



Bayes and Law: a multi-disciplinary research network



This international multi-disciplinary network brings together nearly 100 world-class Bayesian statisticians, scientists, psychologists and legal scholars with practising lawyers, police officers, forensic scientists and journalists. Its focus is on applications of probabilistic reasoning, particularly Bayes' theorem, in the British justice system. It was founded in Summer 2011 by Principal Investigator Norman Fenton, Professor of Risk Information Management at Queen Mary, University of London (QMUL), in collaboration with Amber Marks, Lecturer in Criminal Law and Evidence at QMUL.

Why Bayes and the Law?

Bayes' theorem is a basic rule of probability that provides a logical framework for reasoning about uncertainty. Forensic scientists use Bayes' theorem to assess the weight of the evidence they are asked to analyse and they calculate a 'likelihood ratio' to give a measure of its probative value. They use this information to brief legal teams preparing for trial and in presenting their evidence to judges and juries when they are called to testify as expert witnesses in court.

Challenges

Experience has shown, however, that explaining Bayesian reasoning to laypeople – even highly educated ones such as barristers and judges – is extremely difficult. There is also significant division among scientists over when it is appropriate to use Bayes' theorem, with some believing it should only be used when probabilities can be calculated from a database, and others arguing that all probabilities are subjective and can therefore be estimated.

R v T

This division was brought into sharp relief by an English Court of Appeal ruling in October 2010 (R v. T, EWCA (2010) Crim 2439) that restricted the application of Bayesian reasoning and likelihood ratios to DNA evidence 'and possibly other areas where there is a firm statistical base'. Although this decision was strongly criticised by both statistical and legal experts, opposition to it was weakened by the lack of consensus among the scientific community as to when Bayes' could appropriately be used.

Network Aims

The network was set up in July 2011 to address the problems outlined above. Our aim is to break down the cultural, technical and communication barriers that inhibit appropriate discussion of how Bayesian reasoning might be used in investigative and evaluative forensic science. If a consensus could be achieved about when the use of Bayesian reasoning is appropriate, disagreement over the extent to which it should be applied and the manner in which it should be presented could be resolved by empirical research.

A serious miscarriage of justice

Sally Clark was convicted of the murder of her two children in 1999 after expert witness Sir Roy Meadow claimed there was a less than 1 in 73 million chance that two babies in one family would die of Sudden Infant Death Syndrome. She was released on appeal in 2003 after it became clear that serious statistical errors had been made by Meadow in his testimony. Many newspapers also reported Meadow's evidence as meaning the probability Sally Clark was innocent was 1 in 73 million – a classic example of the prosecutor fallacy.



What is Bayes' Theorem?

First described by the Reverend Thomas Bayes in the 18th century and developed into a widely-used form of probability theory by French mathematician Pierre-Simon Laplace in the 19th century, Bayes' theorem provides a simple formula for updating the probability of a hypothesis (H) given a piece of evidence (E).

$$P(H/E) = \frac{P(E/H) P(H)}{P(E)}$$

The **likelihood ratio** (LR) is the probability of seeing the evidence given the prosecution hypothesis divided by the probability of seeing the evidence given the defence hypothesis.. Calculating the likelihood ratio illustrates the relevance (and potentially the weight) of each piece of evidence.

$$LR = \frac{P(E/H)}{P(E/\bar{H})}$$

The likelihood ratio provides information about the probative value of evidence such as forensic evidence

The Prosecutor Fallacy

A well known error of probabilistic reasoning, known as **the prosecutor fallacy**, is to assume that the probability of seeing a piece of evidence if the defendant is innocent, i.e. $P(E/H)$ is equivalent to the probability the defendant is innocent, if we've seen that piece of evidence, i.e. $P(H/E)$. This can seriously mislead the jury about the probative value of the evidence being discussed, particularly when probabilities are very low, such as in cases involving DNA evidence.

Who are we?

Principal Investigator: Professor Norman Fenton (QMUL)
Co-Investigator: Amber Marks (QMUL)

Other key members include:

- Prof David Balding (UCL)
- Prof Christophe Champod (University of Lausanne)
- Prof Phil Dawid (University of Cambridge)
- Prof Stephen Fienberg (Carnegie Mellon University)
- Prof David Hand (Imperial College)
- Prof Joseph Kadane (Carnegie Mellon University)
- Prof Mike Redmayne (LSE)
- Andrew Rennison (Forensic Science Regulator)
- Bernard Robertson (Editor, New Zealand Law Journal)
- Prof David Schiff (QMUL)
- Prof David Spiegelhalter (University of Cambridge)
- Karen Squibb-Williams (Crown Prosecution Service)
- Prof Franco Taroni (University of Lausanne)
- John Wagstaff (Criminal Cases Review Commission)

If you would like to know more about the Bayes and Law network please visit <https://sites.google.com/site/bayeslegal/home> or email norman@eecs.qmul.ac.uk