**Diploma in Forensic Medical Sciences**

# The Limits On Expert Forensic Evidence in Investigating and Prosecuting/Defending Crime

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## Abstract

There are a number of factors that limit expert forensic evidence in the investigation and prosecution or defence of crime: cognitive bias, problems with reliability and validity of forensic science, admissibility and the changing relationship between science and the law. Recent literature and reports have highlighted these issues, such as those of the US National Research Council in 2009, The Fingerprinting Inquiry in Scotland in 2011, The UK Forensic Science Regulator in 2015 and President's Council of Advisors on Science and Technology in 2016. This dissertation assesses each of these issues in turn, explaining how they act as limits on expert forensic evidence within the criminal justice system, and then outlines the remedies proposed in the literature to these issues. A number of these could be applied as reforms and solutions within both forensic science and the criminal justice system to ameliorate the existing limitations of expert forensic evidence: rigorous national and international standards, new institutions dedicated to maintenance of standards, internal and external peer review, regular audit and competency review, increased peer-reviewed research, education regarding bias, use of linear sequential unmasking and blinding of analysts, strict adherence to admissibility criteria and the development of institutions dedicated to dealing with the growing divide between science and the law. Ultimately, expert forensic evidence must always be corroborated with other forms of evidence and courts should strive to avoid convicting anyone on the basis of single pieces of evidence.

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## List of abbreviations

| | |
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| NAS | National Academy of Sciences |
| NIST | National Institute of Standards and Technology |
| DNA | Deoxyribonucleic Acid |
| UK | United Kingdom |
| PCAST | President's Council of Advisors on Science and Technology |
| USA | United States of America |
| FRE | Federal Rules of Evidence |
| EPA | Environmental Protection Agency |
| CJS | Criminal Justice System |
| CSAFE | Center for Statistics and Applications in Forensic Evidence |
| ISO | International Organization for Standardization |
| NHS | National Health Service |
| CCTV | Closed Circuit Television |
| AI | Artificial Intelligence |

## 1. Introduction

Expert forensic evidence is evidence that is used in order to provide the court with information that is likely to be outside the experience or knowledge of the finders of fact, be they the judge or the jury[1]. It includes a multiplicity of disciplines such as forensic pathology and forensic science which analyse physical evidence obtained from the scene or victim of crime using scientific methods and techniques in order to produce information for use by the court, often in the form of a report or testimony[2]. The expert witness therefore differs from an ordinary witness in that he or she gives evidence of scientific fact and provides opinions based on professional knowledge and experience[3]. Expert evidence plays an extremely important role in court proceedings, is often indisputable and crucial in the administration of justice and is a powerful instrument called upon by members of the legal profession in order to help convict the guilty and acquit the innocent[2,4,5].

However, the use of expert forensic evidence in the CJS is not without its limitations and the flaws in forensic science have become increasingly apparent within recent years[4]. Despite being absolutely essential in many convictions, exonerations and the dispensation of justice, forensic science is simultaneously the 2nd most common contributing factor to wrongful convictions[5]. As a result, not only has the validity and reliability of forensic science evidence been called into question, but its entire scientific basis.

Over the last decade, criticism throughout legal and scientific academia, inquiries and reports such as the Strengthening Forensic Science in the United States report by NAS in 2009 and the Latent Print Examination and Human Factors report by NIST, and revelatory DNA exoneration cases have uncovered the limited research base behind many commonly used forensic techniques, as well as a lack of meaningful standards and problems with the way in which expert evidence is expressed in reports and court testimony[6]. These investigations have revealed that much of what passes for forensic science does not actually meet the minimum scientific standards required in other fields[7], with NAS declaring that “with the exception of nuclear DNA analysis (…) no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source”[8].

In addition, the huge impact of cognitive bias in forensic decision-making has been extensively highlighted. Concerns have been published by a number of reports and regulatory bodies: the US National Research Council in 2009, The Fingerprinting Inquiry in Scotland in 2011, The UK Forensic Science Regulator in 2015 and PCAST in 2016 to name a few[9-12]. Courts and juries often assume that expert witnesses provide impartial and objective evidence, however forensic experts make interpretations from data or observations and are therefore liable to human and cognitive factors. Indeed, cognitive science has shown that even the most committed experts are influenced by factors unrelated to the data in forming their conclusions, and that expert forensic evidence can often be muddied by bias[13]. This clearly represents a significant limit on the use of expert forensic evidence in the investigation and prosecution of crime.

Forensic error has been shown to act as a limit on expert forensic evidence, contributing to over 50% of wrongful conviction cases in the USA later quashed by DNA testing[14]. This has included invalid expert testimony, with the precision and accuracy of many forensic techniques and disciplines being overstated by expert witnesses, and contributing to the miscarriage of justice[14]. As such, expert forensic evidence should only be viewed as one tool of the legal armamentarium to be used in proving a case. There is now a well-recognised danger in relying too much on expert reports and testimony in criminal cases, with a number of wrongful convictions occurring as a result of relying on expert forensic evidence alone[1], with some individuals being convicted based on just a single piece of flawed forensic evidence[2].

In the USA alone, there are 670 cases in The National Registry of Exonerations which involved false or misleading forensic evidence[15]. Out of the 375 DNA exonerations in the USA to date since 1989, a staggering total of 5284 years have been served for wrongful convictions, of which 43% involved the misapplication of forensic science evidence[16]. At least 45% of 194 of the exonerees had expert forensic testimony at their trials that was either invalid, incorrect or biased[17]. 165 of the 375 crimes had their actual perpetrators identified, who had gone on to be convicted of 154 additional violent crimes whilst those wrongfully convicted had been serving prison sentences for their earlier offences[16]. Wrongful convictions are damaging not only to the individual but to society, with lasting psychological, emotional and economic harm[18]. They also devastate family relationships, destroy liberty and reduce public trust in the CJS: often these wrongs cannot be retrospectively corrected[18].

Alongside these significant limitations of forensic science evidence, the divide between science and the law is becoming increasingly apparent, with science outpacing the very legislation that is supposed to govern it[19]. New scientific methods and technologies already in use within the CJS are developing faster than scrutiny and regulation can keep up, therefore representing a growing challenge to courts that is becoming exponentially more difficult to resolve[20]. Simultaneously, some novel forensic techniques could remain unutilised despite possessing profoundly beneficial potential uses in the investigation of crime[21]. In addition, the existing legal and judicial guards against faulty forensic evidence, such as determinations as to its admissibility, are insufficient[6].

Overall it is clear that the scope of the limits on expert forensic evidence are immense and manifold. The importance of confronting these issues cannot be overstressed. These limitations have already led to severe, historical, damaging societal consequences and both forensic science and the CJS are likely to have to undergo unprecedented reform if these problems are to be abrogated. This dissertation therefore aims to elucidate and interrogate the most significant factors limiting expert forensic evidence in investigating and prosecuting or defending crime and it addresses possible solutions to ameliorate them. To achieve this, the latest forensic and legal literature has been examined and the following topics are critically assessed: cognitive bias and its effects in forensic science, the reliability and validity of forensic science evidence and its scientific foundations, the admissibility of expert forensic evidence and whether the law is adequate to keep pace with science and its constant evolution. In addition, recent developments in forensics that attempt to tackle its limitations, as well as possible novel solutions, have been evaluated.

## 2. Main Text

### 2.1 Cognitive Bias and its Effects on Forensic Science Evidence

History has shown that forensic science evidence is an indispensable tool in the investigation and prosecution of crime and defence or exoneration of the accused[4]. However, the CJS has too often treated the data and techniques used within forensic science as existing in isolation, without adequately acknowledging the means by which experts evaluate evidence in order to come to conclusions for use in court[4]. These experts are fallible human beings and are required to make interpretations: they are therefore liable to being influenced by human and cognitive factors, namely cognitive bias[4]. Bias is any systematic error in reasoning that alters one's perception and judgement[22]. Human brains use context, expectation and other factors in order to help process information. These, usually very necessary, cognitive mechanisms can have the side effect of increasing susceptibility to bias. They can cause experts to focus on certain elements of a case with past experience guiding interpretation. This can ultimately lead to experts missing, ignoring, fixating on, or escalating certain issues, leading to biased observations and erroneous conclusions[13].

Biasing mechanisms operate subconsciously and the biased expert is almost always unaware of their bias. Indeed, many professionals have responded to the revelations of bias in forensics with the assertion that they know about the dangers and are therefore unaffected by them[6]. Nevertheless, evidence has shown that no individual is immune to these phenomena: medical professionals, forensic scientists, military personnel and police officers are all at the mercy of cognitive bias[13]. Knowledge, character and good intentions do not enable an individual to overcome the damaging effects of unconscious bias[6]. This is a vital observation as expert testimony carries significant weight in the courtroom as it appears to be objective, impartial and scientific and thus often has an influential effect on the determinations of the jury. In reality, however, the forensic examiner, and indeed any domain in which a human is the analyst, is subject to influences that bias decision making[13].

The forensic experts tasked with making conclusions based on the assessment of physical evidence associated with crime are often exposed to irrelevant contextual information about said crime due to the way in which they work with, and discuss their work with, the police and prosecution[4]. This information, such as details about the suspect, the victim or the alleged crime, which has no bearing on their interpretation of the evidence and resulting inferences, leads to contextual bias. It distorts the perceptions of experts, despite the fact that their decision-making is supposed to be objective and solely based on the evidence[13]. Indeed, studies have shown that experts' conclusions are influenced by whether they have been told facts such as whether a suspect confessed or whether they have an alibi[13]. This can subconsciously colour the experts' analyses of the evidence, and cause incorrect, invalid or overstated conclusions rather than objective judgements[4]. For example, research has shown that individuals judge similarity between facial composites and images of "suspects" as far higher when they already believe the suspect to be guilty, and that when identical fingerprinting evidence is shown to the same examiner but within differing irrelevant contexts, the examiner reaches different conclusions: not in any way a purely objective scientific judgement[13].

Contextual influence is the most prominent type of bias described in the forensic and cognitive science literature however expert forensic evidence is also vulnerable to other biases that limit its use[22]. It is well-known that forensic practitioners are recruited by specific parties such as the police. This can lead to the experts favouring the party retaining them and discrediting or disregarding opposing views in what is known as adversarial bias[22]. Equally, the party themselves tends to select experts whose professional opinions support their case, or those experts with which they have previously had successful professional

relationships: this is a form of selection bias[22]. Furthermore, the experts are paid by the team that seeks their services, and may want to be employed again in future, thus they may make interpretations and conclusions which support their associated party: a type of association bias[22]. This has been shown to occur even when experts are not specifically selected, for example forensic psychologists were found to come to determinations that favoured the desired outcome for their party even when randomly appointed[22]. These issues are further compounded by the fact that experts may have a bias blind spot: professionals may view themselves favourably and over-estimate their objectivity, leading to denial about the existence of bias and an unwillingness to take steps to reduce it[22]. This was exemplified by Pronin et al. who showed that many examiners acknowledged bias in other domains but not their own, and in other examiners but not themselves[23].

Fundamental attribution error is a type of bias which refers to the tendency of an individual to attribute another's actions to their character or personality, whilst attributing their own behaviour to situational factors rather than their disposition[22]. For example, forensic experts may take the view that their courtroom adversaries are stubborn and incompetent rather than identifying the differences in their methodology or interpretation which result in disparate conclusions[22]. This bias fuels an inability for opposing sides to work together in a scientific manner to determine the truth, which is one of the primary duties of the expert witness. Finally, forensic experts are human beings and therefore have views, preferences and beliefs which may colour their analyses. This may lead to confirmation bias, whereby an expert will tend to search for evidence that supports their desired outcome or that confirms their predetermined belief[22]. For example, Elaad recently showed that police investigators were more confident about an individual's guilt than laypeople were, despite the provision of both incriminating and exonerating information, as the nature of their profession dictates that their goal is to identify guilty suspects[24]. Furthermore, cases of wrongful convictions with false confessions have a significantly higher frequency of forensic science errors, emphasising the presence of confirmation and contextual bias[18].

It is clear that expert forensic evidence, specifically forensic science evidence, is at risk of falling prey to bias and, despite often being subconscious phenomena, can lead to the misuse and abuse of science in court. Not only do many types of bias act as a limit on the utility of expert evidence, but cognitive science has also revealed that bias cascades can occur: bias in one facet of a criminal investigation can then colour and "contaminate" other aspects of that investigation with bias, leading to a ubiquity of biased, incorrect or invalid conclusions compromising the case. For example, if a forensic odontologist also knew that the DNA in a case matched a suspect, they are more likely to find a dental match[13]. Furthermore, cognitive bias has a tendency to "snowball": increasing in size, strength and velocity as different components of an investigation influence one another until possibly the entire venture is tainted[4]. The ramifications of this are obvious and extremely concerning: distortion of the truth in court before the finders of fact, and consequent incorrect determinations about guilt or innocence, with miscarriages of justice and guilty perpetrators remaining free to re-offend.

## 2.2 Reliability, Validity and Error in Expert Forensic Evidence

The last two decades have seen numerous reports from government-appointed bodies and independent institutions that have highlighted serious concerns about the scientific foundations of forensic science, such as those published by NAS and PCAST[8,9,12]. This has prompted further interrogation of the discipline by academia and regulators alike, and has uncovered a myriad of issues which threaten the very definition of forensic science as a science: an insufficient research base, lack of meaningful standards, unknown error rates for techniques, invalid testimony, lack of quality assurance and oversight, and a lack of analytical measurements and statistical support for conclusions[5,6,14,18]. Indeed, forensic science is regarded by a large portion of the literature as one of the main correlates of wrongful conviction as a result of its failure to meet minimum scientific standards[18]. These flaws have contributed to many miscarriages of justice and some previously ubiquitously-used forensic techniques such as bite mark and handwriting analysis have been wholly discredited and almost completely abandoned by the CJS[5]. The lack of "science" within forensic science therefore clearly limits its utility in the investigation and prosecution of crime.

A profound poverty of empirical research plagues the discipline of forensic science. Forensic techniques often haven't been sufficiently evaluated by research leading to problems with the expression of results in reports for court[6]. These techniques, to meet the requirements to actually be scientific, should be validated by studies which show that the technique does what it is designed to do, what its limitations are, what standards and protocols should be adhered to when using the technique, and how results from using the technique should be expressed, including error rates[6]. However, as the 2009 NAS report delineated, many forensic disciplines are supported by little or no systematic research to validate their foundational principles and methods[9,10]. Disciplines, even some previously thought to be rigorously scientific, were revealed to lack these foundations. These included ballistics, toolmark identification, document comparison techniques, hair analysis, bite mark analysis and even fingerprint analysis, the last of which has been historically considered a mainstay of the forensic armamentarium in the investigation and prosecution of crime[25]. A recent study showed that crucial scientific information about error rates and likelihood ratios would be beneficial for juries, with jurors adjusting the weight they placed on forensic evidence depending on their understanding of its reliability[26]. This emphasises the importance of establishing these scientific foundations in forensics.

The failure to systematically interrogate these disciplines and establish their reliability and validity means that the CJS, and the scientific community, do not actually know whether they work well, or whether they work at all. Without a strong evidence base and foundational research, the forensic expert ultimately relies upon convention and their own impressions[6]. These may, of course, have value, however the absence of any formal empirical evaluation means that their scientific limitations and the likelihood of error is not known, and thus the reliability of the expert's conclusions is impossible to determine. The expressions of forensic science within reports for the court are also not linked to formal studies regarding accuracy or efficacy[6]. Therefore, these key pieces of expert evidence which may sway the jury one way or another, may actually be completely inaccurate. It is easy to see how this limitation has contributed to wrongful convictions in the past.

In addition to forensic evidence lacking empirical backing and evaluation, concerns have arisen in the literature regarding the expressions used within experts' reports and their expert testimony[6]. Not only is evidence not expressed in a standardised manner, but many expressions may unduly influence and persuade the jury with exaggerations and misrepresentations and the omission of limitations of whichever technique was used[6]. For example, forensic science reports and experts in court may assert conclusions with certainty and ambiguous language such as "cannot exclude" and "consistent with" without also

denoting the likelihood of error in the conclusion or the actual probability of the conclusion being true[6]. This has been emphasised by Grisso who reviewed the most frequent faults within forensic reports and found that 56% offered opinions without sufficient explanation in data or logic, 31% included irrelevant data or opinions, 30% failed to consider alternative explanations and 28% contained inadequate data, to name a few[27]. This accentuates the importance of standardised report writing with clear, unambiguous, scientific language and expression in simple probabilistic terms. For example, in forensic DNA analysis, one of the few forensic science fields found to be both scientifically valid and reliable by NAS and often utilised to overturn wrongful convictions, conclusions are expressed in probabilistic terms, such as a DNA match probability of one billion to one that a defendant left a crime stain[1]. There is a stark difference in the expression of DNA evidence and other types of evidence: DNA evidence is expressed in scientific probabilistic terms whilst other experts can express their opinions in any way they deem appropriate[6]. Indeed, some experts of the more traditional forensic techniques such as ballistics or fibre analysis have previously been allowed to testify and claim that their methods are 100% accurate: a stark falsehood[7]. Conversely, even DNA analysis has been shown to lack an error rate of zero and only single source DNA analysis was found to possess both foundational and applied validity, as opposed to DNA mixture evidence[9]. Furthermore, what experts say at trial may not be understood by the jury: a level of literacy and understanding is assumed however research has shown that there are significant gaps between what expert witnesses say and what lay jurors understand from it[6]. Even the more established forensic domains, such as fingerprint analysis, have been shown to exaggerate their findings and conclusions[6]. Additionally, some have argued that not only are reports misleading but also deficient in content[6]. These issues can compound and accentuate eachother, ultimately leading to incorrect determinations by the finders of fact, and unjust trial outcomes. Taking into account these factors, there is therefore a drastic need for more empirical research, epistemological modesty and standardisation in forensic science evidence and its expression. Indeed, the NAS and the NIST have both insisted that reports must be thorough, contain probabilities where possible and clarify the limitations of analyses within[6].

Forensic error has contributed to over half of the wrongful convictions in the USA later overturned thanks to DNA testing and is major factor in the production of invalid expert reports and testimony[14]. Errors can arise both in laboratory and analytical processes, for example due to negligence or fabrication of results, and also during expert testimony[14]. Saks and Koehler found that 63% of 86 DNA exonerations involved forensic science testing errors[28]. Garret and Neufeld showed that 60% out of a sample of 137 expert forensic testimony transcripts for the prosecution were invalid[29]. This study found that experts misused empirical data or included completely unfounded conclusions regarding the value of their evidence[29]. Similarly, Gould et al. reviewed a sample of 460 wrongful convictions and near misses and showed that the most common forensic error was invalid testimony at trial by experts retained by the prosecution[30]. Experts were found to frequently overstate the precision of their techniques and the incriminatory power of their evidence[30]. Lieberman demonstrated that jurors and laypeople perceive testimony and reports by forensic experts as more accurate and ultimately persuasive than non-forensic evidence[31]. Furthermore, multiple studies have now shown that jurors struggle to differentiate between valid and invalid scientific evidence and struggle to understand probabilistic and statistical information[32]. This emphasises that errors within forensic evidence are likely to be more damaging than errors in non-forensic evidence, as jurors are at risk of improper influence by erroneous “science”. Laypeople often regard science as being powerful, infallible, rigorous and reliable when actually it is often not, as shown by the examples throughout this dissertation. An overreliance on forensic evidence alone in criminal trials is therefore a risk to the entire CJS, so long as a lack of meaningful standards and issues such as error and poor reliability are associated with it.

Not only does forensic science as a whole lack empirical foundation and forensic error within reports and testimony limit its use in the CJS, but individual forensic techniques themselves suffer from specific inadequacies[2]. Many of these traditional methods were developed by police laboratories and progressed outside mainstream science and therefore lack some of the essential qualities of other scientific disciplines[9]. Latent fingerprint analysis is a well-established technique used throughout crime scene investigation, courts and criminal justice[33]. However, unlike DNA, the discipline lacks studies to show the statistical significance of a match to establish the probability of 2 fingerprints being identical. It also has a high false positive rate, lacks validated standards and relies on subjective judgements of fingerprint examiners[2]. Bite mark analysis has been shown to lack any foundational validity and is fraught with a high likelihood of error, inconsistency and cognitive bias[2] and contributed to numerous miscarriages of justice, for example Keith Harward who spent 33 years in prison for a crime he did not commit[17]. Microscopic hair analysis has been accepted scientifically and legally for decades[2]. However, it is now recognised as being highly unreliable, lacking any accepted statistical backing, lacking standards and having only speculative value, with many prejudicial effects[2]. Diatom testing suffers from a high false positive rate however it is thought that a comprehensive analysis of multiple bodily sources of diatoms may ameliorate this[34]. Forensic firearms identification has been found to lack studies confirming the key premise of toolmark uniqueness and reproducibility of said marks[2]. Even forensic DNA analysis, considered the most robust and reliable forensic technique, is not free from limitations. A positive DNA match is expressed in terms of match probability, with a full profile giving a probability of 1 billion to 1. However, with mixed DNA profiles, the effectiveness of DNA analysis falls. For example, in R v Lashley [2000], DNA analysis and statistical evidence showed that the DNA in the case could have come from 7-10 other males in the UK, and as there was no other evidence, the conviction was deemed unsafe, highlighting the need for additional corroborating evidence alongside forensic evidence, even DNA evidence[35]. Furthermore, DNA techniques are limited by contamination and handling errors, such as the case of Adam Scott in 2012 where a man was wrongly accused of rape on the basis of a DNA match with the DNA database however this was the result of his saliva sample from a separate incident contaminating the same DNA plate in the laboratory which carried out the DNA analysis for the rape case. Adam Scott had spent 4 months in custody by the time the case was withdrawn[36]. Therefore there is clearly a danger in relying solely on fallible forensic techniques and in light of these flaws the UK Court of Appeal has asserted that expert evidence must only be judged in light of other evidence in a case and the absence of any other evidence should mean the case fails[1]. Similarly, some studies have warned of the dangers of convicting individuals on the basis of a single piece of forensic evidence, as it is very possible that the technique being used may have as of yet unknown flaws[2]. This fact that expert forensic evidence requires additional confirmatory evidence and cannot be used alone is clearly a significant limit on its usefulness in the investigation and prosecution of crime.

Unfortunately, forensic experts are not only often not experts (a large proportion of forensic scientists have no scientific credentials and few possess advanced degrees) but many are also insufficiently proficient in research methods and statistics to be able to present evidence in a valid, credible and defensible form[6]. This further compounds the problems delineated in the paragraphs above and it is easy to see that the deficiencies of forensic science present a huge limitation on its usefulness to the CJS. Despite this, thankfully there is some evidence that the role of forensic science as a contributor to wrongful convictions is declining over time, suggesting improvements within the field and, correctly, the abandonment of techniques revealed to be flawed and unscientific[37]. Additionally, much of the wrongful conviction data centres on trials involving biological material that can be re-analysed for DNA, such as sexual assault and murder, and therefore much of the data may not necessarily be representative of all miscarriages of justice, and may over-emphasise the inadequacies of expert forensic evidence[18]. Furthermore, some recent changes in procedural rules and guidance, such as the Criminal Procedure Rules and Practice

Directions in the UK, are increasingly strict with regards to the admissibility of expert evidence, the scrutiny of accreditation of experts and the contents of experts' reports[1]. However, despite developments such as these, the judge remains the final arbiter of admissibility in criminal trials.

The existing judicial solutions to deal with the problems with reliability, accuracy and expression of forensic evidence, such as the restriction of what an expert witness can say in a report, in their testimony or limits on its admissibility, are inadequate[6]. These are not solutions at all, as they still enable experts to testify without commenting on failures in evaluation, validation and empirical foundation within their discipline[6]. Trial safeguards are rarely effective at exposing and conveying the limitations of forensic evidence to the jury, and some courts are unwilling to reverse longstanding practice[6]. Leaving it to the process of cross-examination in court to unveil problems with the validity of forensic evidence is problematic as lawyers are not scientifically trained[14] and some research has shown that cross-examination in a mock trial setting does not reduce the impact of invalid testimony[38]. Contrastingly, other studies have shown that cross-examination does increase the ability of mock jurors to recognise a flawed expert witness[39]. Judges are the ultimate gatekeepers on what evidence is admissible but they themselves lack proper understanding of methodological and scientific issues such as falsifiability and error rates, and often prefer to allow juries to decide on the evidence for themselves, which, as shown above, is insufficient given that jurors are at risk of being unable to discern between valid and invalid testimony or reports[14]. Some studies of mock trials have also shown that judicial instructions have no effect on the assessment of evidence by the jury[14]. However, one could argue that this research is not generalisable to real world trials and situations. Nevertheless, the CJS does not currently have effective tools to abrogate the effect of erroneous, invalid and unreliable forensic evidence.

## 2.3 The Admissibility of Expert Forensic Evidence

Evidence is termed as admissible if it is allowed to be received by the court and considered by the finders of fact[40]. In general, the judge acts as the gatekeeper of admissibility, including expert forensic evidence, and determines what evidence is permitted to be heard in court, seen by the jury and allowed to be utilised in their determinations as to whether a suspect is guilty or innocent[41]. By deciding which items of evidence and testimony are admissible, the judge can function as a barrier to biased, invalid, unfounded and inconclusive expert evidence. However, this safeguard often fails in practice, with many judges deeming flawed evidence as admissible, either knowingly or unknowingly, and without preparing jurors appropriately[42]. Many judges also continue to admit evidence from debunked forensic techniques such as bitemark analysis and hair microscopy without critical analysis[42]. The consequences of this includes jurors being misled by faulty forensic science evidence and ultimately miscarriages of justice. Admissibility therefore limits expert forensic evidence in the investigation and prosecution of crime as inadmissible evidence has no utility in the CJS, yet the admission of unsound evidence contributes to unjust, incorrect outcomes.

In adversarial legal systems the burden of proof rests on the prosecution and the standard of proof of the guilt of the accused must be beyond all reasonable doubt[2]. One of the main factors as to whether this proof succeeds or fails is expert forensic evidence and whether it is deemed admissible[2]. The first legal precedent which established guidelines for determining the admissibility of forensic evidence was The Frye Standard in 1923. The court ruled that for a forensic technique to be admissible, it must be generally accepted by a meaningful proportion of the relevant scientific community[30]. This formed the mainstay of guidance until 1975, when the Federal Rules of Evidence were adopted by American courts[30]. Within these, rule 702 stipulated that a witness was an expert if they were so qualified by “knowledge, skill, experience, training or education”[30]. They could therefore testify with an opinion provided that it would assist the finders of fact in understanding evidence or determining a fact and so long as the testimony was based on sufficient facts or data, a product of reliable principles and methods, and provided that the expert had reliably applied said principles and methods to the facts of the case[30]. This was further clarified in Daubert v. Merrell Dow Pharmaceuticals Inc. in 1993 when the US Supreme Court held that rule 702 superseded The Frye Standard[30]. During this case, the court explained that the federal standard includes Frye’s test of general acceptance but also considers the science and its application[30]. In deciding whether a technique or expert should be admissible, therefore, the trial judge should consider the following: the basic theory of the technique and whether it has been tested, whether there are standards for the technique, whether the theory or technique has been peer-reviewed or published, what the error rates are, whether there is general acceptance of the technique, whether the expert accounts for alternative explanations, and finally whether the expert has produced unfounded conclusions by extrapolating from premises in an unjustifiable manner[30]. The court also held that issues regarding faulty or weak evidence can be ameliorated with a proper cross-examination, interrogation of contradicting evidence and judicial instructions to the jury regarding the burden of proof[30]. Rule 702 was then further amended in 2000 and stipulated that the evidence must be based on sufficient facts or data, be the product of reliable principles and methods and that the expert must reliably apply the principles and methods to the facts of the case[2].

Similarly, in the United Kingdom, the admissibility of expert forensic evidence is limited by statute, common law and the Criminal Procedure Rules and Practice Directions[1,43,44]. Expert evidence is deemed admissible where it will be of assistance to the court in helping it form conclusions relevant to the case and is outside a judge’s or jury’s normal knowledge or experience[1]. The expert must also have relevant experience of their field acquired by study or experience and must only give evidence related to their expertise[1]. Their evidence must

also be impartial, unbiased and objective[1]. Finally, the expert's evidence must be reliable: there should be a reliable scientific basis for their evidence or it must be the result of a process recognised as reliable[1]. To determine if evidence is sufficiently reliable to be admitted, a UK court should assess the following: the extent and quality of the data used to form the expert's opinion, the validity of their methods, whether their opinion takes into account the accuracy and reliability of their technique, the views of others who have assessed the evidence, the extent to which the expert's opinion is based on material outside of their expertise, whether the expert takes into account all relevant information and whether the expert's methods followed established practice in their field[1]. The Criminal Procedure Rules also assert that courts should proactively identify flaws in scientific opinions that detract from their reliability, for example the use of hypotheses that have not been sufficiently interrogated, unjustifiable assumptions, flawed data, improper methodology and unsound conclusions[44]. Only once the court is satisfied that the evidence is reliable enough to be admissible can it be tested by the opposition and the jury[1].

Due to the ambiguity and varying application of procedures regarding admissibility, many subjective unreliable opinions and flawed expert reports can still be admitted as evidence and mislead juries despite recognition of their limitations. It has been highlighted that courts have been willing to admit forensic evidence under circumstances that would not permit the admission of similar evidence in a civil case, leading to the phenomenon that defendants in civil litigation have more success at excluding expert evidence than those in criminal trials[45]. This opposes the foundational premise that the law should be more protective of criminal defendants and demand higher standards of evidence[45]. For example, there have been occasions where individuals lacking any training or background have been declared experts by courts and allowed to influence juries, thus exemplifying the inadequacy of admissibility as a guard against faulty expert evidence[30]. For example, a carbon credit fraud trial collapsed when the supposed expert was revealed to lack any training or qualification in the field only after he had already appeared for the prosecution for at least 20 other similar cases. This individual's evidence had therefore been deemed admissible by the courts multiple times, despite him not being an expert at all, and his evidence actually not meeting admissibility criteria[46]. This shows that, even with the gatekeeping of expert evidence through rules on admissibility, proper regulation of expert witnesses is lacking. Expert witnesses are not required to undergo training and are not assessed in their ability as an expert witness before testifying, hence why so many unqualified witnesses make it court. However, The Expert Witness Institute and similar organisations have begun directories of certified, vetted experts to combat this issue although such certification could prove expensive and may deter potential professionals, leading to a reduction in the already limited pool of available experts[47]. In light of this, it is clearly of utmost importance that alongside prudent and thorough considerations of admissibility on the judge's part, there must also be diligent screening of potential experts by their instructing parties. It should be ensured that said experts possess appropriate qualifications, have evidence of their expertise, have undergone training, are able to deliver coherent and sound evidence in court, and have no conflicts of interest or other issues surrounding integrity[47]. Moreover, parties should not select witnesses for the sole reason of supporting their side of events to the detriment of quality and probity.

Expert witnesses and their evidence are critical resources and courts, the public and victims of crimes continue to need and benefit from high quality expert advice[48]. Accordingly, it is important not to deter experts from providing evidence, rather the CJS should take measures to increase the overall quality of said evidence and discern qualified experts from those with insufficient expertise. It is also clear that admissibility safeguards alone are not enough to regulate expert evidence, with multiple examples of these safeguards failing alongside the lack of a system of screening to assure the quality or authenticity of witnesses. Both of these issues limit expert forensic evidence in the investigation and prosecution of crime, as the flawed expert's evidence is tantamount to useless and may contribute to

miscarriages of justice. Admissibility should ideally act as an appropriate limit on faulty forensic evidence and prevent it from being heard in court however this is often not the case. The rules regarding admissibility dictate that expert evidence must be sufficiently reliable however much of science is often unreliable and many new or emerging techniques may yet lack data regarding their reliability thus are unusable in a court of law. This relies on the judge being able to discern between reliable and unreliable methodologies or appropriate and inappropriate forensic experts, which can be difficult decisions to make, especially for someone from outside the sciences, and thus the limits the law places on the admissibility of expert forensic evidence are themselves limited.

## 2.4 The Tendency of Science to Outpace the Law

The final limiting factor on expert forensic evidence to be examined by this dissertation is the tendency of science to outpace the law and whether the law is adequate to deal with the changing nature of science. The literature has highlighted the way in which science is progressing exponentially and constantly changing whilst the legal system is slow, ponderous and antiquated, leading to an increasingly large divide between the two. Indeed, technology develops more quickly than our understanding of how it fits into society, with us only truly understanding the role of a technology once it has already permeated throughout the world[49]. Whereas the law often rests on precedent historical decisions based on socio-cultural factors of the time, one of the main goals of science is to cause societal change, progress and revolutionise knowledge and practice[15]. Science can therefore be viewed as posing an assault on previous thought: including the legal system. Whilst forensic scientific evidence will continue to progress, develop, be revised and improved, it may continue to be restrained by the law and procedure in arguably inappropriate ways, leading to reduced utility despite improving scientific technique and rigour. Ultimately it may be left to judges, lawyers, and other legal gatekeepers to reform aspects of the legal system to accommodate for the rapidly changing nature of scientific knowledge, and to ensure that its progress can continue to be of legal benefit to the public[50].

Science and technology, including forensic science, are advancing at an exponential pace[19]. With each advancement and innovation that occurs, new legal issues may arise. A series of concurrent dramatic changes are currently underway in information technology, communication, biotechnology, medicine, synthetic biology and other fields with wide-reaching legal consequences[51]. Whilst these successive waves change progress at a rapid pace, the legal frameworks that society relies on to regulate and manage this new technology are not evolving in kind, leading to a growing gap between the rate of scientific change and the ability to manage that change through the law[52]. Traditional legal tools are increasingly outdated and ineffective to manage science and the legal ramifications of many new scientific innovations are yet to be determined, as the law is not able to legislate prophetically before technologies such as nanotechnology pose legal issues[19,51]. Despite this divide, many issues regarding science inevitably have to be solved in courts of law. However, legal institutions are often not experts in areas of emerging science which highlights the importance of prioritising the education of the legal community in the complexities of science and technology, as the two will likely clash as continuing advancements come to the fore of society[19]. The options left to society in the face of science progressively outpacing law seem to be to stop or slow the pace of scientific progress (which many would argue is an impossible task) or to improve the ability of the legal system to adapt rapidly in kind, which may necessitate a departure from traditional, historical forms of legal oversight[51].

The tendency of technology and science to accelerate exponentially is now well-documented[50]. Within just the last half-century, humanity has been able to determine the structure of DNA, map the human genome, revolutionise the world with the internet and ubiquitous, ever more powerful computing, as well as make huge advancements in medicine with imaging and robotic techniques[51]. The number of scientific journals available has doubled every 15 years and more scientific knowledge has been documented in the last 40 years than was created in the previous 5000 years[51]. Additionally, the prospect of artificial intelligence becoming involved throughout aspects of human society, technology and medicine now looms more prominently than ever before. With regards to forensic science specifically, it has also seen monumental changes over a short period of time: ever-increasing improvements in precision of toxicological techniques, the birth and widespread use of DNA profiling and increasingly powerful techniques in the analysis of trace evidence, to name a few[52].

The understanding of the increasing divide between science and law has led to questions as to whether the law is adequate to deal with these rapid changes and whether the law can keep pace at all. Many would argue that this is impossible as legal frameworks are based on static rather than dynamic views of society and are a product of their time[51]. For example, the American EPA has had to constantly revise ozone standards with legislation such as The Clean Air Act as science has made numerous discoveries in the study of pollution and air quality[51]. This shows that the law has to constantly retrospectively adjust itself to adapt to new scientific knowledge and change. Furthermore, the legislative process is very slow: only small numbers of issues are able to be addressed at any one time and issues are often prioritised according to political pressures rather than scientific urgency, contributing to the growing mismatch between science and the law[51]. Outdated legislation often remains in effect for years and some laws are made obsolete by scientific development and lawmakers attempt to regulate complex scientific areas with inappropriate or ineffective legislation, such as that of an ordinance passed in March 2004 by Mendocino County in California which incorrectly defined DNA as a protein[53]. Furthermore, there is a paradoxical ossification effect as issues in technology become more complex, with more stakeholders becoming involved and increasing debate or political activity, such as with legal issues pertaining to artificial reproduction[54]. This leads to a delayed and difficult process of law-making which is insufficient to deal with the pace of science[54].

There is uncertainty in the application of existing law to new technology including forensic science[52,55]. As a result, the law can either under or over regulate new technology, or the technology can simply make the law obsolete. The implications of this for expert forensic evidence are huge: potentially beneficial innovative forensic techniques may either have to wait excessively long for legal regulatory approval or may evade legal regulation altogether, with both of these options having potentially harmful societal consequences. Once a forensic technique is granted regulatory approval it may already have been made obsolete by further advances in a field that is developing at exponential pace. The law is therefore left trying to catch up and expert forensic evidence is limited from providing maximal utility in the interest of criminal justice and public good. However, some provisions in English law, such as in R v Clarke [1995], have made it clear that there are no categories of expert forensic evidence that are closed off from being admitted to assist a jury[1]. Nevertheless, flawed or faulty forensic techniques, with concerning legal implications, may evade regulation altogether such as developments in digital forensics, the use of artificial intelligence within forensics and their implications for privacy. This may cause societal harm or set dangerous precedents thus limiting the beneficial impact of expert forensic evidence in the investigation and prosecution of crime.

## 2.5 Solutions to the Limits on Forensic Evidence

This dissertation has aimed to show that the scope of the limits on expert forensic evidence in the investigation and prosecution of crime is huge and multifactorial. In light of this, solutions are required. Recommendations on reforms to both forensic science and the legal system have been proffered by numerous studies and range from measures to address cognitive bias through to new legal procedures aimed at reducing the impact of or the possibility of flawed expert forensic evidence entering courtrooms.

The most significant limitation of forensic science and its use within criminal justice is the issue of error, low reliability and lack of validity. Multiple suggestions to abrogate the impact of this limitation have been discussed in recent studies. Firstly, it has been proposed that the standard scientific measures of rigour seen in other areas of science, such as medical research, should be adopted in forensic science[4]. For example, the use of randomised controlled trials, blinding and other methods to improve the level of evidence behind forensic techniques could be of benefit[4]. However, one could also argue that these types of studies require large samples that might not be achievable in the more niche field that is forensic science. A better solution, therefore, could be the widespread adoption of regular internal and external auditing in forensic institutions, as is the case in clinical medicine, in order to ensure that best practice is being adhered to and to assist with development of uniform standards[13]. Indeed, more research is required to establish the error rates and accuracy of all forensic techniques that aim to be used within a court of law[2]. Work is also required to establish proper, uniform and widely adopted standards in forensics[5] and forensic work should become regularly peer-reviewed[7].

On the legal side of the issue there is a clear need for the education of legal professionals about validity and reliability and courts should take a highly cautious approach to expert forensic evidence that is yet to be scientifically validated, with evidence either rejected as inadmissible, or juries educated as to its limitations[2]. Furthermore, judges should aim to be more prudent in exercising their role as gatekeepers against flawed expert evidence in order to protect the integrity of the CJS and guard against miscarriages of justice[7]. Significantly, legal guidance from the Crown Prosecution Service and the Code for Crown Prosecutors in the UK has established recommendations for the admissibility of expert evidence, such as the need for professional accreditation and academic qualifications, as well as clear rules on what should be contained within an expert's report for it to be admissible[1]. However, this does not negate the problem that it is up to the discretion of a judge to determine whether evidence is admissible or not as, despite all these recommendations, some flawed forensic evidence could still reach the courtroom. An alternative solution, therefore, could be the use of standardised forms via which an expert provides their evidence to a court and then a judge assessing admissibility.

Significantly, work to improve the scientific basis of forensic science is already being carried out by some academic groups and centres. For example, CSAFE is carrying out work to provide a scientific, statistical backing to forensics, with solutions such as software to assign objective similarity scores between matching pieces of trace evidence being developed[15]. In addition, in accordance with the recommendations of NAS and PCAST, many forensic providers have already adopted certification, peer review, safety regulations and ISO standards[9]. Despite this, there is clearly a need for more widespread training and competency standards for forensic practitioners and regular, monitored competency testing with publicly available results[56]. Another possible solution could be the centralisation and nationalisation of certain fields such as forensic science or forensic pathology into a national, uniform, publicly-funded system like the NHS in the UK[56]. However, there are clear barriers to such a massive reform such as budget-related issues and resistance to change within certain scientific and legal fields.

Another factor contributing to limiting expert forensic evidence is the issue of cognitive bias. Some studies have suggested that the effect of bias in forensics could be scientifically alleviated with stochastic computing by transforming biases and mistakes into random noise however the approach by which to achieve this has not been clarified[4]. Other approaches to minimise the impact of bias include the education of judges and lawyers on cognitive bias and its effects[13]. Furthermore, masking techniques to minimise the effect of contextual bias should be utilised where possible. For example, case managers can be used for access of any potentially biasing information whereas the scientists actually involved in the analysis and interpretation of evidence should be blinded to it[13]. One such technique is linear sequential unmasking (LSU): a process by which examiners assess evidence in isolation to ensure it is context-free[13]. Analysts should also be separated from contact with detectives and other individuals who could provide biasing contextual information. Finally, experts require increased training in cognitive bias, its effects and bias minimisation strategies[13]. One interesting bias minimisation strategy from the legal point of view was the introduction of court managed expert evidence (CMEE) by The Land Court of Queensland in Australia[22]. This involves the use of court-appointed convenors who use alternative dispute resolution (ADR) techniques to supervise pre-trial meetings of experts and enable the drafting of impartial, joint expert reports[22]. Not only does this enable experts to counteract one another's biases by considering the strengths and weaknesses of their and opposing views, but it promotes a more collegiate, scientific environment rather than a combative one. Data has shown that this method reduced the number of disputes, increased the clarity of reports and reduced bias[22]. Psychological research has also shown that this technique leads to increased empathy, information openness and mutually-beneficial problem-solving[22]. However, the fact that bias is unconscious means that some elements can never be truly removed and experts may still be exposed to biasing contextual information despite measures to minimise it.

The conflict between the pace of science and the law is a more difficult issue to resolve with fewer potential solutions proposed in the literature. Nevertheless, systems of scientific self-regulation and cooperative regulation under the supervision of government agencies, similar to the process of the UK pharmaceutical industry, have been discussed. However, there are concerns about accountability, conflicts of interest, and a lack of public participation if providers are allowed to self-regulate[51]. An alternative remedy, therefore, could be the development of specialised courts or institutions dedicated to the regulation and oversight of technology, with periodic reviews of technology and enactment of rapidly-adaptable legislative change. The likelihood of such a solution coming to fruition, however, is uncertain. Separate to legislation itself, the establishment of independent institutions with decision-making authority over scientific issues could allow more efficient and rapid adjustments to the regulation of technology without waiting for the legislative machine[51]. On the other hand, increased legal regulations and restrictions on the development of new science could both stifle innovation and reduce the availability of forensic science in the interests of the public good. Recent debate occurred in the UK parliament in March of 2022, with The Justice and Home Affairs Committee publishing concerns that AI tools were being used throughout police forces across the country without proper oversight[20]. The committee called for some restrictive solutions, namely a mandatory register of algorithms used by police and the justice system and establishment of a national body to set strict standards against which to test new technological solutions[20]. The realisation of these measures is yet to be seen.

## 3. Conclusions and Recommendations

In conclusion, expert forensic evidence is at the very core of the CJS worldwide and is an important facet in the investigation, prosecution and defence of crime, often leading to critical scientific evidence that is used to ensure justice is done. However, this dissertation has focused on and delineated the most significant limits on expert forensic evidence in this context: cognitive bias, the lack of a scientific basis in forensic science, the admissibility of expert evidence and the conflict between the pace of development of science and the ability of the law to regulate it. These problems are clearly broad in scope, widely discussed in the literature and have far-reaching societal consequences with many historical cases of wrongful conviction as a result of misapplied or flawed forensic science and concerning levels of bias, error and lack of scientific rigour behind many widely-used forensic techniques. The use of judicial rulings on admissibility are an inadequate mitigant. These issues will continue to grow, change and develop with the tendency of exponential, rapid change within science and many have already come to the fore of public discussion such as concerns with the use of inadequately-regulated AI techniques in UK police forces and criminal justice[20]. Effective solutions are therefore urgently necessary in order to abrogate the existence and impact of these limitations within the CJS. Some recent developments, such as that of CSAFE and their research into the statistical basis of forensics, show that there is work being done to improve forensic science and ensure it can remain at the forefront of the pursuit of justice[15].

There are a number of important recommendations to be made in order to ameliorate the limitations of expert forensic evidence. There is a clear need for uniform national and international standards throughout forensic disciplines in order to reduce bias and maintain minimum levels of quality, increase reliability and scientific rigour. There has already been progress in this area, with many laboratories and institutions adhering to the ISO 17025 standard however this needs to be more widespread, comprehensive and robust[57]. New institutions dedicated to creating wider-reaching standards for forensics, designed to achieve uniformity within the field, could assist with this. Standards should be meticulously maintained and adhered to, with the use of internal and external peer review, regular audit and presentation or discussion of audit results at local, national and international levels so as to maintain transparency, quality and develop new standards. Practitioner competency should also be regularly reviewed and appraised by professionals from outside the practitioner's institution. More high quality peer-reviewed research is also required to continue to solidify the scientific basis of forensic science, determine accuracy, establish validity and the error rates of techniques, to enable greater confidence in forensic conclusions that are then used as critical evidence in the investigation and prosecution of crime.

Cognitive bias within forensic practice could be minimised through a number of measures. Forensic disciplines should strive for independence of their institutions and providers from police or other legal institutions in order to minimise conflicts of interest and institutional bias. Furthermore, the discussion of cognitive bias should continue, with education aimed at scientists, police and members of the legal profession on the effects of cognitive bias and how to minimise its impact. Increased awareness of lawyers and judges could also lead to more scrupulous assessment of the admissibility of expert forensic evidence and more effective gatekeeping. The use of blinding techniques such as LSU and the separation of scientists performing analyses from sources of extraneous biasing information are extremely important measures that would significantly reduce the effects of contextual bias. Recent studies have supported the prospect that LSU could be easily implemented into many forensic fields such as firearms identification and forensic entomology[58,59]. Studies have also shown that bias-minimisation strategies such as CMEE and ADR may counter expert bias in ways existing procedures cannot[22]. These methods should be trialled at a larger scale than occurred in Queensland, and research into their viability at the national level is required.

Regarding admissibility, there should be strict adherence to CPS and similar guidance on admissibility, with more prudent judicial gatekeeping. The standardisation of forensic reports for use in court would assist judges in this task, and would serve to enable expression of expert evidence in a uniform, standardised manner with minimisation of exaggeration or misrepresentation of evidence. It would also ensure that comments on accuracy, error rates, confidence and limitations of the technique used to reach a conclusion would be included in reports. In order to stem the growing divide between science and the law, and to equip the law to deal with the rapidly changing nature of science, measures such as those proposed by The Justice and Home Affairs Committee of the UK Parliament should continue to be discussed, developed and trialled. New institutions dedicated to dealing with the problems and issues caused by technological progress are required alongside the expansion of powers of existing institutions, such as that of the Forensic Science Regulator in the UK.

Regardless of what solutions are adopted by the CJS and forensic science in order to address its limitations, strong corroboration of forensic evidence with other forms of evidence, such as witness testimony or CCTV footage, should be mandatory. Courts should strive to never convict individuals based on a single piece of forensic evidence, as the warnings from history regarding wrongful convictions due to flawed or misapplied forensics couldn’t be clearer. The overarching goal of forensic science is to assist the police, the court and the public in achieving justice and avoiding injustice, and expert forensic evidence could become a much more powerful, beneficial tool in the criminal justice armamentarium if its limits are comprehensively addressed.

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