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GENERAL PAPER

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Scientist vs the law

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Abstract An Australian case study is presented in which defendants convicted of manufacturing a drug of abuse were acquitted on appeal because of shortcomings in the prosecution's case that established the identity of the material seized. The need to have proper standard operating procedures that can be followed routinely and correctly is highlighted.

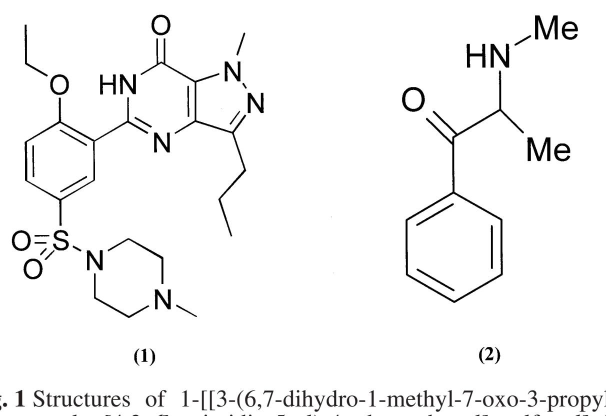
Education is needed for forensic analysts and the legal profession to try and produce systems in which the proper outcome is achieved.

Keywords Forensic science · Courts · Uncertainty · Accreditation

A recent judgment in the Court of Criminal Appeal of New South Wales highlights a problem faced by courts and scientists [1]. Australia has an adversarial system of justice that is derived from the English system. In each case, a plaintiff has to persuade the court of his or her case, while the defendant argues the opposite. The end of the case is when the Court, a judge acting as a jury, or a jury of ordinary men and women, determine for or against the plaintiff's case. The case in hand is the trial of Regina (the Queen) v three gentlemen who were found guilty of 'knowingly taking part in the manufacture of not less than the commercial quantity of a prohibited drug, namely methcathinone.' On appeal, the convictions were overturned on the grounds that the jury did not take sufficient account of the shortcomings of the Crown's evidence of identity of the alleged drug.

In the local press, much was made of the suggestion that they were really trying to make the male anti-impotence drug 'Viagra' (sildenafil)! If this were indeed a serious defence it is difficult to see how a synthetic chemist might have decided to make structure (**1**) via structure (**2**) (Fig. 1).

In this paper the analytical chemistry of the case is explained, and broader issues are discussed that relate to matters relevant to accreditation and quality assurance. The nature of expert opinion in the Australian system is also presented.



(1) (2)

Fig. 1 Structures of 1-[[3-(6,7-dihydro-1-methyl-7-oxo-3-propyl-1*H*-pyrazolo [4,3-*d*]pyrimidin-5-yl)-4-ethoxyphenyl] sulfonyl]-4-methylpiperazine monocitrate (Sildenafil marketed as Viagra) and (**2**) methcathinone

Chemical evidence in R v Piggott, Griffiths and Simeon

The case discussed here highlights the importance of forensic evidence being of the highest quality, and being able to be shown to be so in court. The issue was not complex, and was essentially: was a quantity of white powder found in the premises of the defendants the chemical substance methcathinone (Fig. 1 (structure **2**)) or not?

The initial analysis was by gas chromatography mass spectrometry (GCMS), identifying methcathinone against a literature spectrum (in the absence of a reference sample). The GC retention time was later compared with that of a reference standard of methcathinone. The transcript of the trial refers to a 'manual', which appears to have been the standard operating procedure (SOP), which specified the degree of matching of peak intensities between the mass spectrum of the unknown and a literature reference spectrum (±20%). Under cross examination the analyst admitted that the practice of the laboratory was to perform visual matching only, and that in fact the differences of peak heights between the sample spectrum and a literature spectrum were indeed greater than 20%. There is no doubt that the laboratory should have followed the manual. However, it may be seen why the arbitrary ±20% was ignored. First the barrister read the criterion "±20% of reference spectra" as an instruction to take the peak height of the reference and determine limits at ±20% of that height. In this case the most abundant ion intensity was of m/e 58, and measured against this intensity the next peaks in the literature were m/e 77 (11%) and m/e 51 (11%). These literature values are given in whole number percentages which implies at least a range of ±0.5% before any other considerations of precision are made. In cross examination the barrister determined that the allowable ±20% range of m/e 51 and 77 was ±2.2%. As 1% of this is already taken up in the significant figures, it may not be surprising that it is difficult to find a match between the ion intensities measured in the forensic laboratory and those in the literature taken under possibly very different conditions. The measured ion intensities of m/e 58 and m/e 77 were 29% and 24% respectively, and much was made of the discrepancy.

It was argued by the witness from the forensic laboratory that the manual was 'not supposed to be read in a black and white fashion' [2] which merely compounded the problem, faced with the interpretation by the defence expert [3]:

– It's a part of the quality accreditation re laboratory. You must have adequate documentation of the procedures that you use for analytical chemistry, and these procedures and protocols are to be followed by all staff.

It is easy for scientists to believe that lawyers cannot appreciate the proper scientific method, but in this case the trial judge stated the problem with some clarity [4].

– ... gave in evidence that, in relation to these tests, he had not done them in accordance with the manual – "technically", again he said – in that he had not run a standard at the end of each blank, nor had he included duplicate runs as indicated by the manual. He claims, however, that the reference to "duplicates" relates to quantitation, not identity testing, even though the manual apparently indicates otherwise. He agreed that his runs in respect of these samples, however, was "technically" deficient, because they did not comply with the manual.
  You have heard the evidence relating to the importance of complying with these set standards and counsel's submissions to you in relation to that .... You may ask yourselves whether substantial non-compliance with these set standards, designed to produce validity in the results of an analysis, can be properly regarded as merely technical.

Those interested in quality assurance in the chemical laboratory may thank the learned judge for pointing out what the laboratory may have temporarily forgotten. When a standard was finally sourced, the attempts of the laboratory to match the retention time with that of the seized material were also riddled with error. Given (from where it is not clear) a window of ±0.2 min to match the GC retention time of a sample with a standard, the one chromatogram presented to the court showing a match had a retention time of 9.55 min compared with the standard 9.8 min. Under cross examination it was admitted that the window might have been increased without documentation or reason, in what must be said was unprofessional conduct by the analyst.

It is clear to me that the scientists were convinced that they had identified methcathinone, but fell into the trap of believing that their own belief was all that was needed to satisfy the court. The fact that the jury found the defendants guilty shows that, despite the shortcomings of the evidence, they believed the laboratory's story. It was left to the judges of appeal to understand the need for absolute and demonstrable reliability of the chemical evidence.

The importance of quality assurance in forensic evidence has been highlighted by a judge of the New South Wales Supreme Court [5]:

– "5.28 It is essential, in those circumstances, that there be an added emphasis on the adoption of high standards of competence, adherence by laboratories to protocols, and acceptance of a duty to the court on the part of criminalists and forensic scientists, as an adjunct to the adoption by the Courts themselves of procedures, which are designed to improve the quality and the manner of presentation of expert evidence.

5.29 In this regard the need for quality assurance and quality control is imperative, carrying with it matters such as the regular checking of forensic laboratories by random blind sampling, the recording of error rates, and the giving of attention to the training of technicians not only in a way which ensures their competence, but which also brings home to them the significance and potential consequences of their work, so far as suspects and victims of crime are concerned."

What should have been done

The saying 'to be wise after the event' may well be applied to this paper. However, the essence of good quality assurance systems is that they promote being wise *before* the event, thus avoiding the unfortunate consequences of inappropriate action.

The problem in this case was the difference between the analyst's absolute certainty about the identity of the sample, and his inability to demonstrate this to the court. While professional judgement should count for a great deal, the courts demand solid and very formal proof. Therefore members of a forensic laboratory should:

1. Be well aware of the standard operating procedures and other systems underpinning the accreditation of the laboratory
2. Expect to follow those procedures until a satisfactory outcome is achieved
3. Be able to explain in court the scientific basis of their conclusions
4. Not to allow themselves to be pressured by management, police or judicial officers to produce a substandard analysis and opinion

This case also highlights the need to involve everyone in continual rounds of quality improvements. The matching requirements using library spectra clearly do not work. A simplistic ±20%, although sounding plausible, was not suitable for this situation. It may be that a technical person in the laboratory had noticed this problem before, but without the culture of preventative action he or she would not have been encouraged to raise the matter. Changing SOPs is not an easy matter once a laboratory has been accredited, but it can be done if properly documented and justified. The effort would have been well paid back in this case.

Accreditation to ISO/IEC 17025 [6, 7] should ensure that the proper infrastructure, methods, staff and procedures are in place, and it will be of interest to see what steps are taken by the Australian accreditation body (NATA).

Expert opinion

To clarify the role of an expert witness, and to provide guidance for experts and lawyers, the Federal and State courts of Australia have adopted similar codes of conduct for expert witnesses [8].

The Federal guidelines start with a clear definition of the role of an expert witness:

- General duty to the court
- An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise

An expert is, at the court's discretion, absolved from the hearsay and opinion rules and so must take care that he or she does not abuse this freedom. The guidelines then explain how an expert should establish his or her expertise, how to set out evidence, and how to document properly the exact nature of the expertise on which the evidence is based. Finally the expert must add the following declaration to any opinion given:

- "[The expert] has made all the inquiries which [the expert] believes are desirable and appropriate and that no matters of significance which [the expert] regards as relevant have, to [the expert's] knowledge, been withheld from the Court."

The need for this declaration has helped experts stand up to clients who, while not wishing to suborn a witness into actively lying, have suggested there is no need to mention everything that has come to light (especially the bits that are prejudicial to the client's case). I would argue that this approach has an advantage over practice in the USA courts, where the expert is very much part of the 'team'.[9]

In the case at hand, one of the problems identified by the Appeal Judges was the very poor quality of the evidence given by the defendants' expert analytical chemist. On the witness stand he railed against the work done by the forensic laboratory in quite intemperate language. Despite correctly pointing out the obvious deficiencies in the identification of the alleged drug, he allowed himself to overstate his case to the point where the jury may have stopped listening to the science. Perhaps the following taken from the judgment, as an example of the language used by this expert, could well be used in training expert witnesses how not to conduct themselves in court [11]:

- Some of the results he described as "absolutely amazing". He described the GCMS results of August 2000 as "...this rubbish proffered in evidence...". He described test results as "dreadful" and obliquely accused the Crown experts of being biased.

The jury were in the best position to assess his demeanour and these illustrations show why they might not have been inclined to place much weight on his evidence.

The role of the expert

In the case presented here, neither expert came out with any credit. The forensic laboratory failed to maintain its standards, did not produce reliable results and so the prosecution eventually failed. In particular the evidence given in court by the prosecution's analyst appeared to suggest that he was not fully prepared nor did he understand the importance of the admissions he was forced to make under cross examination. The defence expert had the easier task of explaining to the court the nature of standard operating procedures and their place in a quality system, and why the disregard shown by the forensic analyst rendered the identification of the substance unreliable. However he also did not manage to do his job properly, because the jury placed no weight on his evidence, possibly because of the manner in which he gave it.

It is important that expert witnesses understand that their job is to provide the court with appropriate opinion, and not to try the case in lieu of the judge and jury. It may sometimes be difficult. In a recent case, I discovered that an expert called by the opposition had used atomic numbers instead of atomic weights to determine the amount of substance from a measured weight. In conference with the barrister, I explained that this schoolboy howler would allow him to repudiate totally the witness' evidence. However the barrister remained unimpressed, reminding me that I had explained that an atomic number is about half the atomic weight of an element and so the relative values calculated would not change that much. Despite my entreaties that this was such an egregious fault that the so-called expert could not have survived the ignominy of its revelation in court, the barrister did not make the point. He had realised that there was enough against the opinion of this witness, and that the correction would not have made a deal of difference to the discussion of the results, while confusing the court still further over the nature of atomic chemistry. The barrister's job is to win the case, not to strike a blow for scientific truth.

Uncertainty and the law

There is an opinion that courts cannot accept the concept of uncertainty. It is said by some forensic scientists that if evidence is presented on, for example, blood alcohol levels, with a certain (low) probability that the concentration was actually below the legal limit [10], courts will never be able to convict a drunk driver again. Lawyers have also advanced that opinion, and barristers have occasionally taken the opportunity to pretend ignorance of even the most basic statistics. In a patent case in which I had measured blood glucose levels by two methods on each of eight replicate samples, and had shown by a t-test that the means of each method differed significantly, I was asked the following. "Professor, you have made 16 measurements?" "Yes". "And they are all different?" "Yes". "So surely, 15 of them must be wrong!" I forbore from correcting him – "*at least* 15 of them are wrong".

Against this pessimistic view of the courts' ability to embrace uncertainty comes discussions (unpublished) in the Australian Academy of Forensic Science, in which senior judges have pointed out that although the ultimate judgment (Guilty/Not Guilty) has no uncertainty, to arrive at that point the court has to weigh many matters that are uncertain. In assessing the credibility of witnesses, the weight a certain piece of evidence is to be given, and so on, a judge or jury must grapple with imponderables. Scientific evidence is of a better quality because quantifying uncertainty places bounds on results that are usually absent from other types of evidence. There may be a conception that scientific evidence has to be absolute, otherwise the very credibility of 'Science' is at stake, but this is to make too much of the scientist's evidence, which must take its place with all other aspects of the case. A better dialog with the courts should allow understanding of an uncertainty expressed with a given confidence interval. It may be that a court will want measurements made to a greater precision than the conventional 95% confidence interval, which, of course, can be delivered by the scientist.

Misuse of statistics and inference

Grappling with statistics is not, as we have seen, a strong point of the legal profession. The concept of probability is crucial to assessing the worth of DNA matching [12], or indeed the matching of any chemical data. More complex issues have the power to confuse, if handled in such a way. A famous case of illogical reasoning was during the trial of the American personality O J Simpson, in which a statistician advised that the probability of a known wife beater actually killing his wife was very small (1/10,000). Writing it as a conditional probability $\Pr(M|B)=0.0001$ where M is a murdered wife, and we are given the prior information that the husband is a wife beater (B). As pointed out in a letter to Nature after the trial [13], the real probability that was of significance is $\Pr(G|M,B)$ – the probability that given a murdered wife (M), and the fact that the husband was a wife beater (B), that the husband was the killer (G). This can be estimated by a Bayesian approach to be at least one third.

Courts in England [14] and Australia [15] have set their faces against the overuse of statistics to give what appears to be a definitive probability of the guilt or innocence of the defendant. The case of R v Adams established that to use Bayes' Theorem or similar method in a criminal trial to bring together probabilities "plunges the jury into inappropriate and unnecessary realms of theory, and complexity deflecting them from their proper task" [14, 15].

Conclusions

An analyst has a primary duty to determine properly what he or she is asked to do, whether for court, or any other client. The existence of accreditation, quality assurance, SOPs and the like, is to bring demonstrable rigour to a complex procedure. Courts bring out the worst in the system. Clever lawyers can tease out inconsistencies of approach or transgressions of SOPs. When they are desperate, the system allows for considerable obfuscation in cross examination. However this is not the fault of the legal system. When liberty is at stake mere opinion, no matter how well founded, is no substitute for evidence correctly acquired, interpreted and defended in court. If, as may be the case here, the laboratory was accredited to follow SOPs that were not appropriate, the way forward is not to disregard the SOPs, thus invalidating the whole process, but to seek to change them.

There is clearly plenty of scope for education, of legal people, and of scientists.

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