note 1.

[100] Mark R. Phillips et al., *Double-Blind Photography Administration as a Safeguard Against Investigator Bias*, 84 J. APPLIED PSYCHOL. 940 (1999).

eyewitness misidentification demonstrated the power of information by indicating that when the suspect is known, it is more likely for the investigator to unconsciously steer the witness towards the suspect.[101] Similarly, research in facial recognition and decision-making has demonstrated that when information is given concerning a suspect with regard to their guilt, people have the tendency to perceive more similarities between a facial composite and the suspect.[102]

Studies carried out by Kassin and Fong (1999)[103] demonstrated variations in interrogation methods when an assumption of guilt had previously been established. The findings demonstrated that when investigators had a presumption of guilt there was sometimes an unconscious tendency to be more aggressive and intimidating in interrogation towards the suspect. Mock jury studies have demonstrated that confessions of a crime have more impact on verdicts than other forms of evidence.[104] This is considered to be because most people believe that people do not confess to a crime they did not commit.[105]

For prosecutors it has also been identified that there are some cognitive pitfalls when involved in an investigation. For example, it has been observed that the prosecution can shape the investigative direction for example, by determining who to investigate, and once an arrest is made, they determine whether to bring charges or not, what charges to bring and what sentence to seek.[106] This processing approach for prosecutors may lead to potential ways that cognitive bias may impact upon decision-making.[107] Indeed, the phenomenon of confirmation bias could in complex cases lead to the natural tendency to review the case report for confirming evidence and not exculpatory evidence that might contradict the given hypothesis.[108] It has also been shown that people can fail to look for evidence that disconfirms a given hypothesis and this can lead to tunnel vision in investigations where investigators could potentially fail to investigate alternative theories of the crime.[109] People are motivated to consolidate their beliefs in a manner that strengthens their initial perspective. Numerous studies have demonstrated that expectations and motivations can affect how events, people and evidence are perceived.[110] For example in studies where subjects were told in advance that a person had particular personality characteristics, they had the ten-

[101] *Id.*

[102] Steve D. Charman & Gary L. Wells, *Can Eyewitnesses Correct for External Influences on Their Lineup Identifications? The Actual/Counterfactual Assessment Paradigm,* 14 J. EXPERIMENTAL PSYCHOL. APPLIED 5 (2008).

[103] Saul M. Kassin & Christina T. Fong,*"I'm Innocent!": Effects of Training on Judgment of Thruth and Deception in the Interrogation Room,* 23 LAW & HUM. BEHAV. 499 (1999).

[104] Saul M. Kassin & Katherine Neumann, *On the Power of Confession Evidence: An Experimental Test of the Fundamental Difference Hypothesis,* 21 LAW & HUM. BEHAV. 469 (1997).

[105] Saul M. Kassin, *Why Confessions Trump Innocence,* 67 AM. PSYCHOL. 431 (2012).

[106] Burke, *supra* note 78.

[107] *Id.*

[108] Findley & Scott, *supra* note 96.

[109] Burke, *supra* note 78.

[110] Jerome S. Bruner & Mary C. Potter, *Interference in Visual Recognition,* 144 SCI. 424 (1964).

dency to see those qualities in that person regardless of whether those characteristics were present or not.[111] In criminal investigations this could have severe effects, especially if an individual is being judged by investigators where the initial belief presented to each actor in the system is that the defendant is guilty.[112]

Research and policy makers have started to realize the significant role the science of psychology plays in the study and prevention of wrongful convictions.[113] It is estimated that over 300 individuals have been exonerated by post-conviction DNA testing.[114] Miscarriages of justice have been identified where there have been a range of causes of error, including fallible eyewitness identification, false confessions, police and prosecutorial misconduct and forensic science error.[115]

Forensic science plays a complex role in the study of wrongful convictions where it has been argued to be both part of the problem but also the solution.[116] For example, DNA evidence has helped to exonerate scores of wrongfully convicted suspects, however in some cases, errors in the DNA evidence were identified. One example of this discussed by Thompson et al. (2009)[117] is the case of Josiah Sutton's (1998) wrongful conviction for rape, where DNA and eyewitness identification was involved in the original case. The analyst testing for DNA in the case was aware that the victim had identified Sutton as one of the rapists. It has been argued that this information may have induced a confirmation bias and led the analyst to focus on evidence supporting Sutton's guilt and ignoring facts inconsistent with that theory.[118] It has been asserted that if forensic scientists are aware of the desired outcome, it is possible that they might unwittingly be influenced to interpret ambiguous data to support a given theory formulated by investigators such as the police and prosecutors.[119] The criminal justice system presumes the independence of different types of evidence but these findings suggest that the reality of criminal investigations may not afford such independence of evidence[120] where in some cases the judgments of forensic scientists could significantly be influenced by psychological factors.[121]

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[111] Mark Snyder & Nancy Cantor, *Testing Hypotheses About Other People: The Use of Historical Knowledge*, 15 J. EXPERIMENTAL SOC. PSYCHOL. 330 (1979).
[112] Findley & Scott, *supra* note 96.
[113] Saul M. Kassin et al., *Police-Induced Confessions, Risk Factors, and Recommendations: Looking Ahead*, 34 LAW & HUM. BEHAV. 49 (2010).
[114] INNOCENCE PROJECT, http://www.innocenceproject.org/ (last visited Nov. 24, 2014).
[115] Brandon L. Garrett, *Judging Innocence*, 108 COLUM. L. REV. 55 (2008).
[116] William C. Thompson, *Beyond Bad Apples: Analyzing the Role of Forensic Science in Wrongful Convictions*, 37 SW. U. L. REV. 971 (2009).
[117] *Id.*
[118] *See* Thompson, *supra* note 116 for more a detailed report regarding the Sutton case and also the Innocence Project's website *available at* http://www.innocenceproject.org/Content/Josiah_Sutton.php. For further information, *see also* SIMON LEVAY, WHEN SCIENCE GOES WRONG: TWELVE TALES FROM THE DARK SIDE OF DISCOVERY 181-98 (2008).
[119] Findley & Scott, *supra* note 96.
[120] Kassin, *supra* note 105.
[121] Kassin et al., *supra* note 1.

VI. Cognitive Bias and Forensic Science

The judgments of forensic scientists being influenced by cognitive factors are very different to the effects in investigators' bias, problems in eyewitness identification, and other elements in criminal cases, as discussed above. The problems in these areas are well known, and jurors (as well as judges) have started to take them into account.[122] However, scientific evidence by experts has a different status. Forensic evidence has predominantly been viewed as immune to bias effects, and regarded as objective and impartial.[123] Myers and Booker[124] (1991) and Dror et al. (2005)[125] highlighted the mental cognitive process behind the opinion of an expert known as elicitation. This consists of four cognitive tasks: defining the question, remembering the accurate information, making a decision and reaching a conclusion. In a forensic context this would be known as "what is classified as evidence, what is recognized as collected evidence, and what is examined and how it is interpreted."[126] The expert must first understand what has been asked of them in order to answer a question. This demands a specific focus on the accurate information, and the limitation of personal speculation.[127] However, when an expert tries to consider the accuracy of information, different cognitive factors (as mentioned previously) will play a vital role, and might cause selective attention towards information causing an observer effect.[128] This essentially means that what is remembered and perceived by the expert depends upon the perceiver themselves.[129]

The power of schemata and other combined cognitive processes will affect each expert individually for what is remembered as accurate data. Forensic context generally involves large amounts of multivariate information, often too complex for one individual to process.[130] The decision-making of an expert is also dependent upon the manner in which problems are structured and presented. The same problem can result in different decisions depending on how the problem is framed and displayed.[131] For example, studies have shown that forensic experts will evaluate evidence differently depending upon whether they are consulting for

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[122] Itiel E. Dror, *Cognitive Neuroscience in Forensic Science: Understanding and Utilising the Human Element*, 370 Philosophical Transactions Royal Soc'y B (2015).
[123] Mnookin et al., *supra* note 31.
[124] Mary A. Meyer & Jane M. Booker, Eliciting and Analyzing Expert Judgment: A Practical Guide 459 (1991).
[125] *See* Dror et al., *supra* note 59.
[126] Craig Cooley & Brent E. Turvey, *Observer Effect and Examiner Bias: Psychological Influences on the Forensic Examiner in* Crime Reconstruction 61 (W. Jerry Chisum & Brent E Turvey eds., 2011).
[127] *See* Meyer & Booker, *supra* note 124.
[128] Bruce Budowle et al., *A Perspective on Errors, Bias, and Interpretation in the Forensic Sciences and Direction for Continuing Advancement*, 54 J. Forensic Sci. 798 (2009).
[129] Simon E. Blackwell & Emily A. Holmes, *Modifying Interpretation and Imagination in Clinical Depression: A Single Case Series Using Cognitive Bias Modification*, 24 Applied Cognitive Psychol. 338 (2010).
[130] Fraser-Mackenzie et al., *supra* note 56.
[131] Phillips et al., *supra* note 100.

the prosecution or defense.[132] Internal and external factors (as discussed in section IV) could affect the decision-making outcome. It has also been demonstrated that the internal factors will vary at different times, which can cause the same expert to diverge in their judgment on the same identical decision.[133]

The end result for a forensic scientist is to reach a scientific conclusion based on the relevant evidence and to communicate the results in a manner that can be understood by non-scientists.[134] There is a growing acceptance by the forensic science community of the value of probability frameworks as a means to offer a comprehensible format for the formulation and presentation of opinions in forensic science, such as the estimation of a likelihood ratio.[135] Uptakes of these standards have varied considerably across disciplines and jurisdictions. For example in the Netherlands, the likelihood ratio is considered as standard practice for bullet comparison and is actively being expanded to other disciplines. However in the United States, likelihood ratio comparison is not common in disciplines other than DNA analysis.[136] The debate about the best way to present the results of complex forensic analysis in court has not included the body of empirical evidence collected by psychologists in the decision-making field and reasoning under uncertainty. Numerous psychological studies suggest that people often have difficulties understanding probabilistic and statistical estimations.[137] Some have therefore suggested that a verbal equivalent to statistical approaches should be applied in order to communicate statistical data. The use of verbal equivalents may present difficulties since the research within psychology indicates that the meaning attributed to a single word can vary for each individual, and from context to context.[138] A study by de Keijser and Elffers (2012)[139] addressed the question of how a decision maker interprets evidence presented in the form of likelihood ratios. To examine how well judges, lawyers and experts in the Netherlands understood evaluative expert opinions expressed, de Keijser and Elffer provided subjects with realistic technical forensic reports using the scale recommended by the Netherlands Forensic Institute. The result indicated that the majority of experts frequently had difficulties interpreting the likelihood ratio and had a very limited insight into the conclusion of the final report.[140]

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[132] Daniel C. Murrie et al., *Are Forensic Experts Biased by the Side That Retained Them?*, 24 PSYCHOL. SCI. 1889 (2013).
[133] Kassin et al., *supra* note 1.
[134] Victoria A. Springer, *Expectancy Effects in Forensic Evidence Handling: Social Psychological Perspectives*, 7 J. INST. JUST. & INT'L STUD. 311 (2007).
[135] Kristy A. Martire et al., *The Expression and Interpretation of Uncertain Forensic Science Evidence: Verbal Equivalence, Evidence Strength, and the Weak Evidence Effect*, 37 LAW & HUM. BEHAV. 197 (2013).
[136] Kassin et al., *supra* note 1.
[137] Gerd Gigerenzer & Adrian Edwards, *Simple Tools for Understanding Risks: From Innumeracy to Insight*, 327 BRIT. MED. J. 741 (2003).
[138]David V. Budescu et al., *Effective Communication of Uncertainty in the IPCC Reports*, 113 CLIMATE CHANGE 181 (2011).
[139] Jan de Keijser & Henk Elffers, *Understanding of Forensic Expert Reports by Judges, Defense Lawyers and Forensic Professionals*, 18 PSYCHOL. CRIME & L. 191 (2012).
[140] *Id.*

Although, it is often helpful to calculate the probability that a particular event occurred by chance when evaluating the significance of scientific data. This approach is feasible where a background database is available such as with DNA profiles. However calculations of this type could be misleading when focused too narrowly on a given outcome[141] with epidemiologists arguing that there is a tendency to assign baseless significance to random data by viewing it post hoc in an unjustifiably narrow context.[142] In DNA analysis, incomplete or partial DNA profiles are often encountered and it can be difficult to interpret such profiles and establish the number and identity of contributors to a mixed sample.[143] Therefore, if a DNA analyst presumes the DNA of a defendant might have produced the observed profile, it could potentially increase the confidence of the analyst that the defendant was a contributor.[144] Moreover analysts might then ignore and/or fail to identify other ways in which the same data might have arisen if the defendant was not a contributor.

The degree and content of the contextual information forensic scientists should know about a case has received minimal attention in the forensic science literature to date. Some commentators have argued that the ignorance of the facts of a case may cause forensic scientists to ask and answer the wrong questions, which could potentially be harmful to an investigation.[145] However, cross communication could potentially affect all stages of the elicitation task involved in a forensic investigation and cause judgment and decision-making to be unreliable from the initial analysis to the court.[146] The four cognitive elicitation tasks (Defining the question, remembering the accurate information, making a decision and reaching a conclusion) are all relevant to the forensic conceptual framework and any expert in the field of forensic science. As a result there has been a rise in interest across the forensic science domains as to which stages cognitive biases may arise during an investigation, with empirical research being conducted within different forensic domains to investigate the effect of cognitive biases.[147]

Studies conducted to assess the cognitive processes and the tendency for bias within human decision-making in the forensic field are being undertaken within a number forensic domains. Research has indicated that human error due to cognitive patterns can influence and cause a reduction in the objectivity of forensic experts when analyzing evidence.[148] Various factors such as extraneous context, time pressure expectation, and motivational statements have been shown to have an influence on observation and decision-making.[149] In the following sub-sections

[141] Thompson, *supra* note 92.
[142] *Id.*
[143] Thompson, *supra* note 116.
[144] Thompson, *supra* note 92.
[145] *See* Thompson, *supra* note 14.
[146] *Id.*
[147] Kassin et al., *supra* note 1.
[148] William C. Thompson & Simon. A Cole, *Psychological Aspects of Forensic Identification Evidence in* EXPERT PSYCHOLOGICAL TESTIMONY FOR THE COURTS 31 (Mark Costanzo, Daniel A. Krauss & Kathy Pezdek eds., 2007).
[149] Dror & Fraser-Mackenzie, *supra* note 51.

examples of empirical research undertaken within the domain of cognitive bias and forensic science, are presented.

A. FINGERPRINT COMPARISON

Within the fingerprint domain, studies have indicated that experts were more likely to be biased when they were subjected to different types of contextual information.[150] In many of these experiments, the majority of experts reached different conclusions and were inconsistent in their analysis when provided with new contextual information and whilst undertaking new visual imaging.[151] These findings were most pronounced when the participating expert forensic examiners did not know they were taking part in a study, and were confident that they were undertaking casework, and most importantly, believing the contextual information.[152]

It is furthermore important to recognize that cognitive biases can also affect technologies and the systems used by forensic examiners. This has been demonstrated in the AFIS system database used for fingerprint identification where the fingerprint examiners were affected by the position of the matching print in the 'line up.' This was established by demonstrating the degree of false exclusion and inconclusive identifications across a series of mark evaluations.[153]

B. DNA

Research into judgment and decision-making has also been applied in the DNA domain. Studies by Dror and Hampikian (2011)[154] on DNA analysis were conducted using a mixed DNA sample from a adjudicated criminal case involving a gang rape where DNA experts had analyzed the complex DNA mixtures and concluded that the evidence implicated the suspects that were identified in the plea-bargain by a cooperative assailant. The DNA experts concluded in their pretrial conclusion that the suspects could not be excluded from being providers to the mixture DNA sample. Dror and Hampikian (2011) presented the same DNA mixture to 17 neutral North American expert DNA examiners with no contextual information or case background provided. Only 1 expert agreed with the original examination. Four of the DNA experts stated the sample to be inconclusive and 12 excluded the suspect in question.[155]

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[150] Itiel E. Dror et al., *Contextual Information Renders Experts Vulnerable to Making Erroneous Identifications*, 156 FORENSIC SCI. INT'L 74 (2006).
[151] Dror & Charlton, *supra* note 71.
[152] Dror et al., *supra* note 59.
[153] Itiel E. Dror et al., *The Impact of Human-Technology Cooperation and Distributed Cognition in Forensic Science: Biasing Effects of AFIS Contextual Information on Human Experts*, 57 J. FORENSIC SCI. 343 (2012).
[154] Itiel E. Dror & Greg Hampikian, *Subjective and Bias in Forensic DNA Mixture Interpretation*, 51 SCI. JUST. 204 (2011).
[155] For detailed information with regards to the study *see* Itiel E. Dror & Greg Hampikian, *Subjectivity and Bias in Forensic DNA Mixture Interpretation*, 51 SCI. JUST. 204 (2011).

C. FORENSIC ANTHROPOLOGY

In forensic anthropology, empirical studies within cognitive bias demonstrated confirmation bias within the assessment of sex, ancestry and age at death when conducting a biological profile.[156] The study examined the non-metric biological profile interpretations of forty-one non-novice participants within the field of physical anthropology who all assessed the same remains. Each participant was semi-randomly assigned into one of three groups, where two of the groups were given extraneous contextual information before conducting the analysis, with a third group acting as a control with no context provided. The result of the study demonstrated that the decision-making outcome of the participants, based on visual assessments, was vulnerable to extraneous contextual information.[157]

The effects of external manipulations that involve observer expectations have also been studied for the visual assessments of trauma analysis on skeletal remains.[158] The result of this pilot study indicated that the evaluation of trauma identifications were higher amongst participants assessing trauma images in a high trauma context, compared to participants evaluating the same pictures in a setting with low trauma expectations.

D. BULLET COMPARISON

Research has also demonstrated that diverse manipulations of context may affect people differently and it is often within ambiguous cases where the levels of cognitive bias will have the most affect on the outcome.[159] Kerstholt et al. (2010)[160] presented a study on bullet analysis with the intention to observe whether additional incriminating contextual information would affect the expert when observing similarities between two bullets. The results, however, indicated that the contextual information given in the case had no effect on the conclusion. It is therefore important to acknowledge that bias may affect the process but not necessarily the decision-making outcome of the forensic examiner.[161]

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[156] Sherry Nakhaeizadeh et al., *Cognitive Bias in Forensic Anthropology: Visual Assessment of Skeletal Remains is Susceptible to Confirmation Bias*, 54 SCI. JUST. 208 (2014).
[157] *Id.*
[158] Sherry Nakhaeizadeh et al., *The Power of Contextual Effects in Forensic Anthropology: A Study of Biasability in the Visual Interpretations of Trauma Analysis on Skeletal Remains*, 59 J. FORENSIC SCI. 1177 (2014).
[159] William C. Thompson & Simon Ford, *The Meaning of a Match: Sources of Ambiguity in the Interpretation of DNA Prints in* FORENSIC DNA TECHNOLOGY (Mark A. Farley & James J. Harrington eds., 1991).
[160] Jose Kerstholt et al., *Does Suggestive Information Cause a Confirmation Bias in Bullet Comparisons?*, 198 FORENSIC SCI. INT'L 138 (2010).
[161] Beatrice Schiffer & Christophe Champod, *The Potential (Negative) Influence of Observational Biases at the Analysis Stage of Fingermark Individualisation*, 167 FORENSIC SCI. INT'L 116 (2007).

E. OTHER FORENSIC DOMAINS

Within fire scene examinations, the Arson Research Project conducted studies to assess the role of expectation and contextual information involved in fire scene investigations.[162] The research acknowledged that unreliable and domain irrelevant information could cause a biased interpretation when conducting fire scene examinations.[163] Similar studies have been conducted within forensic odontology where various types of contextual effects and biasing influences could impact upon the analysis of bite-marks.[164] This finding has also been acknowledged in other domains such as forensic handwriting and document examinations[165] and bloodstain analysis.[166]

Although confirmation bias normally operates outside of conscious awareness, forensic examiners may have some insight into the cognitive motivational and emotional factors that may affect the decision-making processes. Charlton et al. (2010)[167] conducted a series of semi -structured interviews of fingerprint examiners where the examiners expressed a personal interest in solving crime and catching the offenders. The study indicated that cognitive motivational factors might influence the performance of a forensic expert. Training and experience could also have an effect upon expert decision-making, and the individual differences will characterize the degree to which a particular context will affect an expert.[168]

F. COGNITIVE BIAS AND REAL CASES

The issue of bias and cognitive vulnerability has also been demonstrated to be some of the sources of error in high profile forensic cases such as those of Shirley McKie in Scotland,[169] Brandon Mayfield in the US,[170] and Amanda Knox in Italy.[171] Commentators on these cases have asserted that it is important to acknowledge the numerous pitfalls that can occur within decision-making when

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[162] Paul Bieber, *Measuring the Impact of Cognitive Bias in Fire Investigation*, SCI. TECH. 3 (2012).
[163] *Id.*
[164] Mark Page et al., *Context Effects and Observer Bias--Implications for Forensic Odontology*, 57 J. FORENSIC SCI. 108 (2012).
[165] Bryan Found & John Ganas, *The Management of Domain Irrelevant Context Information in Forensic Handwriting Examination Casework*, 53 SCI. JUST. 154 (2013).
[166] TERRY LABER ET AL., RELIABILITY ASSESSMENT OF CURRENT METHODS IN BLOODSTAIN PATTERN ANALYSIS (2014) *available at* https://www.ncjrs.gov/pdffiles1/nij/grants/247180.pdf.
[167] David Charlton et al., *Emotional Experiences and Motivating Factors Associated with Fingerprint Analysis*, 55 J. FORENSIC SCI. 385 (2010).
[168] Schiffer & Champod, *supra* note 161.
[169] In January 1997 four Scottish fingerprint examiners claimed they found junior officer Shirley McKie's thumbprint on the bathroom doorframe of the home of murder victim Marion Ross. McKie claimed she had never been into the house but was arrested and charged for perjury. In 1999 vindication for Shirley McKie came when two American. fingerprint experts determined that the print was not hers. *See* Dror & Cole, *supra* note 9 for further information.
[170] Robert M. Stacy, *Report on the Erroneous Fingerprint Individualization in the Madrid Train Bombing Case*, 56 J. FORENSIC IDENTIFICATION 706 (2006).
[171] Kassin, *supra* note 105.

justice agencies arguably work too close together, and where tunnel vision, social conformity, group thinking and context biases can have significant influences resulting in a chain of biased interpretations.[172] In the Shirley McKie case, the Scottish government specifically set up the Fingerprint Inquiry (under the Inquiries Act 2005) to address the steps, which were taken to identify the fingerprint associated with McKie, which led to the case of *HM Advocate v. McKie 1999*.[173] The goal of the inquiry was to report on findings of fact and determine the consequences of steps taken in this case as well as provide recommendations for the future. The inquiry report was published in December, 2011 with one of the findings articulated in the report concerning the decision-making processes in fingerprint analysis and the manner of presenting analysis conclusions.

VII. Addressing Cognitive Bias in Forensic Science

There is still a lack of practical solutions to address such bias being applied within both the forensic sciences and criminal investigative procedures. Indeed where such solutions are implemented there is considerable variation between each discipline, jurisdiction and country. Even though there is a growing acceptance of the role of cognitive biases and its implications in forensic science and criminal investigations, in practice, procedural changes do not seem to have been structurally implemented.[174] One of the potential reasons for this could be the misinterpretation of cognitive biases being an ethical issue. Cognitive biases occur without awareness or intention and are the predictable result of the human cognitive and psychological systems, rather than intentional misconduct. It has been demonstrated that cognitive biases cannot be conquered by will- power, as it is not possible to be fully appreciative of the extent to which people are affected by cognitive errors.[175] Although education in human cognition could potentially improve the decision-making of an expert, it is not possible for education alone to minimize and reduce cognitive biasing effects.[176] A number of different approaches have been identified as means of addressing cognitive bias in the forensic sciences as outlined in the following section.

A. Addressing Cognitive Bias in the Legal System

Within the legal system one of the proposed solutions for prosecutors is to incorporate the practice of providing pro-defense counterarguments to the prosecutorial interpretation of the evidence against the defendant.[177] Generating explanatory counterarguments can mitigate belief perseverance by simply switching between prosecution and defense mind-sets to produce plausible explanations of

[172] Dror & Cole, *supra* note 9.
[173] *See* Fingerprint Inquiry, *supra* note 7.
[174] Reinoud D. Stoel et al., *Bias Among Forensic Document Examiners: Still a Need for Procedural Changes*, 46 Austl. J. Forensic Sci. 91 (2014).
[175] Thompson, *supra* note 116.
[176] Kassin et al., *supra* note 1.
[177] Findley & Scott, *supra* note 96.

both guilt and innocence for each piece of evidence.[178] Other solutions within law enforcement (other than educating judges, prosecutors and defense lawyers about cognitive biases) have been to include additional unbiased decision-makers in the process by providing 'fresh look reviews.'[179] In addition, solutions have also been proposed regarding legal decision makers being educated with regard to the procedure by which the forensic examiner reaches their conclusion.[180] This is an important step given that the decision-making processes during evidence collection, analysis and interpretation are likely to be strongly related to how evidence is presented and evaluated in court.

Cross talk and information change between different units of the justice system occurs routinely in forensic investigations. However, too much communication of irrelevant information at the earliest stages of a crime scene investigation has been argued to potentially lead to system failure.[181] The National Academy of Sciences in the United States has reported that crime laboratories should not fall under the umbrella of law enforcement, which is the case in some other countries and jurisdictions.[182] For example, Washington, D.C. formally separated its laboratories from the police and instead established the District of Columbia Consolidated Forensic Laboratories. The consequence of law enforcement agencies collaborating too closely with each other creates the risk of cognitive biases altering the judgment and interpretations of an expert at the initial stage of a forensic investigation. For example, if analysts are exposed to contextual facts regarding the crime there is the potential for the effective 'double counting' of evidence. This may occur if the analyst is influenced by the evidence of a confession in the determination of uncertainty regarding a possible match of a fingerprint which could lead the jury to think they are receiving two independent pieces of evidence (confession and fingerprint evidence), as they are unlikely to know that the result of the print analysis was affected by the evidence of a confession.[183]

B. Case Manager Model

Some of the proposed solutions regarding the minimization of cognitive influences and prevention of double counting of evidence in forensic science have been to separate various laboratory functions by assigning them to different people.[184] One suggestion is to apply a case manager model. The role of the case manager typically includes communications with police officers, participation in the decisions of what specimens to collect at a crime scene and what tests to run. Case managers will therefore be responsible for placing the test results in context and assessing the importance of forensic observations with various theories of

[178] Burke, *supra* note 78.
[179] *Id.*
[180] Kassin et al., *supra* note 1.
[181] Thompson, *supra* note 92.
[182] Stoel et al., *supra* note 174.
[183] Thompson, *supra* note 14.
[184] *Id.*

what occurred.[185] Such an approach allows case managers to understand the context of a case and analysts to be blind to domain irrelevant context and thereby protected from contextual bias. Similar solutions have been proposed by Saks et al. (2003),[186] who proposed the creation of evidence and quality control officers (EQC), who could act as highly trained individuals within exhibit management units. Their main responsibilities would be to filter out domain irrelevant information, formulate the questions to be answered in the least suggestive way, and coordinate the submission of the evidence to the appropriate section.[187]

It is crucial for the 'success' of any forensic analysis, interpretation and presentation that the collection of evidence is carried out accurately and appropriately.[188] By adopting these models, crime scene collections, sampling procedures, and analysis have the potential to be shielded from cognitive factors to a greater degree. This will strategically separate (to the best of our abilities) judgments and evaluations from being contaminated by cognitive biases at the earliest stage of an investigation. In addition, it will also allow forensic scientists to extract contextual knowledge that is of relevance. It is asserted that a blind procedure will only eliminate domain irrelevant information, allowing forensic scientists to deal in an effective way with the complexity and uncertainties involved at a crime scene.[189]

C. *Addessing Cognitive Bias in the Laboratory*

It is understood that in forensic laboratories, the decisions, interpretation and verification stages could also be affected by human factors. In DNA analysis, sequential unmasking has been suggested as a hybrid approach to minimize the potential for contextual bias where a known DNA profile might affect the interpretation of an evidence sample.[190] It has been suggested that this approach addresses the issue by offering the means of analysts making an initial examination of samples prior to learning the profiles of suspects or known contributors.[191] However, the verification stage also needs to be considered when combating cognitive biases. In many forensic laboratories verification stages are mainly performed on positive identifications, potentially causing base rate regularities.[192] Very often the second examiner verifies the first examiners work knowing the decision-making outcome. One proposed solution includes blind verifications,

[185] Itiel E. Dror, *Practical Solutions to Cognitive and Human Factor Challenges in Forensic Science*, 4 Forensic Sci. Pol'y & Mgmt. 105 (2013).
[186] Michael J. Saks et al., *Context Effects in Forensic Science: A Review and Application of the Science of Science to Crime Laboratory Practice in the United States.*, 43 Sci. Just. 77 (2003).
[187] *Id.*
[188] Morgan & Bull, *supra* note 19.
[189] Dror, *supra* note 185.
[190] Dan E. Krane et al., *Sequential Unmasking: A Means of Minimizing Observer Effects in Forensic DNA Interpretation*, 53 J. Forensic Sci. 1006 (2008).
[191] Thompson, *supra* note 116.
[192] Dror, *supra* note 185.

whereby the verifier does not know the conclusion of the first examiner, and is unaware of what decisions they are verifying.[193]

Another potential solution suggested to enhance accurate judgments and decision-making in forensic science techniques using match judgments[194] (such as DNA analysis and fingerprint examination) is the filler control method.[195] This approach provides forensic examiners with a minimum of three samples rather than two for comparison, including a crime scene sample, suspect sample and filler(s) samples. It is suggested that this method will enable the forensic examiner to know which sample is from the suspect and which are from the fillers,[196] thereby protecting examiners from contextual influences in the estimation of error rates for the techniques used as well as the individual analysis.[197]

It is also important to acknowledge that not all laboratories have the resources or time to apply all these procedures. Therefore, solutions have been proposed in the form of adopting a triage approach where each laboratory assesses the case in question and assigns resources where they are needed.[198] The degree of vulnerability to cognitive bias is dependent upon the complexity of the case (i.e., how difficult it is, how near it is to the decision threshold) as well as to the level of exposure to biasing information; each laboratory can use the triage approach to classify cases into different procedures (such as the level of blind verification) according to their vulnerabilities to bias.

D. OTHER SOLUTIONS

Discovering the different predictors of errors causing interpretation issues within each forensic domain is also an important factor. For example in the fingerprint domain, quantitative image measures for estimating error rates have been applied to discover objective predictors of error.[199] Within the fingerprint domain estimating an overall error rate can be challenging, though some fingerprint comparisons may be more accurate compared to others that are historically more prone to bias interpretations. The study by Kellman et al. (2014) indicated that the distribution of error rates varies depending on the visual content of the specific comparison. It highlighted how the difficulties of assessing fingerprints might impact on how judges and juries understand the admissibility of a specific fingerprint comparison[200] and outlined the underlying factors that make some

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[193] *Id.*

[194] In match judgments forensic experts judge whether two complex patterns are adequately similar, to determine if both derived from the same source. *See* Dror & Cole, *supra* note 9 for further information.

[195] Gary L. Wells et al., *Forensic Science Testing: The Forensic Filler-Control Method for Controlling Contextual Bias, Estimating Error Rates, and Calibrating Analysts' Reports*, 2 J. APPLIED RES. MEMORY & COGNITION 53 (2013).

[196] *Id.*

[197] Saks et al., *supra* note 186.

[198] Dror, *supra* note 185.

[199] Philip J. Kellman et al., *Forensic Comparison and Matching of Fingerprints: Using Quantitative Image Measures for Estimating Error Rates through Understanding and Predicting Difficulty*, 9 PUB. LIBR. SCI. 1 (2014).

[200] *Id.*

fingerprints more difficult to compare has a strong impact upon the training of fingerprint experts and the selection of examiners.[201] The study advocates that forensic examiners need to have the cognitive ability to perform the task given to them and that developing tests that specifically focus and quantify these abilities are needed in any forensic domain in order to better allocate the manpower to the right job.[202]

Technological solutions to address cognitive biases could potentially be very useful. A good number of recent studies in forensic science are now based on new metric methods where statistics, algorithms and technology are applied. The increase of forensic technology has greatly improved forensic work. However it is important to acknowledge the new spectrum of cognitive challenges these technologies might provide. For example as mentioned earlier, the use of the AFIS system could potentially create base rate regularities amongst expert's expectations.[203] Huge searches on databases could also create a higher chance to find incidental similarities when comparing if a mark from a crime scene comes from the same source as known marks.[204] Therefore, forensic scientists must consider such implications in the use and establishment of technological solutions. Understanding the function of cognitive errors, in any methodology including technical ones, will allow forensic scientists to design and modify methods of the highest accuracy.

Considering how science and law continue to interrelate and that the issue of scientific standards within the forensic disciplines is rising, the forensic science community must be committed to not only continuing to address the issue of cognitive biases but also to ensuring the most effective implementation of valid solutions. Although laboratories such as the FBI and NIST have modified their standards and procedures to minimize biasing effects, few laboratories and forensic domains have followed to date.

VIII. Future Directions

The research within the field of decision-making has highlighted the dynamic and active nature of human information processing and how it can lead to the distortion of incoming data, resulting in biased conclusions. It has shifted its focus to not only concern human judgments in the social and psychological domains, but has also emerged within law enforcement agencies and forensic disciplines. The context sensitive nature of each forensic case means that human interpretations are highly important, valuable and necessary. Humans are still needed to interpret results of highly sensitive and accurate analytical techniques, and to classify and identify evidence within the forensic science process. This creates a complexity and controversy regarding how to best deal with human factors that could cause interpretation issues. Thus, it is important for the forensic science community to not underestimate and minimize the importance of these issues as they have been demonstrated not only to affect expert interpretations

[201] *Id.*
[202] Dror, *supra* note 185.
[203] Dror et al., *supra* note 59.
[204] Mnookin et al., *supra* note 31.

across numerous forensic disciplines, but to also affect the human role at the different stages of the forensic science process. Recognizing the role cognition plays in the collection, analysis, interpretation and presentation of evidence will enable the forensic science community to address the concerns raised by reports such as the National Academy of Sciences report (2009) in theUnited States and the Law Commission (2011) in the United Kingdom.

The debates regarding the admissibility of expert opinion in court that has also been highlighted by the National Academy of Sciences (2009), Forensic Regulator in the UK and by the Law Commission for England and Wales (2011) has helped to clarify the need for research within cognitive biases in forensic science. The presentation of erroneous information has been shown to not only bias judgments of those assessing the evidence in a specific case, but also to change the way in which evidence is presented during a trial. This has been recognized in high profile cases, such as those mentioned earlier, to have a major impact upon the final verdict.

Another issue is that the parameters regarding what is considered best practice varies amongst forensic disciplines, where the handling of evidence at crime scenes and within laboratories diverges noticeably between countries and jurisdictions. In order to establish good procedures for minimizing cognitive bias it will be important to offer approaches that can be sufficiently generalizable for different investigations and sample examination, but that are also sufficiently context sensitive to each case and each sample within it. It is widely recognized that every crime scene is different and it is therefore important to incorporate context sensitivity when looking to establish universal protocols for each discipline. However, it is still important for each forensic discipline to identify measures that minimize cognitive issues at every stage of the forensic science process pertinent to that discipline. The main challenge for every forensic domain is to find an appropriate balance of which solutions to implement[205] and under which circumstances in addition to identifying the risks and benefits associated with each approach. [206]

It is, therefore, important for the role of cognitive forensics, the understanding of the central role of cognition in forensic science, to be addressed in every forensic science domain. Cognitive forensic science goes beyond the issues of confirmation bias and context bias and deals with all forms of judgments and decision-making involved in forensic disciplines.[207] This is essential in order to understand how human examiners reach conclusions and how research in cognition could enhance forensic science procedures and practices. In addition, it will inform and help to identify which solutions to apply in different disciplines and scenarios as well as guiding the allocation of the right people for the right task.[208] Therefore continuation of empirical research within cognitive forensics will be at

[205] Dror, *supra* note 185.
[206] Christophe Champod, *Research Focused Mainly on Bias Will Paralyse Forensic Science,* 54 SCI. JUST. 107 (2014).
[207] Stoel et al., *supra* note 174.
[208] Dror, *supra* note 185.

the very least, important, if not essential, to further improving the value, weight and admissibility of forensic evidence.

The forensic science community, and in turn the law enforcement agencies, have come far in the development of highlighting cognitive bias issues. More empirical studies addressing cognitive bias are being conducted across many of the forensic science domains to establish the extent to which cognitive issues impinge on forensic investigations and analysis.[209] By furthering the understanding of cognitive issues within specifically forensic frameworks, the evidence base for developing viable solutions to cognitive bias in practice can be further developed. In order to continue the contribution of forensic science to the realization of the true scientific value of forensic evidence, it is imperative to continue to develop our understanding of cognitive bias and the measures to minimize its impact in the forensic sciences.

[209] Found, *supra* note 12.