Twelve Guiding Principles and Recommendations for Dealing with Quantitative Evidence in Criminal Law

For the use of statisticians, forensic scientists and legal professionals

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This document has been produced by participants of the Programme "Probability and Statistics in Forensic Science" (FOS) held at the Isaac Newton Institute for Mathematical Sciences, Cambridge, July-Dec, 2016. It represents the views of the organisers and participants named below, and it is intended to complement existing guidelines (such as those from RSS [1], ENFSI [2], and PCAST [3]).

Recommendations in red are more specifically geared towards statisticians, those in green toward forensic scientists, those in blue towards legal professionals, those in black applies to all.

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We dedicate this report to the memory of Steve Fienberg.

PRINCIPLE 1

Probability is intrinsic to understanding the impact of evidence.

Evidence which indicates facts that are certain is rare. There is virtually always some degree of uncertainty and, since probability is the mathematical science of uncertainty, it is the right framework to handle it.

Recommendations

- **Law schools and forensic courses should teach sufficient basic statistical and probabilistic thinking to recognise and avoid common fallacies such as the prosecutor's fallacy.**
- **Statisticians (including the class of experts who should be more accurately referred to as *Forensic Mathematicians*) should learn the legal rules for admissibility of evidence and duties of expert witnesses.**
- **Statisticians need to take responsibility for challenging the claims that probability is inconsistent with legal reasoning**

PRINCIPLE 2

Contextual information is sometimes necessary for investigators or forensic scientists to produce informative analyses. But, to avoid cognitive biases, such as confirmation bias, forensic scientists should be provided with the minimal amount of contextual information.

Recommendations

- **Organizations in different forensic disciplines should establish principles of contextual information that are or are not relevant, and communicate these principles to investigating agencies. Forensic scientists should discuss with the investigator exactly what contextual information is required to allow an unbiased, useful analysis to be made.**
- **In 'statistics-led investigations' (such as where anomalous death rates in hospitals, together with confirmation bias, lead to charges of criminal activity) the court should consider the advice of a statistician, and not rely only on, for example, a medical professional simply because the statistics concern medicine.**

PRINCIPLE 3

If there is to be an overall quantitative evaluation of the impact of forensic evidence then statisticians, forensic scientists and legal professionals should work together.

Improvements to the quantitative evaluation of evidence will not come from simply demanding that statisticians be recruited to provide input.

Recommendations

- **Forensic scientists can often benefit from working with statisticians when the value of scientific evidence is to be quantified.**
- **Statisticians must be explicit about the assumptions they are making when quantifying forensic evidence and discussion with forensic scientists can ensure that those assumptions are realistic.**
- **Legal professionals need to know the basics of the probabilistic language, in order to understand the value of scientific evidence, especially in conjunction with other evidence. Lawyers should be able to present this *evidence synthesis* clearly and comprehensibly to judges and juries.**

PRINCIPLE 4

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.

Recommendations

- **Forensic scientists should articulate, and attempt to quantify, possible sources of error, such as contamination rates and false positive rates where relevant, once such rates are reliably established.**
- **Statisticians should attempt to include all sources of uncertainty about their parameters and models. Where this is not feasible, the possible errors should be explained in accompanying text.**
- **Legal professionals should understand and expect this information, and probe for possible sources of uncertainty when it is not presented by the experts.**

PRINCIPLE 5

The Likelihood Ratio (LR) is a simple and effective measure of probative value of evidence when used with care

The ***likelihood*** of a hypothesis *H* (such as "shoemark at crime scene comes from Fred's shoe") on the basis of some evidence *E* (such as "shoemark matches a shoe owned by Fred") is the probability of finding *E* if *H* is true. For an alternative hypothesis (such as "shoemark at crime scene comes from Jane's shoe") the LR is the ratio of the two likelihoods. The LR tells us which hypothesis is better supported by the evidence. When the two hypotheses are mutually exclusive and exhaustive (such as when the alternative hypothesis is '*Not H'* as in "shoemark at crime scene does not come from Fred's shoe") the LR tells us more. In this case if the likelihood of *H* is greater than the likelihood of the alternative (so the LR is greater than 1) we can ***also*** conclude that the probability of *H* ***increases*** as a result of finding *E*, while the probability of the alternative decreases.

Recommendations

- **Wherever possible the likelihoods for all reasonable alternative hypotheses should be considered (so that the set of hypotheses is exhaustive). If only certain hypotheses are being considered, it should be explained that only LRs for pairs of these hypotheses are being presented. In cases where multiple hypotheses and/or multiple items of evidence need to be combined, the LR may be better used in conjunction with methods such as those given in Principle 6.**

- **Statisticians should avoid, as far as possible, selecting hypotheses on the sole basis that their likelihoods are easy to compute.**

- **Legal professionals must understand that a LR about a pair of source level hypotheses (such as 'shoemark does or does not come from suspect shoe') may tell us nothing about offense level hypotheses (such as 'guilty' or 'not guilty') or even activity level hypotheses (such as 'suspect was or was not at the crime scene').**

PRINCIPLE 6

Most cases consist of multiple interdependent items of evidence which need to be combined correctly. Evidence synthesis is the process of assessing the combined weight of all relevant pieces of evidence.

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 solutions that inappropriately assume independence are inadequate. Graphical representations of evidence can be very helpful to model dependencies.

Recommendations

- **All those involved in evidence analysis at all stages of a criminal investigation should be aware of the need to model dependencies, and of the existence of methods, such as graphical methods, that support this.**
- **Interactive software exists to perform computations on probabilistic graphical models (Bayes nets), enabling users to explore the impacts of different assumptions. While it may be difficult to introduce such methods directly in court, they are helpful for evidence synthesis at any of the phases of an investigation preceding the trial.**

PRINCIPLE 7

The word “match” is often taken to mean “of the same origin”, whereas in fact it means that the measured characteristics of two items are the same to within an agreed tolerance.

Recommendations

- **It is not necessary, and often not desirable, to reduce the results of forensic analyses to a statement that two items “match”. Instead, the degree of similarity should be assessed. If possible, the degree of similarity should be expressed statistically, as should its implications for the hypotheses.**

PRINCIPLE 8

Any forensic database can be useful, as long as its scope and relevance are well understood.

There is not a clear distinction between databases that are scientifically valid and those which are not. **All** forensic databases (including DNA databases) have limitations, and many are "convenience databases" rather than a true random sample from a relevant population. However, all of them can be improved over time, and in most cases some data are better than none, as long as reasonable assumptions are made and the available data used appropriately.

Recommendations

- **Where a database is used in an investigation, its precise relevance for the population under study should be determined. If the database is not fully representative of the population, then correct statistical inferences can still be drawn if adjustments are made based on reliable statistical methods. In situations where such adjustments are not possible, case-specific databases should be constructed with care.**
- **Wherever possible, forensic databases should be 'open source' with publicly available and complete documentation concerning the methodology used in gathering the data.**

PRINCIPLE 9

Software used in forensic analysis should be validated, documented, and used for purposes that lie within the scope of the validation.

Software used to support forensic analysis can be extremely powerful, but it should not be assumed that the courts will accept their results without question, especially when competing software provides different results from the same evidence.

Recommendations

- **As different software applied to the same evidence can produce different results, statisticians should be aware that lawyers can reasonably seize on such differences to discredit both the software and the associated forensic science. They should be prepared to explain fully the reasons for the discrepancies.**
- **Lawyers should seek justifications of different results from the same evidence.**
- **Software should be accompanied by a single document explaining what it does, the assumptions it depends on, the justification for those assumptions, and the validation tests that have been performed to check that the software reliably serves its intended purpose.**

PRINCIPLE 10

Well-founded subjective assumptions can play an important role in forensic analysis. For a procedure to be scientific these assumptions should be made explicit.

Subjective assumptions are an unavoidable component of any criminal investigation. This is not merely the province of judges or juries.

Recommendations

- **In reports and testimony, forensic experts need to explicitly articulate all key subjective assumptions being made, as well as their justifications, and their implications for the evaluation of the probability of hypotheses.**
- **Statisticians ditto.**
- **Legal professionals should probe for assumptions that have not been made explicit.**

PRINCIPLE 11

Bayesian analysis is a standard method for updating probabilities after multiple items of evidence are observed, and is therefore highly suited for evidence synthesis.

Anybody who must make a judgment about a hypothesis such as ‘guilt’ (including pre-trial investigators, judges, juries) informally starts with some prior belief about the hypothesis and updates it as evidence is revealed. Sometimes there may even be objective data on which to base a prior probability. Bayesian inference is a valid method for calculating the updated probability.

Recommendations

- **Forensic scientists can provide likelihoods without having to consider prior probabilities if they are asked only to evaluate the probative value of the evidence (see Principle 5).**
- **When using Bayesian reasoning, statisticians should justify prior assumptions wherever possible, for example, using external data; otherwise, they should use a range of values for priors, and a sensitivity analysis to test the robustness of the outcome with respect to these values.**
- **Basic statistical and probabilistic thinking taught in Law schools should cover Bayes’ Theorem.**

PRINCIPLE 12

Exceptional care is required to communicate the statistical analysis and synthesis of evidence to judges and juries

To communicate the meaning of complex probabilistic and statistical analyses of forensic evidence in court, it is important to be able to explain these analyses understandably to judges, lawyers and juries.

Recommendations

- **Forensic scientists may make use of methods such as argument charts or graphical models, which have been developed for use in a forensic context.**
- **Statisticians can help expert witnesses and legal professionals present probabilistic statements with a variety of methods, such as computing likelihood ratios, using a verbal scale, or constructing graphical models.**
- **Legal professionals as well as forensic scientists and statisticians should consider the findings by cognitive psychologists on lay understanding.**

References

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3. PCAST. Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods. (2016). https://www.theiai.org/president/201609_PCAST_Forensic_Science_Report_FINAL.pdf