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Notes and Comments

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Scientific Statistical Methodology and The Doctrine of "Reasonable Doubt" in Criminal Law; (With Specific Reference to the Breath Analysis for Blood Alcohol) Empirical Fact or Legal Ficton?

Lawyers pride themselves on being men of reason. After all, they postulate, it is the "reasonable man" who is enshrined at the apex of the Anglo-American legal system in the adjudication of civil disputes; it is the legally trained mind that proves so finely honed a tool in the area of problem solving in private practice; the rational decisional process is the hallmark of the judicial mind. Where the life or liberty of an individual is in contention this expert "sense" of reason is brought one step further — the criminal law, with few exceptions, will not countenance a mere "preponderance of evidence" or "balance of probabilities" in the establishment of the burden of proof; there must be a greater degree of certitude. This latter goal is attained through the application of the doctrine of "reasonable doubt".

The parameters with which we need be concerned, at least in the context of the imprecise "social organism" that constitutes law, are thus obvious. It is something less than *absolute certainty*.[1] The necessary legal goal will have been attained once any arbiters in the criminal decisional process have reached an *abiding conviction to a moral certainty* as to the guilt of an accused person.[2] The posterior

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1. A negative type of definition was rendered in a recent American decision when the Wyoming Supreme Court ruled that finding guilt beyond a *reasonable* doubt does not mean finding it to an absolute certainty. *Cosco* v. *State* (1974), 521 P. (2d) 1345
2. Perhaps the best definition of reasonable doubt was that given by a Canadian

parameter (absolute certainty), can be expressed very simply in the terminology of mathematical probabilities. *Absolute certainty* must be taken to mean (both to the mathematicians and mere lawyers) one hundred percent probability. The problem arises in defining the anterior parameters. An abiding conviction to a moral certainty, expressed in terms of mathematical probability, is certainly something less than one hundred percent. The question is, of course, exactly how much less? At exactly what point in the integrum do mathematical probability and legal "reason" coincide?

This conundrum has been dealt with rather extensively in the past. It is interesting to note that as long ago as the second half of the seventeenth century, Leibnitz, the famous scientist, applied an elementary scale of mathematical scholastic proofs in endeavouring to assess moral certitude in both criminal and civil legal proceedings.[3] In recent times, Professors Finklestein and Fairley were learned proponents of the utilization of scientific methodology in certain instances in order to augment mere legal "intuition".[4] Tribe was their worthy protagonist who pointed out the obvious thin ice. In that respect Professor Tribe could be likened to that sanguine cynic (unknown to the authors of this article) who once observed that: "Statistics are like a bikini — what they reveal are interesting, but what they obscure can sometimes prove vital". The main case in point was that of *People* v. *Collins;*[5] The prime bone of contention was the use of the Bayesian[6] approach in a legal context.

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judge, Mr. Justice Mathers, in the case of *R.* v. *Krafchenko* (1914), 17 D.L.R. 244 at 262, where in in his direction to the jury in a murder case, he stated that the prosecution would have satisfied the onus of proving the guilt of the accused beyond a *reasonable doubt* once the jurors had attained "an abiding conviction to a moral certainty" to the effect.

3. Leibnitz, G. W., *Allgemeine Untersuchungen Über Die Analyse Der Begriffe Und Wahren Satze* (1686)

4. See: (a) M.O. Finkelstein and W. B. Fairley, *A Bayesian Approach to Identification Evidence* (1970), 83 Harv. L.R. 489; (b) L.H. Tribe, *Trial by Mathematics: Precision and Ritual in the Legal* Process (1971), 84 Harv. L.R. 1329; (c) M.O. Finkelstein and W. B. Fairley, *A Comment on "Trial by Mathematics"* (1971), 84 Harv. L.R. 1801; (d) L. H. Tribe, *A Further Critique of* Mathematical Proof (1971), 84 Harv. L. R. 1810

5. (1968) 68 Cal. (2d) 319; 438 P.(2d) 33; 66 Cal. Rptr. 497 (Supreme Court of California *en banc)*

6. See: J. Cornfield, *The Bayesian Outlook and its Application,* Biometrics (December 1969) 617 at 617: "The Bayesian outlook can be summarized in a single sentence: any inferential or decision process that does not follow from some likelihood function and some set of priors has objectively verifiable deficiencies. The application of this outlook is a largely extra-mathematical task, requiring the selection of likelihoods and priors that are appropriate to given problem situations,

In order to refresh your memories, *People* v. *Collins* dealt with a case of assault and robbery. The prosecution's evidence as to identification came from two sources. The victim, who had been assaulted from behind, stated that she saw a young woman with blond hair running down the alley which was the scene of the crime. An independent witness stated that a Caucasian woman with a blond ponytail ran out of the alley and left in a yellow automobile driven by a Negro with a beard and moustache. Relying on these descriptions the police arrested what they thought was the appropriate inter-racial couple. At their trial the prosecution was able to deduce, by means of an expert witness, statistical "evidence" to the effect that the probability that they were not the couple in question was something in the order of one in twelve million. Thus the statistical inference of guilt was overwhelming; and so the trial court ruled. The conviction was overruled on appeal, the Supreme Court of California holding that the mathematical formulations were subject to attack and should not have been admitted in evidence.

Very few such instances of extreme probability are likely to be encountered. Perhaps even rarer are cases of extreme diversity in probability. One such example, a Swedish overtime parking case, has been noted by Professor Tribe.[7] [8] There, a police officer had ticketed a car parked in a one-hour zone after he noted that the tire valves of the front and rear wheels at the curbside of the car were in the same positions before and after a period in excess of one hour. The driver's defence was that he had moved his car during the material time and had returned to the same parking spot; where, fortuitously, his tires came to rest in approximately the same positions as before. The court noted that, assuming the front and rear tires rotate independently of each other, the probability of such an event happening would be 1 in 144. If we were to express this in percentage terms, it would equate to 0.694%. This the court held was not sufficient to establish guilt beyond a reasonable doubt. However, the court further noted that if all four wheels on the car

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with the determination of what is appropriate requiring . . . 'responsible and independent thinkers applying their minds and imaginations to the detailed interpretation of verifiable observations'".

7. *Supra*, note 4 (b) at 1340.

8. This particular case, reported in *Svensk juristidining*, 47 (1962) 17-32, was also discussed by H. Zeisel and H. Kalven Jr. in an article entitled: *Parking Tickets and Missing Women: Statistics and the Law*, in *Statistics: A guide to the Unknown*, ed. J. M. Tanur (San Franscisco: Holden Day Inc., 1972) at 102-11.

rotated independently of one another, then the probability of the four valve stems coming to rest in the same positions as when the car had been initially parked would be 1 in 20,736. In percentage terms, this would be equivalent to 0.00482%. Such a probability would be more than ample for conviction.

Although the above cases are interesting, they are so isolated in nature that they apparently do little to lay down definitive guidelines in the area with which we are concerned. However, they are of more than academic interest, particularly if they are examined in terms of positive probability. In *Collins,* the probability that the man and woman arrested were the guilty parties is so overwhelming as to almost equate to 100%. This holds true even if one were to grossly discount some of the computations used by the prosecution's expert witness. An infinitesimal deviation from 100% would not be absolute certainty, but it would certainly be something very close to it. Analyzing the Swedish parking case in the same manner, it is readily ascertainable that the first probability referred to (1/144 or 0.694% works out to a 99.306% (100%-0.694%) probability that the accused was guilty. In the event that the valves are noted for all four tires which rotate independently, the probability is 1/20,736 (0.00482%) or 99.995% (100% — .0048%) that the accused was guilty. Are the courts really capable of rendering that fine a mathematical distinction between guilt and non-guilt — particularly where the difference is a mere ²/₃rd's of a percentage point? Is the judicial sense of discernment really that much more perceptive than the mathematician's? Where this problem can become of large importance is in the area of the criminal law where the prosecution relies quite heavily on the use of modern technical apparatus to secure a conviction. The polygraph or lie detector, radar, fingerprinting, "voiceprinters", Breathalyzers; these are only some of the more obvious examples which come immediately to mind. All of these scientific aids to contemporary law enforcement are subject to some degree of error both in their operation and in the interpretation of their results.[9] It is the Breathalyzer that is at present probably the most extensively utilized scientific instrument in court proceedings; indeed most jurisdictions have Breathalyzer evidence uppermost in mind when enacting criminal legislation pertaining to the offences of impaired and drunken driving. Therefore, it is with

9. This question has recently been discussed by David Patterson in *What Can Science do for the Law* (1975), 15 The Forensic Science Society 3.

the mathematical treatment of Breathalyzer evidence that this paper will primarily deal.

The Breathalyzer can be described as a machine that renders direct readings of the concentration of ethyl alcohol by volume in an individual's bloodstream.[10] Chemically ethyl alcohol can be oxidized to acetic acid. A vial containing a solution of potassium dichromate in sulfuric acid in a fixed concentration is inserted into the instrument. Prior to oxidation, potassium dichromate is yellow-orange in color. As oxidation progresses the solution gradually changes to green, the change in color being directly proportional to the degree of oxidation. The suspect is asked to breathe deeply into the mouthpiece of the instrument, thus emitting alveolar[11] air which passes through the dichromate solution. A "colorimeter" scans the solution photoelectrically, and, in the event of any color change, a needle on the machine moves over a dial marked off in calibrations equivalent to a direct percentage reading of the volume amount of ethyl alcohol in the alveolar breath.

We have sketched the physical makeup and the operation of the Breathalyzer with a very broad brush. However, our description should suffice to point out, even to the scientifically uninitiated, that this instrument is certainly error prone. The exact degree of error inherent in the operation of the Breathalyzer has recently been reviewed by one researcher from both a scientific and legal standpoint, and he concluded that the accuracy with which breath alcohol levels can be determined is about $\pm 10\%$.[12] This is equivalent to $\pm 0.025\%$ of alcohol in blood.[13]

To a certain extent, law enforcement agencies tend to minimize these error characteristics, as it is generally accepted that a blood alcohol level as determined from breath measurement is about 0.005% (5 mg alcohol/100 ml blood) *lower* than that of measurements obtained from chemically analyzing an actual venous

10. For a more detailed discussion see R. F. Brokenstein, *The Evolution of Modern Instruments for Breath Alcohol Analysis* (1960), 5 Journal of Forensic Sciences 395.

11. For the purposes of simplicity "alveolar" breath can be described as "deep-lung" breath. For a more detailed description see (a) N. H. Spector, *Alcohol Breath Tests: Gross Errors in Current Methods of Measuring Alveolar Gas Concentrations* (1971), 172 Science 57; (b) K. M. Dubowski, *Biological Aspects of Breath-Alcohol Analysis* (1974), 20/2 Clinical Chemistry, 294.

12. W. S. Lovell, *Breath Tests for Determining Alcohol in the Blood* (1972), 178 Science 264

13. *Supra*, note 11(a)

blood sample.[14] [15] In this respect it is certainly true that an accused driver is given the benefit of some doubt in the given accuracy of any breath measurement. What has not been widely publicized, however, is the large variation that can exist amongst individuals in regard to the relative values of alcohol per unit of volume in the bloodstream and alcohol per unit of volume in the alveolar breath. The accepted multiplicative factor in this regard is 2100, that is: that in any given individual the concentration of alcohol per unit of volume of blood is accepted as[16] 2100 times that of the concentration of alcohol per unit of volume of alveolar breath. All measurements made with the Breathalyzer are based on this factor of 2100, it is a scientific principle that emanates from what is known as "Henry's Law".[17] [18]

To the knowledge of the authors, there has been to date no serious attempt to analyse breath tests statistically for blood alcohol levels of intoxicated drivers. This we shall now attempt to do; commencing with a statistical treatment of the errors inherent in any scientific measurement and concluding with percentage probabilities of verifiable accuracy relating to the various degrees of impairment and intoxication. We shall use as our benchmark a rather typical criminal statute in this respect: namely the relevant provisions of the Criminal Code of Canada,[19] the ".08" type of legislation now familiar to many workers in this field.

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14. B. B. Coldwell and H. W. Smith, *Alcohol Levels in Body Fluids After Ingestion of Distilled Spirits* (1959), 37 Can. J. Biochem. 43

15. Report on Impaired Driving Tests, ed. B. B. Coldwell, Queen's Printer, Ottawa (1957)

16. (a) M. F. Mason and K. M. Dubowski, *Alcohol, Traffic, and Chemical Testing in the United States: A Resume and Some Remaining Problems* (1974), 20/2 Clinical Chemistry 126
 (b) Proceedings of the Ad Hoc Committee on Blood/Breath Alcohol ratio (January, 1972), Indiana University Law School, Indianapolis, Indiana

17. Henry's Law states that at constant temperature the concentration of a gas dissolved in a solvent is proportional to the pressure of that gas above the solution. Thus the air in the lung picks up a fixed proportion of alcohol from the blood with which it is equilibrated.

18. The variation between breath alcohol and blood alcohol levels will be discussed later. See p. 359, Fig. 2 *infra*.

19. R.S.C. 1975, c. 93, s. 17 provides as follows: "236. (1) Every one who drives a motor vehicle or has the care or control of a motor vehicle, whether it is in motion or not, having consumed alcohol in such a quantity that the proportion thereof in his blood exceeds 80 milligrams of alcohol in 100 millilitres of blood, is guilty of an indictable offence or an offence punishable on summary conviction and a liable
(a) for a first offence, to a fine of not more than two thousand dollars and not less

Error Statistics

Every measurement has an error associated with it. By repeating the measurement many times a distribution of the values can be obtained from which an average value can be calculated. The error associated with the average value can be assigned with a degree of confidence determined by the spread in the distribution of the original measured values. An example of the variations of a measurement is in the determination of the velocity of light in vacuum (Table 1).

TABLE 1

Velocity of light in vacuum*

Year of Determination	*C(km/s)*	*Probable Error (± km/s)*
1874	299990	200
1879	299910	50
1882	299860	30
1883	299835	60
1902	299901	84
1906	299784	10
1923	299782	30
1926	299798	15
1928	299786	10
1932	299774	4
1936	299771	10
1937	299771	10
1940	299776	6
1970+	299792.50	0.10
Present+	299792.458	0.012

*R. T. Birge (1941), Rep. Progr. Phys. 8, 90
+E. R. Cohen (1974), Res/Div. 25, 32-26

The table shows how the value of a simple physical constant determined over many years gradually increases in precision (the error decreases) though the absolute value can change considerably. A physiological constant (the (2100 factor) is more subject to error and to a great variation from one individual to another.

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than fifty dollars or to imprisonment for six months or to both;
(b) for a second offence, to imprisonment for not more than one year and not less than fourteen days; and
(c) for each subsequent offence, to imprisonment for not more than two years and not less than three months . . . .

The error in a measurement is usually expressed by using the sample standard deviation which is occasionally defined as the square root of the mean of the sum of squares of deviations d_i

$$s^1 = \sqrt{\frac{\sum\limits_i d_i^2}{N}} \qquad (1)^{20}$$

where N is the sample size and d_i is defined as

$$d_i = x_i - m \qquad (2)$$

with x_i being the value of a single measurement and m the average (or mean) of all the measurements in the sample, i.e.

$$m = \frac{\sum\limits_i x_i}{N} \qquad (3)$$

The sample standard deviation is usually defined[21] by

$$s = \sqrt{\frac{\sum\limits_i d_i^2}{N-1}} \qquad (4)$$

For large samples $N \simeq N\text{-}1$ and little differences exists between formulas (1) and (4).

The Gaussian distribution or error curve is the relationship which often characterizes the distribution of observations about a mean value

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20. Σ refers to the sum of,
i.e. $\Sigma x_i = x_1 + x_2 + x_3 + x_4 \ldots\ldots x_n$

21. The square of the sample standard deviation is the sample variance. In order for this quantity to be an unbiased estimator of the population variance, σ^2, we need to alter the quantity in equation (1) slightly.

The equation is given by

$$f_{(x)} = \frac{1}{\sqrt{2\pi\sigma^2}} \; e^{\frac{-(x-\mu)^2}{2\sigma^2}}$$

where μ is the population mean. When $x = \mu$, $f_{(x)} = \frac{1}{\sqrt{2\pi\sigma^2}}$ and when $x = -\infty$ or $+\infty$, $f_{(x)} = 0$. This is shown in figure 1.

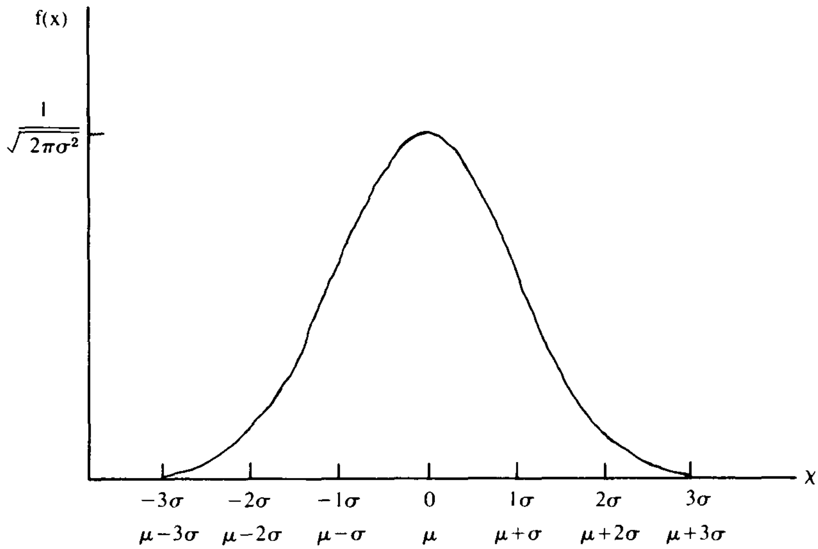

Figure 1 — Gaussian Distribution Plot

of $f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \; e\text{-} \frac{(x-\mu)^2}{2\sigma^2}$

showing deviations from the mean in terms of $\pm 1\sigma$, $\pm 2\sigma$, and $\pm 3\sigma$

The area of the curve bound by $x = \mu - \sigma$ to $x = \mu + \sigma$ corresponds to 68.3% of the total area and implies that the value of the sample mean is between $\mu \pm \sigma$ with a probability of 0.68.

Similarly 95.4% of the distribution (area) lies within the limits $x = \mu - 2\sigma$ to $\mu + 2\sigma$ and 99.7% of the distribution lies within the limit $x = \mu - 3\sigma$ to $x = \mu + 3\sigma$.

The Breath and Blood Alcohol Relationship

The factor relating blood alcohol to breath alcohol level (2100) is an empirical factor determined experimentally by simultaneously measuring the alcohol level in breath and blood many times and in many individuals. The analysis of one such study (footnotes 14 and 15) is shown in Figure 2 where the (Breath alcohol — Blood alcohol) is plotted against the frequency of occurrence for 253 tests in which alcohol levels ranged from 0.000% to 0.22% (0 to 220 mg/100 ml). An analysis of the results shows that the breath alcohol values are on the average 5 mg/100 ml lower than the blood alcohol results. The standard deviation s, is 12.3 mg/100 ml (14).

Figure 2, as plotted by the authors, conforms with the standard "Gaussian" configuration, thus enhancing confidence in the accuracy of our interpretation of the results. A more rigorous statistical treatment of the results is presented in the Appendix. The calculated probabilities are not significantly different from the simplified treatment which follows.

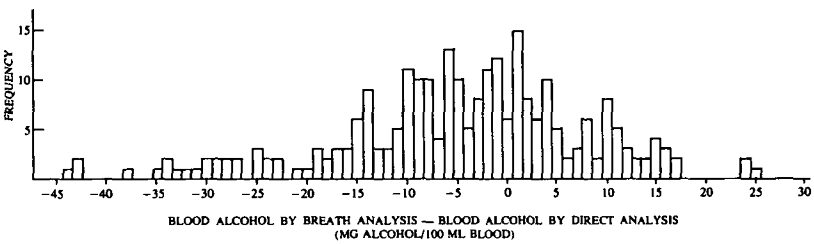

Figure 2 — Plot of Frequency against (Blood alcohol by breath analysis — Blood alcohol by direct analysis) in mg of alcohol per 100 ml of blood in 253 tests.

The Criminal Code of Canada specifies 80 mg alcohol/100 ml blood as the limit of sobriety.[22] The essence of that particular specified offence is that an accused possess a level of alcohol in his blood stream in excess of 80 mg alcohol/100 ml blood (0.080%). However, the breath alcohol instrument can only give blood alcohol values with limited confidence based on the standard deviation and probability consideration. For example, a driver who is assigned a blood alcohol level of 105 mg/100 ml (0.100%) from breath tests would be considered to have a reading[23] of $x \pm s$ or (105 - 12.3)

22. *Supra*, note 19

23. One might note that since σ is unknown the t distribution should be used in setting these limits. However when $N = 253, t_{(252)}$ is very well approximated by a standard normal variate.

mg/100 ml to (105 + 12.3) mg/100 ml i.e. 92.7 to 117.3 ml/100 ml with 68.3% confidence or $\frac{100 - 68.3}{2} = \frac{31.7}{2} = 15.8\%$ probability that his blood level is in fact lower than 92.7 mg/100 ml.

Similarly for a higher confidence level the error limit must be enlarged, i.e. for x ± 2s or (105 - 24.6) to (105 ± 24.6) i.e. for 80.4 to 129.6 mg/100 ml, the confidence level is 95.4%. Thus there is a 2.3% probability that the blood level can be lower than 80.4 mg/100 ml. With an error allowance of 3s there is only 0.14% probability that his blood level can be lower than 68.1 mg/100 ml.[24]

Table 2 gives the percentage probability that a specific measurement x is lower than x - $n\sigma$ where n has values of from 0.5 to 5.

Table 2

Proportion of the normal distribution curve lying below various values of $\mu - n\sigma$

n	*% probability*
0.5	30.9
1.0	15.9
1.5	6.7
2.0	2.3
2.5	0.62
3.0	0.14
3.5	0.023
4.0	0.0032
4.5	0.00034
5.0	0.00004

The foregoing data can lead to some interesting analysis. A previous researcher delving into the field of statistics and legal evidence concluded that it was seldom possible to apply an exact probability term to the doctrine of reasonable doubt.[25] This is perhaps a classic understatement. Referring back to *Collins* and the *Swedish parking* cases, we believe it would be fair comment to state

24. A value of 5 mg/100 ml alcohol is added to these values to correct for the fact that the breath alcohol instrument gives lower values of blood levels.
25. H. Zeisel, *Statistics as Legal Evidence* (1960), International Encycolopedia of Social Sciences Vol. 15, ed. D. L. Sills (MacMillan & Co., 1960) at 246-50

that there the courts did not accept circumstances verging on absolute certainty as sufficient to establish guilt beyond a reasonable doubt. This is difficult, if not impossible, to reconcile with the breath alcohol statistical data. It should be obvious from both a legal and mathematical point of view that by far the most contentious issues arising in court proceedings based on breath alcohol evidence are those involving drivers who have incurred readings within the 0.08% to 0.11% range. Engaging in a very rough computation, it is readily observable that this particular segment of the evidentiary spectrum is subject to a probability of innocence somewhere in the neighbourhood of a few percent. (See Appendix) We believe that it is fair comment to state categorically that there are literally thousands of drivers convicted daily as being guilty beyond a reasonable doubt in various jurisdictions around the world on the basis of this type of evidence.

There are probably many readers at this juncture who will seize upon our findings as proof positive that the legal profession can be accused of worshipping false idols; that they have become object slaves to some of the glittering machines spun off by our modern technology. Here, the authors come out not necessarily on the side of the angels, but on the side of Finkelstein and Fairley. With all due respect to Professor Tribe, it should be recalled that the speed of light is "measured" in a vacuum; this is not the case in measuring the efficiency of a legal system. Lawyers and judges should not be adverse to marshalling all weapons at their command in the aim of furthering justice. Is not the objectivity of evidence produced by the breath alcohol analyzer with all its inherent defects, preferable in most respects to that of the subjectivity of an arresting police officer? It is here that Professor Tribe contributes most greatly to our collective wisdom, for, like Diogenes, he points out the pitfalls of mere technological evidence. We should not, in all circumstances, remain convinced that an 99% probability equates to an abiding conviction to a moral certainty. Yet our courts do appear to remain so convinced. We can only advance several hypothetical reasons for their so doing.

Firstly, the sheer magnitude of the numbers bandied about in cases like *Collins* renders them automatically suspect. This is unfortunate, as it leads to the impugning of the validity of *all* statistical evidence. This path can only lead to the ultimate *reductio ad absurdum,* where an accused would never be convicted on the basis of statistical evidence. Score one for Finkelstein and Fairley.

Secondly, the legal profession, like all other professions, is subject to a certain amount of innate conservatism. Professionals can become addicted to familiar jargon and to accomplishing tasks in a repetitive manner. The breath alcohol analyzer has become an established adjunct in criminal proceedings relating to drunken driving; this enhances its credibility. Score one for Tribe.

Thirdly, there is a distinct possibility that judges and lawyers have committed the very simple error of confusing probabilities with possibilities. Philosophically, anything is possible, even the most unlikely defence put forward by an accused, and this might explain a court's reluctance to convict even in the most obvious of cases. But let us suppose that the hypothetical *reasonable man* (who just happened to be a Cockney) was placed in the position of the judge trying the Swedish overtime parking case. The defence lawyer explains that his client drove away, returned to the very same parking spot, and his wheels just happened to come to rest in *exactly* the same position as before. The Cockney's obvious response would be: "Not very bloodly likely!" Score one for the Cockney and score another for Finkelstein and Fairley.

Fourthly, and perhaps most importantly, it is possible to argue that the probability demarcation line changes with the severity of the crime. Even though we all pay lip service to the dogma of reasonable doubt, justice dictates a gradually ascending scale for the magnitude of the proof required. The results of a conviction for drunken driving are not nearly as significant as those for a conviction of murder. Score one for justice.

Our conclusion cannot be definitive. All that can be said with absolute certainty is that reasonable doubt, insofar as our investigations led us, lies somewhere between the parameters of 2.5σ and 4σ, i.e. between 0.7% and 0.0005%. But this should not serve to refute the efficacy of the scientific method. To do so would mean going even beyond the Holmesian concept of law; and we all know this to be inconsistent with both logic and experience.

Appendix

If we were to suggest a possible procedure one is as follows. If we apply linear regression techniques to Coldwell and Smith's data (note 14 and 15), and model being

$$Y_i = \beta_0 + \beta_1 X_i + e_i \qquad i = 1, —, 253$$

with β_0 and β_1 being constants, x_i — the i^{th} breathalyzer reading and Y_i the i^{th} blood alcohol reading ($e_i \sim N(0, \sigma^2)$ and independent) we find that the equation of the least squares line is $Y = 0.0027 + 1.027X$ ($R^2 = 0.884$, Residual SS = 0.0001538)

Using the above least squares line and the underlying assumptions we calculate:

$X = x$	$P\{Y < 0.08 \mid x\}$	
0.090	0.111232	11.12%
0.100	0.020281	2.03%
0.110	0.002396	0.24%
0.120	0.000106	0.0011%
0.130	0.000003	0.0003%
0.140	0.0000001	0.00001%

where x is the percentage of blood in alcohol as determined by a breath analysis and P is the probability of the actual blood level being 0.08% or less. Thus the question of what constitutes reasonable doubt can (in this instance) be put into a mathematical context without questioning the applicability of the methods involved.