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Mystical Infallibility: Using Probability Theorems to Sift DNA Evidence

At the height of the O.J. Simpson trial in March,1995, Alan Dershowitz, Harvard law professor and advisor to the defence legal team, stated on US television that only about one tenth of one per cent of wife batterers actually go on to murder their wives. In a case being litigated as much in the media as in the courtroom, Dershowitz was trying to put a favourable spin on the admitted evidence that Simpson had beaten his wife. But in a letter to the science journal *Nature*, Jack Good, a Virginia Polytechnic Institute statistics professor, called the statement "highly misleading for the woman in the street." By combining Dershowitz's statement with other uncontroversial facts about the case in a statistical device called Bayes Rule, Good went on to show that if a battered wife is murdered, there is a better than even chance the murderer is her husband. Good ends his letter with the admonition: "It shows once again, and dramatically, that the simple concept of the Bayes factor is basic for legal trials. It is also basic for medical diagnosis and for philosophy of science. It should be taught at the pre-college level!"[1]

Given that this degree of fervour is unusual in a mathematician, lawyers should perhaps take Good's advice seriously. That is the purpose of this paper. It will give a summary of the Bayes Rule, look at how the courts have dealt with it and suggest how it might be used to assess criminal trial evidence so the accused is not prejudiced or, more seriously, wrongly convicted.

First, it is worth looking at Good's reasoning on the Simpson case. He accepts that Dershowitz's statement is true, but argues it is more legally relevant to estimate the probability that a husband murdered his wife when we know she was battered by her husband *and* we know she was murdered in 1994 by someone who is unknown at this stage. Combining the 1/1000 probability that a batterer will murder his wife and the probability of 1/10 that he will do it in 1994 (Good does not provide the reasoning for this latter probability in his letter) gives a probability of 1/10,000 that a wife batterer will kill his wife in 1994. Using the overall US annual murder rate of 1 per 10,000, the probability of a woman being murdered by someone not her husband is also, coincidentally, 1/10,000. Thus it is equally probable that a woman will be murdered by her batterer husband as by any other person or,

1 I.J. Good, "When batterer turns murderer" (1995) 375 Nature 541.

to put it in another form, the probability that the husband is guilty is one out of two. This result can be refined by taking the 1994 US murder rate for women victims (1/25,000) [2] as opposed to Good's rate for all victims (1/10,000). This refinement means it is probable seven times out of ten that a batterer husband is guilty of his wife's murder in the absence, of course, of contradictory evidence.

Although Professor Good's statistical reasoning was not used in the Simpson trial,[3] it appears to be a useful tool for triers of fact to fairly consider numerical circumstantial evidence in criminal trials and in civil trials, such as the tort of negligence, where proof of causation is necessary. Mathematically, Bayes Rule is a conditional probability theorem, defined by the equation:

$$\Pr(B|A) = \frac{\Pr(A|B)\Pr(B)}{\Pr(A|B)\Pr(B) + \Pr(A|\underline{B})\Pr(\underline{B})}$$

where: $\Pr(B|A)$ means the probability of event B given that event A has occurred,
$\Pr(A|B)$ means the probability of event A given that event B has occurred,
$\Pr(B)$ means the unconditional probability that event B will occur,
$\Pr(A|\underline{B})$ means the probability of event A given that event B has not occurred,
$\Pr(\underline{B})$ means the unconditional probability that event B will not occur.[4]

It is important, however, that statistical evidence like Bayes Rule be properly presented by expert witnesses, by counsel in argument and by judges in their charge to the jury. Such care is especially critical when dealing with the probability issues inherent in the presentation of DNA profile evidence in criminal cases. Because the high probabilities usually associated with a positive DNA match between a crime sample and an accused are so

2 *Sourcebook of Criminal Justice Statistics 1997*, (Washington, D.C.: U.S. Dept. of Justice, Bureau of Justice Statistics, 1998).

3 Simpson's defence did attempt to undermine the prosecution's DNA match evidence by statistically combining estimates of the probabilities that the blood samples from Simpson's glove, sock and car were contaminated in the laboratory, planted by police and compared with an inappropriate DNA match database. See W.C. Thompson, "DNA Evidence in the O.J. Simpson Trial" (1996) 67:4 University of Colorado Law Review at 827, and J.J. Koehler, "On Conveying the Probative Value of DNA Evidence: Frequencies, Likelihood Ratios, and Error Rates" (1996) 67:4 University of Colorado Law Review at 859.

4 D. Downing and J. Clark, *Statistics the Easy Way*, 3d ed. (New York: Barron's, 1997) at 69.

persuasive, cases are now being brought to court with little or no corroborating evidence. But, as statisticians David Balding and Peter Donnelly point out, while the consequences of erroneous reasoning can be most serious, "many studies show that untrained intuition is prone to error in reasoning with probabilities."[5] The particular error being warned about is the "prosecutor's fallacy," so named because it usually favours the prosecution in a criminal case.

To explain the fallacy, Balding and Donnelly propose that you are playing poker with the Archbishop of Canterbury (the authors are British and there the Archbishop is supposed to be an icon of honesty).[6] On the first hand of the game, the Archbishop deals himself a straight flush. There are two questions that could be asked of this unlikely occurrence:

1. What is the probability of the Archbishop dealing himself a straight flush if he were playing honestly?
2. What is the probability that the Archbishop is playing honestly, given that he has dealt himself a straight flush?

The answer to the first question is three in 216,580 — a small number. The answer to the second question, more relevant to assessing the probative value of evidence, would likely be higher, closer to one, if you think the Archbishop is honest. The authors make two points here: the low probability answer to the first question does not imply a low probability answer to the second, and, while the first answer is certain, the second will depend on your assessment of your playing companion's honesty.

Very small probabilities are also inherent in DNA identification evidence. A "crime sample" such as hair, blood, or semen is collected at the scene and compared with a sample taken from the defendant. The samples are said to "match" if the lengths of certain DNA (deoxyribonucleic acid) fragments are the same at three to five specific locations on each chromosome. An expert will usually calculate the probability that DNA from a randomly chosen innocent person, unrelated to the defendant, will match the DNA profile from the crime sample. Questions similar to those asked of the Archbishop's card-playing luck and ethics can then also be asked in connection with the DNA probability evidence:

1. What is the probability that the defendant's DNA profile will match the profile from the crime sample, if he or she is innocent?
2. What is the probability that the defendant is innocent, given that his or her DNA profile matches the profile from the crime sample?[7]

The first question assumes the defendant is innocent and asks about the chances of getting a match. The second question assumes the defendant's profile matches and asks about his or her innocence. The probability in the first question is usually low and can be ascertained with some certainty by experts in the field. This does not, however, ensure that the probability in the second question is low and it is this question which is of interest to the courts. The prosecutor's fallacy consists of giving the answer to the first question as the answer to the second. The authors add, "In general, statements which refer to the probability that the defendant is the source of the crime sample, or to the probability that the defendant is the culprit, are examples of the prosecutor's fallacy."[8] The role of the court, according to Balding and Donnelly, is to assess the DNA evidence along with all other

5 D.J. Balding and P. Donnelly, "The Prosecutor's Fallacy and DNA Evidence", [1994] Criminal Law Review 711.
6 See above at 713.
7 See above at 716.
8 See above at 716, footnote 18.

evidence and they suggest that to do this within the laws of probability requires the use of Bayes Rule. They note lawyers' concerns with numerically assessing the weight of court evidence, but say, "[i]n the present context, Bayes Rule seems to provide the only coherent method for combining other evidence with the numerical evidence associated with the DNA profiles."[9]

When used in this way, the logic of the Bayes Rule can be shown by weighing two alternative scenarios, each with two components:

1. a. The defendant is the culprit and
   b. the crime sample DNA profile matches that of the defendant.
2. a. Someone other than the defendant is the culprit and
   b. that person's DNA profile matches that of the defendant.

The authors say that the assessment of the probabilities of components 1.a and 2.a should be made on the basis of evidence other than the DNA evidence. If the jury assesses the probability of this evidence as low, for example if it tends to exonerate the defendant, or if the match was observed through a search of a DNA data bank or through a sample obtained for unrelated reasons, then the DNA evidence may not be sufficient to establish the defendant's guilt beyond a reasonable doubt.

Balding and Donnelly conclude that it is not possible to say that the defendant is the source of the crime sample, solely on the basis of the DNA evidence. It is also not appropriate for an expert witness to assess the other evidence. Therefore, the expert cannot give an opinion as to whether the defendant was the source of the crime sample. Such inferences are a matter for the trier of fact alone.

Both the prosecutor's fallacy and the other issue raised by Balding and Donnelly, that DNA evidence should be quantitatively combined with other evidence using Bayes Rule, emerged in two recent English Court of Appeal cases. One of them, *R. v. Adams*, was the first English case in which the Crown had relied exclusively on DNA evidence to establish identity.[10] The defendant was charged with rape and at his trial a prosecution expert testified that his DNA profile and one obtained from the crime scene matched. The chance of a randomly chosen unrelated man matching the profile was said to be one in 200,000,000. Professor Donnelly, co-author of the paper cited above, also testified. The decision reported him as saying that "it was logical and consistent for the jury to deal with the rest of the evidence in statistical terms and for the jury to do this using the Bayes Theorem." [11] Donnelly identified four areas of evidence that the jury could evaluate this way: the attacker had a local accent; the victim could not identify the defendant as her attacker; the defendant's own alibi evidence; and the alibi evidence of another person. Using his own probability assumptions about those areas of evidence and the Bayes Rule (or Bayes Theorem, as it is called here), Donnelly reduced the one in 200,000,000 chance that the attacker was not the accused to a one in 55 chance.[12] Revealingly, if the DNA match probability had been one in 2,000,000 and the same non-DNA probabilities were used, Donnelly calculated that the accused was twice as likely to be innocent as he was to be guilty.

9 See above at 717.
10 *R. v. Adams*, [1996] 2 Criminal Appeal Reports 467 (English Court of Appeal).
11 See above at 468F.
12 For details of this evaluation, see Appendix.

Adams was convicted at trial and appealed on the basis that the judge should have excluded the DNA evidence because it was no more than a rough estimate, inconclusive by itself and inadequate to found the prosecution's case. The Appeal Court had grave doubts as to whether the Bayes Rule was properly admissible, "because it trespasses on an area peculiarly and exclusively within the province of the jury, namely the way in which they evaluate the relationship between one piece of evidence and another." This trespass occurred, the Court held, because the items of evidence were assessed separately rather than "in the light of the strength of the chain of evidence in which it forms a part." More fundamentally, according to the Court, "[j]urors evaluate evidence and reach a conclusion not by means of a formula, mathematical or otherwise, but by the joint application of their individual common sense and knowledge of the world to the evidence before them."[13] Accordingly, the Court found that, "[t]o introduce Bayes Theorem, or any similar method, into a criminal trial plunges the jury into inappropriate and unnecessary realms of theory and complexity deflecting them from their proper task."[14] The Appeal Court decided that the trial judge concentrated his efforts on attempting to explain the defence argument based on the Bayes Theorem to the jury, and did not give sufficient guidance on how to evaluate the prosecution case, which was based entirely on the DNA evidence. A re-trial was therefore ordered.

In *R. v. Doheny,*[15] the English Court of Appeal again addressed the role of expert evidence in assessing the statistical validity of DNA matches. Again, the defendant was convicted of rape and appealed on the basis that the forensic evidence was presented to the jury in a misleading and inaccurate manner. In arriving at a probability that the DNA match was random, the prosecution's DNA expert combined the results of a multi-locus probe test, from many DNA locations of unknown origin, with the results of single locus probe tests, from single known DNA locations. Because these two tests may not be independent, the Court found that the DNA expert inappropriately combined them and for that reason, allowed the appeal. But in coming to that decision, the Court offered the following *obiter* comments on the prosecutor's fallacy:

> The significance of the DNA evidence will depend critically upon what else is known about the suspect. If he has a convincing alibi at the other end of England at the time of the crime, it will appear highly improbable that he can have been responsible for the crime, despite his matching DNA profile. If, however, he was near the scene of the crime when it was committed, or has been identified as a suspect because of other evidence which suggests he may have been responsible for the crime, the DNA evidence becomes very significant.[16]

The Court endorsed Balding and Donnelly's contention that DNA evidence should not be used alone: "[T]he random occurrence data deduced from the DNA evidence, when combined with sufficient additional evidence to give it significance, is highly probative."[17] This task is one for the jury, the Appeal Court warned, and "the scientists should not be asked his [sic] opinion on the likelihood that it was the defendant who left the crime stain, nor when giving evidence should he use terminology which may lead the jury to believe that he is expressing such an opinion."[18] The Court, however, strongly endorsed the

13 See note 10 at 481E.
14 See above at 482D.
15 *R. v. Doheny*, [1997] 1 Criminal Appeal Reports 369 (English Court of Appeal).
16 See above at 373D.
17 See above at 373F.
18 See above at 374G.

comment in *Adams* deprecating the use of Bayes Theorem.

In the meantime, Adams was convicted on his retrial. Again, the Crown's case rested entirely on DNA evidence and again Adams's defence called Professor Donnelly to show how the Bayes Theorem could be used to integrate the non-DNA probabilities with the DNA probabilities. The trial judge allowed Donnelly to give the jury a questionnaire about the non-DNA evidence it had heard during the trial. The defence invited the jury to answer each of the 24 questions as a numerical probability and to substitute its answers in a formula at the end of the questionnaire to give the jury's view of the probability that the defendant committed the offence. While the trial judge left it open for the jury to use the questionnaire, he characterized it as a statistical approach and contrasted with the common sense approach, "which juries in this country have used for many, many years, pretty satisfactorily."[19]

Adams appealed on the grounds that the prosecution should not be allowed to adduce statistical evidence of DNA match probabilities unless the defence is allowed to call statistical evidence on the probabilities of non-scientific evidence, and that the trial judge should not have encouraged the jury to apply their common sense rather than applying the Bayes Rule. After calling reliance on Bayes Theorem evidence "a recipe for confusion, misunderstanding and misjudgment"[20] the Court held that "[i]n cases such as this, lacking special features absent here, expert evidence should not be admitted to induce juries to attach mathematical values to probabilities arising from non-scientific evidence adduced at trial."[21] The Court did not directly address the defence argument that if the numerical probabilities for non-scientific evidence were inadmissible, then numerical probabilities for the DNA match evidence should also be inadmissible. Instead, it merely described with approval the normal course in such trials of presenting only the DNA evidence numerically. The appeal was dismissed.

In Canada, courts have varied greatly in the attention they have paid to the issues of the prosecutor's fallacy or the use of the Bayes Rule to assess DNA evidence with other evidence. The three cases considered here come from the Courts of Appeal of three different provinces. In *R. v. Baptiste*, the defendant, an interior B.C. aboriginal man, was appealing a conviction of murder while committing sexual assault.[22] His appeal was based, in part, on the fact that there was no database of interior Indians with which to scientifically estimate the chances of a DNA match.[23] The British Columbia Court of Appeal appeared satisfied that as long as the results were expressed in qualitative rather than quantitative terms, the evidence could be admitted. As appears common in some Canadian cases, the prosecutor's fallacy was breached in *Baptiste* without any reported comment from the bench or counsel. For example, the prosecution's expert "testified that the possibility of the semen found in the victim's vagina coming from someone other than the appellant was remote."[24]

What is, perhaps, an extreme reaction to scientific and statistical evidence in a case involving DNA matches can be found in *R. v. Legere*.[25] The appellant was again an aboriginal man appealing a conviction of murder while committing a sexual assault. His appeal

19 *R. v. Adams (No. 2)*, [1998] Criminal Appeal Reports 377 at 381 (English Court of Appeal).
20 See above at 384D.
21 See above at 385C.
22 *R. v. Baptiste* (1994), 88 Canadian Criminal Cases (3d) 211 (British Columbia Court of Appeal).
23 See above at 222 to 223.
24 See above at 223.
25 *R. v. Legere* (1994), 35 Criminal Reports (4th) 1 (New Brunswick Court of Appeal).

argument largely focused on "whether or not the frequencies of genetic patterns might be different because of ethnic ancestry, regional variations or the fact that inter-breeding has occurred in any particular geographic area."[26] The New Brunswick Court of Appeal accepted, without discussion, the Crown's evidence on the scientific and statistical issues raised by the accused's argument, except to comment that the prosecution's population geneticist had experience with data from human populations while the defence's population geneticist worked with data from insect populations.

In *R. v. Terceira*, the Ontario Court of Appeal took a more careful approach to DNA match evidence.[27] First, the Court observed that "[i]n the absence of other qualification, a match is no more than a failure to exclude a suspect's DNA from the crime scene." [28] This obvious, but hitherto unremarked, point was perhaps prompted by the second Guy Paul Morin appeal, where DNA techniques, not available at the time of his original trial, found no match between Morin and the crime of which he was convicted. This fresh evidence resulted in the conviction being overturned and Morin being acquitted.[29] But when a match is found, *Terceira* said that probability statistics would have to be applied to determine its significance. The defence objected to the admission of actual figures for random match probability, arguing that the prejudicial effect of the high probability numbers would outweigh their probative value. The Court left this issue in the hands of the trial judge:

> I do not believe that there should be an absolute prohibition against the introduction of specific match figures. The appellant correctly notes that the case-law reflects conflicting conclusions as to the admissibility of DNA probability statistics. It was justifiable to admit the probability statistics in this case, and it might be in others. I would leave the matter to the discretion of the trial judge in the particular case.[30]

The use of numbers was justified in *Terceira* because "[t]he problem with qualitative modifiers such as rare, unlikely and remote is that they are awkward and fail to convey the potency of the match."[31] The Court pointed out that the defence was able to present the probability numbers of its own experts and to cross-examine the prosecution's experts and the trial judge had taken care to instruct the jury, "[n]ot to get bedazzled or unduly swayed by some of the large numbers used in the DNA evidence."[32]

But the statisticians did get one of their two main issues acknowledged by a Canadian court. *Terceira* did consider the concern "that the jury will be permitted to fall into what is referred to as 'the prosecutor's fallacy': equating the probability of a random match with the probability of the appellant's innocence."[33] In this case, the Court found that the judge had properly instructed the jury and that "there is no basis for an inference that the jury would have used the statistics as a predictor of the likelihood of guilt."[34] Leave has been granted to appeal *Terceira* to the Supreme Court of Canada.[35]

The introduction of DNA profile matching evidence over the last six years has added an enormously seductive weapon to the prosecutor's arsenal. One Ontario trial judge referred to its "mystical infallibility."[36] Unlike, say, fingerprints, a person's genetic code is impossible to cover up, can be identified in very small scraps of real evidence, and may be recovered long after the event. But it comes at a cost. Again, unlike fingerprints, it cannot

26 See above at 18.
27 *R. v. Terceira* (1998), 38 Ontario Reports (3d) 175 (Ontario Court of Appeal).
28 See above at 184.
29 *R. v. Morin* (1995), 37 Criminal Reports (4th) 395 (Ontario Court of Appeal).
30 See note 27 at 195.
31 See above at 200.
32 See above at 201.
33 See above at 200.
34 See above at 200.
35 *R. v. Terceira*, [1998] Supreme Court of Canada, Applications for Leave to Appeal No. 126 (Quicklaw).
36 *R. v. Melaragni* (1992), 93 Canadian Criminal Cases (3d) 348 at 354 (Ontario General Division).

absolutely match a crime scene sample with a particular defendant — almost, but not quite. The prosecutor has to allow that there are likely others out there with the same DNA characteristics as the person she wants to convict. The prosecution expert has to express this likelihood as a very small number, usually a one in several millions probability. These kinds of numbers and the science that produces them seem to unsettle the courts. Consider the trial judge's charge to the jury in *Legere*:

> Forget about discrete alleles, forget about Hardy-Weinberg theory equilibrium, forget about polyzygotes, monozygotes, even. I don't understand those things and you don't either and we're not expected to understand them, we're not scientists ... You may have understood Dr. Carmody's new equation that he devised when I didn't. [37]

There seem to be real fears being expressed there. The fear that courts may mechanically reach verdicts by formula is well founded. For example, a formulistic verdict was argued in the classic case that started the probability evidence debate, *People* v. *Collins*.[38] Prosecutors in California tried to convict a bearded black man and a white woman with a blonde ponytail driving a yellow car on the basis of the low probability that another couple of that description could have been in the vicinity of the purse-snatching with which they were charged.

The other fear, of having to explain ideas one doesn't understand, could perhaps have been alleviated if the judge's legal education had included the type of statistical instruction identified by Professor Good. Instead, judges retreat behind the jury's "common sense and knowledge of the world." And here we meet another fear — the real concern of Balding and Donnelly that untrained intuition is prone to error when reasoning with probabilities. The struggle to reconcile these two opposing fears is reflected in the cases surveyed in this summary paper. The courts have generally taken three approaches to resolving this dilemma:

1. *The experts give the answer.*

This approach was passively adopted in two of the Canadian cases noted above: *Baptiste* and *Legere*. It has been shown to be based on false statistical reasoning (prosecutor's fallacy) and has been rejected by the English courts, most firmly in *Adams (No 2)*, and by the Ontario Court of Appeal in *Terceira*.

2. *Don't use any numbers.*

In *Baptiste*, because of difficulties with the database, the expert could only describe the probabilities associated with the DNA matches as "remote" and "extremely remote." In *Terceira*, the argument for excluding quantitative statements of DNA match probabilities was based on admissibility rather than technical issues. In that case, the Appeal Court found that the jury was not overwhelmed by the magnitude of the numbers but left it open that a judge in another case might decide differently.

3. *Numbers are permissible for science but not for other evidence.*

This reflects the current position of the English Court of Appeal. It rejects instruction of juries on the use of statistical formulae, such as Bayes Rule, to evaluate DNA and non-scientific evidence together. The issue does not appear to have been raised in Canadian

37 See note 25 at 21.
38 *People* v. *Collins*, 438 Pacific Reporter 2d 33 (California 1968). This and subsequent cases prompted legal scholars to devise mathematical models that could be applied to judgments. Most of these models required the finder of fact to determine the probability of the event in question and compare it with a fixed standard. See for example: Neil Cohen, "Confidence in Probability: Burdens of Persuasion in a World of Imperfect Knowledge" (1985) 60 New York University Law Review 385.

courts. The strong possibility of an erroneous conviction is graphically illustrated by comparing two of the cases considered in this paper. Attaching reasonable numerical probabilities to the non-DNA evidence in *Adams*, Professor Donnelly used Bayes Rule to calculate that, had the DNA match probabilities been one in 2,000,000 instead of one in 200,000,000, the probability of the accused's innocence would have been twice as great as his guilt. Yet in *Terceira*, the lowest DNA match probability found by the Court was one in 1,800,000 and the highest, one in 1,500. Thus, it is quite possible that an innocent person could be convicted of a very serious crime based on a court's common sense consideration of seemingly compelling DNA evidence that, when looked at mathematically, could not prove guilt on a balance of probabilities, let alone beyond a reasonable doubt.

The real possibility of a serious miscarriage of justice requires that judges stop denying their math phobia and admit that, like most people, they and juries cannot reason well when presented with probabilities. As a matter of urgency, courts should adopt workable ways of quantitatively weighing evidence such as DNA matches where very low probabilities are expressed numerically. One approach might be to leave the decision to introduce numerical, as opposed to descriptive, probability evidence in criminal trials in the hands of the prosecution, with the provision that should it decide to go that route, the defence has the option of quantifying the non-scientific evidence. Before such a scheme is feasible, however, legal and statistics scholars will have to design an easily understood and manipulated explanation of the Bayes Rule and judges and lawyers will have to learn how to use and explain it. Thus in trials where probability evidence is being offered, either it and the non-probability evidence must be expressed qualitatively and evaluated in the normal way, or both must be expressed numerically and evaluated using the Bayes Rule.

There is a further possibility that the seductiveness of statistics could produce "evidence" on the basis of historical group behaviours. Compelling as Professor Good's example might be, it does rely on the argument that because wife-beaters are generally prone to murdering their wives, this particular wife-beating defendant is likely to have murdered his wife. The Supreme Court of Canada, however, may have opened the way for this type of expert opinion-based character evidence to be admitted. In *R.* v. *Mohan*, Justice Sopinka stated:

> Before an expert's opinion is admitted as evidence, the trial judge must be satisfied, as a matter of law, that either the perpetrator of the crime or the accused has distinctive behavioral characteristics such that a comparison of one with the other will be of material assistance in determining innocence or guilt. [39]

Although the rule requires that the type of crime being prosecuted could only be committed by persons with distinctive behaviour characteristics, this was not established for the crimes with which Dr. Mohan was charged.[40] The rule here should be that statistical evidence should only be based on large populations and separated only into very broad categories such as by sex. In particular, the use of such evidence in small, isolated, intermarried communities, as in *Baptiste* and *Legere*, without well-documented databases for that community and without careful probability analysis could again lead to erroneous convictions.

39 *R.* v. *Mohan*, [1994] 2 Supreme Court Reports 9 at 37.
40 D.M. Paciocco & L. Stuesser, *The Law of Evidence*, (Concord: Irwin Law, 1996) at 122.

Appendix

Professor Donnelly's expert evidence as to the steps the jury might have taken if it had applied the Bayes Theorem to the evidence in *Adams* can be reconstructed from the transcript of his examination in chief reproduced in the Court of Appeal decision:[41]

1. Assuming a 75 per cent chance that the accent evidence meant the attacker was a local man, combined with a local male population between the ages of 18 and 60 of about 150,000, the chance the attacker was the accused is one in 200,000 (1/150,000 x 75/100).

2. Assuming a 90 per cent chance that an innocent man would not match the victim's description of her attacker and assuming a 10 per cent chance that the victim would describe someone who was not her attacker, the chance the attacker was the accused is one in 9 (10/100 x 100/90).

3. Assuming the accused's alibi evidence was neutral, the chance the attacker was the accused is one in one.

4. Assuming a 25 per cent chance a witness would give an alibi if the accused was guilty, and assuming a 50 per cent chance the witness would give an alibi if the accused was innocent, the chance the attacker was the accused is one in two (25/100 x 100/50).

5. As the four probabilities described above are independent of each other, they can be multiplied together to give a chance, based on the non-DNA evidence, that the attacker was the accused of one in 3,600,000 (1/200,000 x 1/9 x 1/1 x 1/2).

6. Assuming a 100 per cent chance that the crime scene DNA would match the accused's DNA if he were the attacker, and accepting the one in 200,000,000 chance that the DNA samples would match if he were *not* the attacker, and combining those with the one in 3,600,000 chance that the attacker was the accused based on the non-DNA evidence, gives an overall chance that the attacker was *not* the accused of one in 55 (1/200,000,000 x 100/100 x 3,600,000/1).

41 See note 10 at 470 to 477.