The Alan Turing Institute

Response to the House of Lords inquiry: Forensic Science in Criminal Justice

13 September 2018

Response of The Alan Turing Institute to the House of Lords Select Committee on Science and Technology's Inquiry into Forensic Science in Criminal Justice

The Alan Turing Institute is the UK's national institute for data science. Five founding universities – Cambridge, Edinburgh, Oxford, UCL and Warwick – and the UK Engineering and Physical Sciences Research Council created The Alan Turing Institute in 2015. Our university network has since expanded to thirteen partners, including Exeter, Bristol, Southampton, Birmingham, Queen Mary University of London, Leeds, Manchester and Newcastle. This response was put together on behalf of the Institute by Amy Wilson (Turing Fellow, University of Edinburgh), Primoz Skraba (Turing Fellow, Queen Mary University of London), Amber Marks (Queen Mary University of London), Norman Fenton (Queen Mary University of London), and Ian Walden (Queen Mary University of London), in consultation with Helena Quinn (Senior Strategy Officer) and Cosmina Dorobantu (Policy Fellow).

Question 1: Is forensic science contributing to the delivery of justice in the UK?

1. Norman Fenton believes that forensic science is contributing to the delivery of justice in the UK, but that it is also contributing to injustices, particularly those caused by errors of probabilistic and statistical reasoning. In his response, Fenton writes:

> While some common errors of probabilistic reasoning are well known and even recognized as dangerous by the judiciary (such as the prosecutor's fallacy[1]), most are not. I believe injustices are occurring widely because of misunderstandings about the *probative value of forensic match evidence*. Specifically: what can we reasonably infer if there is evidence that some forensic 'trace' (which could be DNA, a fingerprint, a shoe mark, a fibre, etc) has a profile that matches the profile belonging to a particular person? It is widely (but wrongly) assumed that if the 'trace' is DNA or a fingerprint than the profile match is equivalent to an identification, i.e. that the trace must have come from the person. However, because many forensic traces from crime scenes are only 'partial' and may be subject to various types of contamination, the resulting 'profile' is not sufficient to 'identify' the person; many people would have a partial profile that matches.

2. Fenton believes that the problem outlined above is particularly salient in the case of 'low template' DNA evidence and mixed profile DNA evidence. He notes that:

> Modern lab techniques enable us to identify partial DNA profiles from extremely tiny amounts of DNA. In such situations, the prosecution could reasonably assert that "DNA matching the defendant was found at the crime scene". I have been involved in cases where such assertions have a dramatic impact on the judge and the jury, while even defence lawyers assume their case is impossible to defend. But to interpret this as 'proof' that the defendant must have been at the crime scene may be to grossly exaggerate the probative value of the evidence in favour of the prosecution case.

3. In her response, Amber Marks highlights the unnecessary effort and costs sustained by police forces and courts to evaluate forensic science of minimal probative value. She gives the example of "expert evidence of drug traces (EEDT) on banknotes,[2] relied upon in prosecutions in the United Kingdom but rarely, if ever,

[1] Fenton, N. E., & Neil, M. (2011). Avoiding Legal Fallacies in Practice Using Bayesian Networks. Australian Journal of Legal Philosophy, 36, 114–150.

[2] Marks A, 'Expert Evidence of Drug Traces: Relevance, Reliability and the Right to Silence' (2013) 10 Criminal L Rev 810

admissible in prosecutions in other jurisdictions." Despite the effort and costs involved, such evidence is unlikely to contribute to the delivery of justice and Marks notes that "unsuccessful challenges to its reliability have the perverse effect of inflating its perceived probative value."

Question 2: What are the current strengths and weaknesses of forensic science in support of justice?

4. Norman Fenton considers the main weakness to be the fact that "the statistical aspects of forensic evidence are often either simply overlooked (because they are considered too difficult) or poorly presented by both lawyers and forensic scientists." With respect to the latter, Fenton gives the following example:

> Consider the situation where a fibre found on a person X is determined to 'match' the fibres on a particular article of clothing C relevant to a case. Typically, a lawyer asserts that "This evidence means we cannot rule out the possibility that X was in contact with C." But this type of statement is not very helpful because what we are actually interested in is the probability that X was in contact with C, while the original statement is simply asserting that this probability is 'not zero.'

5. There are ways to quantify the probability that X was in contact with C, and Fenton points out that there are "databases on fibres that provide information about the frequency of different fibres among the population of fibres, and hence which can provide an estimate of the probability we require." Although estimating the probability seems like a straightforward calculation, Fenton notes that is not trivial due to the fact forensic databases have various limitations. We will return to this point in our response to question 3.

Understanding and use of Forensic Science in the Criminal Justice System

Question 3: What is the scientific evidence base for the use of forensic techniques in the investigation and prosecution of crimes? Are there any gaps in that evidence base?

6. Researchers identified three areas where more work is needed in order to improve the scientific evidence base for the use of forensic techniques in the investigation and prosecution of crimes: mitigating the limitations of forensic databases, evaluating the probative value of DNA evidence, and assessing the combined weight of all pieces of evidence. We will discuss each recommendation below.

Mitigating the limitations of forensic databases

7. Norman Fenton highlights forensic databases as "the main 'scientific evidence' used when it comes to determining the statistical/probabilistic implications of forensic evidence." While these databases are often useful in assessing the probative value of the evidence, Fenton notes that they have limitations. In particular, many of the databases are not representative of the population under study. Without appropriate statistical corrections, the use of forensic databases can lead to incorrect statistical inferences (i.e. incorrect estimates of the probability that person X was in contact with C, to use the example from the previous question). Besides employing appropriate statistical corrections when evaluating the probative value of the evidence, Fenton also recommends updating and improving the databases: "wherever possible, forensic databases should be 'open source' with publicly available and complete documentation concerning the methodology used in gathering data."

Evaluating the probative value of DNA evidence

8. In recent years, researchers have been making significant improvements in our ability to detect DNA profiles from extremely small samples. Fenton notes that these improvements create an opportunity for improved

justice by increasing our ability to solve forensic cases, but – without additional research – can also lead to injustices. Fenton believes that we need much more experimental research into background DNA: how easily and for how long different types of DNA remain on different types of substances. For example, if traces of DNA from people's skin remain on car seats for months, the DNA found on a car seat from a London cab can 'match' the DNA of thousands of people. In his response, Fenton underlines the fact that, to properly evaluate the quality of the 'match' from a DNA car seat, we need answers to questions such as 'how long after a person sits on a car seat is that person's DNA profile detectable?'

Assessing the combined weight of all pieces of evidence

9. In their responses, both Amy Wilson and Norman Fenton point to the need to understand how evidence should be interpreted and evaluated. In any criminal investigation, there are multiple pieces of evidence. Each piece has an associated degree of uncertainty: even DNA matches are not 100% certain. Furthermore, each piece of evidence is collected with some error: even the most careful crime scene investigator alters the evidence through the process of collection or examination. To complicate matters further, the pieces of evidence are often interdependent. More research is needed to (1) quantify the uncertainties associated with the matches resulting from each piece of evidence, (2) evaluate the error rates associated with the collection and analysis of each piece of evidence, and (3) understand how to assess the combined weight of all these uncertain, error prone, and interdependent pieces of evidence. Regarding this final point, Fenton notes:

> When there is a need to quantify the overall impact of multiple pieces of evidence involving various related hypotheses (such as source level, activity level, and offense level hypotheses), simplistic statistical solutions that inappropriately assume independence are inadequate. More sophisticated methods, such as Bayesian networks, are necessary for computing the correct statistical/probabilistic conclusions to be drawn.

Question 4: How can the Criminal Justice System be equipped with robust, accurate and transparent forensic science? What channels of communication are needed between scientists, lawyers and the judiciary?

10. Statistical analyses and results are difficult to communicate to an audience that does not have prior knowledge of statistics. This is why Norman Fenton recommends that "exceptional care is required to communicate the meaning of complex probabilistic and statistical analyses of forensic evidence in court in a way that is understandable to judges, lawyers, and juries."
11. Besides the importance of clearly communicating the outcomes, processes, and limitations of the statistical analyses during the actual trial, Fenton also believes that prior to the trial, it is crucial that everyone involved in the evidence analysis process recognises the need to model the dependencies between the pieces of evidence and is aware of the existence of methods and tools that make this possible. There are, for example, interactive software tools that perform computations on probabilistic graphical models (Bayesian networks). These tools can enable criminal investigators to explore the impacts of different assumptions.

Question 5: What is the level of understanding of forensic science within the Criminal Justice System amongst lawyers, judges and juries? How can it be improved?

12. Norman Fenton believes that the level of understanding of forensic science among lawyers, judges, and juries is poor. In his response, Fenton notes:

> There needs to be much greater awareness that all evidence is subject to potential errors that should be articulated and, if possible, quantified. When a lay witness (such as an eyewitness) makes an assertion

(such as 'defendant was at crime scene'), it is accepted that the actual truth of the assertion depends on the accuracy of the witness. The same is almost invariably the case when an expert witness, such as a forensic scientist, makes an assertion like 'two samples match'. Errors can and do occur at every level of evidence evaluation: sampling, measurement, interpretation of results, and presentation of findings. Forensic scientists should articulate, and attempt to quantify, all such possible sources of error. And legal professionals should understand and expect this information, and probe for possible sources of uncertainty when it is not presented by the experts.

13. Furthermore, Fenton argues that the meaning of the word "match" in the context of forensic evidence needs to be re-evaluated. Currently, "a match" between two pieces of evidence is understood to mean that they come from the same source (i.e. they have the same origin). Fenton notes, however, that two pieces of evidence are branded "a match" when their measured characteristics are the same (within an agreed tolerance) and that a more helpful focus would be to assess and discuss the degree of similarity between the two pieces of evidence, rather than to reduce the results of forensic analyses to a simple statement that the two items "match."
14. Finally, Fenton also underlines in his response the fact that there is a "misunderstanding within the British judiciary about the role of probability – and particularly Bayesian probability – in the law." Fenton believes that the misunderstanding is leading to miscarriages of justice resulting from unreliable analyses and descriptions of forensic evidence.[3]

Question 6: Is the current training available for practitioners, lawyers and the judiciary appropriate?

15. In forensic investigations, it is very rare to come across evidence that clearly points to facts. "There is virtually always some degree of uncertainty," Fenton notes, and, since probability is the mathematical science of uncertainty, lawyers and the judiciary should receive basic training in probability and statistics. This would enable them to understand the statistical analyses presented, to identify any weaknesses in the analyses presented, and to avoid common fallacies such as the prosecutor's fallacy.
16. Despite the importance of probability and statistics to evaluating evidence in forensic cases, the training currently available to lawyers and the judiciary is suboptimal. Amy Wilson points out that the Royal Statistical Society has partnered with other organisations to develop materials on statistics and probability for lawyers and the judiciary.[4] While the efforts of the Royal Statistical Society in this space are a good start, more training is needed, and Fenton believes that law schools and forensic classes are the right environments to provide that training.
17. Regarding practitioners, Amy Wilson and Norman Fenton agree that it is crucial that they have a solid understanding of probability and statistics. Fenton adds, however, that statisticians should also have some basic legal training. In particular, they should learn the legal rules for admissibility of evidence and the duties of expert witnesses.

Standards and Regulation

Question 9: What role should the Forensic Science Regulator have? If the Forensic Science Regulator is to have statutory powers, what should these be?

[3] Fenton, N., Neil, M., & Berger, D. (2016). Bayes and the Law. Annual Review of Statistics and Its Application, 3(1), 51–77. http://doi.org/10.1146/annurev-statistics-041715-033428

[4] See http://www.rss.org.uk/RSS/Influencing_Change/Statistics_and_the_law/Practitioner_guides/RSS/Influencing_Change/Current_projects_sub/Statistics_and_the_law_sub/Practitioner_guides.aspx?hkey=2cfdf562-361e-432e-851b-ef6ff5254145 and https://www.statslife.org.uk/news/3616-rss-and-icca-publish-guide-to-statistics-for-legal-professionals

18. Amber Marks recalls a report by the office of the Forensic Science Regulator on 'Expert Evidence of Drug Traces' (EEDT)[5] that resulted from concerns raised by the Council for the Registration of Forensic Practitioners (now defunct), which raised the question of which bodies are expected to report concerns to the Regulator in its absence. She notes:

> The Report concluded that the complexity in the interpretation of EEDT was such as to necessitate a clear policy on the part of the prosecuting authorities regarding its use at trial. No such policy has resulted and EEDT continues to be relied upon by the prosecution in prosecutions and civil proceeds of crime applications. This suggests that such recommendations from the Regulator should be binding on the Crown Prosecution Service, or alternatively suggests that the Regulator could have gone further in recommending a policy or giving a clearer indication regarding the circumstances, if any, in which this form of expert evidence could be of sufficient probative value to adduce.

Forensic Science Research Landscape

Question 12: How should further research funding for forensic science be justified? What should be the focus of such research? What is the role of UK Research and Innovation, especially considering the interdisciplinary nature of much forensic science?

19. Two major justifications for further research funding for forensic science are: improved efficiency in the criminal justice system and reducing the incidence of miscarriages of justice.
20. Norman Fenton notes that improved efficiency includes not only "improvements in specific types of forensic methods" but also methods "such as Bayesian networks that enable us to combine the multiple (possibly conflicting) pieces of evidence that arise in any case to determine the overall probative value of the evidence." These other methods have the potential to enable the Crown Prosecution Service to "determine much more efficiently and accurately whether a case should proceed to trial."
21. Miscarriages of justice could also be reduced, for example through experimental research in DNA transfer, which Fenton describes as "determining the extent to which different types of DNA on different types of surfaces may be 'innocently transferred.'" He gives the example of someone who is wearing clothing made of a particular material who sits on a chair made of another particular type of material; depending on the types of materials it will be more or less easy for DNA to transfer from the chair to the clothing, and then possibly transferred again to another type of surface. Research into this type of DNA transfer is needed to avoid increasing miscarriages of justice.
22. Furthermore, Amy Wilson and Fenton both emphasise the need for interdisciplinary research, and identify UK Research and Innovation's role as the provider of greater funding for opportunities in interdisciplinary projects that do not fit into the traditional research councils' remits.
23. Indeed, Fenton points out:

> "Effective research in forensic science is critically dependent on interdisciplinary collaboration. This requires the involvement not just of forensic scientists and lawyers, but also mathematicians/statisticians and cognitive scientists (the latter being required to boost understanding of how best to present certain types of evidence and how to avoid biases in both investigating and interpreting evidence)."

[5] J. Adams, Analysis of Currency for Target Controlled Drugs, Report to the Forensic Science Regulator, July 2009.

24. Wilson also identifies the need for greater opportunities for funding for projects that bridge the gap between academia and industry; she notes that with cuts to police force budgets it can be difficult to obtain funding from industry to convert academic research into impact.

Question 13: Where are the gaps in research and understanding of forensic science? How and by whom should the research questions be articulated to fill these gaps?

25. The greatest gaps identified by respondents include understanding of forensic statistics, the impact of new forensic technologies on the legitimacy of the criminal justice system, and the narrow approach to expertise observed in court.

Understanding of forensic statistics

26. Amy Wilson asserts that a gap in forensic science research emerged when the Forensic Science Service (FSS) was closed, specifically, with the disbanding of the FSS team that focused on forensic statistics.
27. As with all sciences that are based on data, forensic science is dependent on understanding the statistics that underpin it. Primoz Skraba points out that there is always a certain probability that a certain pattern appears "randomly." In the physical sciences, this is typically overcome through repeated experiments; however, Skraba notes that in forensic science, "conclusions must be drawn from an individual measurement." Probabilities can also be a useful tool if there are sufficient statistics to back them up, such as statistics on DNA that have been gathered at the population level over several decades of genetics research. The problem is that many types of data are not as well understood.
28. Skraba warns that this problem could be exacerbated through the use of machine learning and automatic algorithmic analysis. Amy Wilson agrees that with new forensic science methods, the need is growing for new statistical methods to ensure "that the data resulting from the application of these methods can be used to inform the legal process." Moreover, Skraba notes:

> "The outcome [of automated analyses] is often treated as truth, whereas, in reality, mistakes may be common. In the past, one could rely on population statistics being normally distributed. However, for these new methods, the error rate is often difficult to assess. New methods need to be developed which, as far as possible, are robust to, or independent of, the underlying assumptions. This requires additional statistical techniques for the forensic setting with an emphasis on understanding uncertainty (i.e. how much can what we do not know affect our analysis)."

Impact of new forensic technologies on the legitimacy of the criminal justice system

29. Another emerging gap is the increasing use of demographic and personal data by companies to identify individuals, which is likely to be used in forensic science in the future. According to Skraba, "while a company's misidentification may result in a misplaced advertisement, the consequences in forensic science may be more severe." Indeed, this is not limited to use by private companies; forensic technologies are being used now by agencies such as the Metropolitan Police through its Gangs Matrix, which has raised concerns around the legitimacy of using predictive tools in criminal justice.[6] Amber Marks notes:

> "So-called 'intelligence-led' policing aims not merely to detect, investigate, and prosecute offences, but to deter and disrupt the activities of those deemed likely to commit crime in the future. Risk scores generated by police algorithms are shared with multiple agencies and this results in often stigmatic and punitive repercussions for the individual involved, including in policing, educational and medical settings,

[6] Marks, Amber and Bowling, Ben and Keenan, Colman, 'Automatic Justice? Technology, Crime and Social Control' R. Brownsword, E. Scotford and K. Yeung (eds), The Oxford Handbook of the Law, Regulation and Technology, OUP, 2017.

decisions on benefits and housing entitlements and deportation proceedings, while obviating the procedural safeguards of the criminal trial. The issues raised are not restricted to privacy implications and data protection compliance, but to the role and legitimacy of the criminal justice system as a whole."

Approach to expertise observed in court

30. Furthermore, in understanding of forensic science, Norman Fenton notes a mismatch in the expectations of judges compared to the need to understand the broader context of for specific pieces of forensic evidence. He highlights that there is a tendency for judges to favour narrow expertise in presentation of evidence; however, someone with broader expertise who is able to provide both "any required statistical analysis of the specific forensic evidence" *and* "the statistical evidence of multiple related, dependent but different pieces of forensic evidence" would be of more value to the criminal justice process.

31. Finally, regarding how and by whom research questions should be articulated, Wilson recommends that interdisciplinary teams of statisticians, forensic practitioners, research scientists, lawyers and the judiciary should work in collaboration. She also notes that a central body is needed to bring together the small number of forensic statisticians to create research synergies and a venue for statisticians to collaborate with forensic scientists and the legal profession.

Digital Forensics

Question 16: Are there gaps in the current evidence base for digital evidence detection, recovery, integrity, storage and interpretation?

32. Several methods already exist for using digital forensics, such as verifying a chain of custody to ensure that digital data remains unaltered. Verification of integrity of digital data such as this can be incorporated into police protocols. However, Primoz Skraba warns that it is increasingly easy to artificially generate digital data, such as video and speech. Being able to distinguish between this data and real data is getting more and more difficult with the growing sophistication of the methods used for generating this type of data. Skraba gives an example:

    "The current challenge for the research community in this area is generated artificial video from a single image of a person. Unless techniques are developed to confirm the authenticity of data (such as video from mobile phones), it will be difficult to use such evidence in the investigation and prosecution of crimes."

33. In addition, the accuracy of the data used in these methods is crucial. Skraba recalls the cases in the United States criminal justice system in which 'data-driven' produced biased results due to the bias present in the input data:

    "Famously, automatic sentencing programs handed down harsher sentences to African-Americans, due to this inherent bias being present in the data. It is therefore critical that the biases in the data also be identified and understood, lest it be taken as ground-truth."

Question 17: Is enough being done to prepare for the increasing role that digital forensics will have in the future? Does the Criminal Justice System have the capacity to deal with the increased evidence load that digital forensics generates?

34. Ian Waldon asserts that digital forensics has become one of the principal strands of forensic science. He explains:

> "As we spend more of our lives online, the digital footprints such activities generate have become a component of most investigations, whether the crime is carried out online or offline. Broadly, digital forensic material is generated either on the devices we have, from mobile phones to the Internet of Things (e.g. connected thermostats), or the services we use, such as WhatsApp and eBay, as well as a combination of the two. These devices and services operate within complex, layered ecosystems, with potential valuable forensic material generated and distributed at every level. The use of such data generates numerous data 'problems' for investigators, including that of analysis (e.g. the volumes involved), attribution (e.g. identifying the user), availability (e.g. data retention), integrity (e.g. operating properly), jurisdictional (e.g. not held in the UK) and protected data (e.g. use of encryption). Addressing these data problems already represents a serious challenge for law enforcement agencies, which is only becoming greater as the sources of digital forensics proliferate exponentially in the face of static or diminished resources. The potential impact on defendants and the protection of their rights was highlighted earlier this year with the collapse of a series of rape cases."

35. He suggests that the capacity building in forensic skills that is currently taking place among law enforcement officers is required at every level of the criminal justice system, "including prosecutors and the judiciary." However, it goes further than the criminal justice system; Walden highlights that digital forensic education is needed at the tertiary level, "to raise public understanding of the issues involved in digital forensics that extend beyond criminal justice, to include areas such as regulatory compliance, information security, and competition policy."
36. Moreover, while he recognises that some digital forensics standards exist, such as ISO/IEC 27037: 2012, adoption is not widespread, and they do not cover all components of the digital forensic process. He calls on governments to "facilitate and encourage industry to invest more in standards development and deployment."

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