Why do we need good forensic science?

A Jamieson
Lothian & Borders Forensic Science Lab, 11 Howden Hall Rd, Edinburgh EH16 6TF, United Kingdom
A paper presented at the Forensic Science Society AGM and Autumn Conference "Agony and Ecstasy", November 2001

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Many court cases depend on the evidence of eye witnesses. There are over 700 academic research papers on this topic. There is a large body of research that demonstrates the lack of reliability of this form of testimony [1]. The history of the justice systems of the world provide many examples of flawed decisions that are a direct consequence of flawed eye witness testimony. In America, research has shown that inaccurate eye witness testimony is the main factor leading to false convictions.

One research project examining eye witness testimony showed subjects a video of a staged crime [2]. The perpetrator could not be seen, and was not in the set of pictures or mug-shots subsequently shown to the subjects. Despite this, EVERY subject still claimed to be able to identify the perpetrator. The investigators then randomly split the subjects into two groups. One group was given some kind of confirmation (a nod, any kind of agreement) when they identified a suspect from the mugshots. The other group received no indicators. Over half of those who had some form of positive affirmation had an increased confidence in their perceived ability to identify the culprit compared with only a sixth of the control group. Of these, 13% claimed to be able to make out every detail of the perpetrator's face while NONE of the control group did.

Of course there are many contributory factors to incorrect eyewitness testimony – not all of them totally dependent on the eye witness – even changing a question can influence the answer. Compare "Did you see a knife?" with "Did you see THE knife? All of this is compounded by the fact that there is a tendency for all of us, including jurors, judges and lawyers, to believe that witnesses are more accurate than they actually are, and, that there is a correlation between the confidence of a witness in their opinion and the veracity of that opinion.

It is partially for this reason that courts rely on supposedly dependable physical evidence to help them decide on the most likely version of events. The evidence may be reliable. But what about the selection, recovery, analysis, interpretation, and reporting of the findings deduced from this physical evidence? This is the domain of the forensic scientist.

The scope for error in the forensic process

The diligent, professional, dispassionate and impartial scientist will glean the maximum information from the most meagre physical evidence. The appliance of science will recover and analyse the slightest of traces to get to the truth of the matter. Or so the thinking goes. But mistakes have happened and will continue to happen.

Experts are as capable of getting it as disastrously wrong as other witnesses. Many mistakes we know about. But, how many times are errors not discovered? How many times are the innocent jailed on the basis of flawed scientific evidence? Some errors are preventable. They may be deliberate or they may be unintentional. The unintentional may be caused by an error anywhere in the chain of search, recovery, analysis, interpretation or report. Errors may be caused by ignorance: ignorance of the system; ignorance of the purpose of the examination; ignorance of the science. Maybe even ignorance of the fact that the science, even though generally accepted, is flawed.

We can design systems for everything. We can even design them to look for mistakes. But they happen.

How are the number of errors minimised? They will not be completely eliminated. To prevent or minimise errors we must first understand what we are doing and why we are doing it. It is the function of the expert witness to explain and interpret scientific results to the jury – a position unique to the expert witness.

The expert and the court

The decision that the court makes regarding the admissibility of the expert's evidence is whether it contributes information that will allow the jury to decide on the merit of the prosecution case? (A trial is a test of whether the prosecution have proven the charge against the accused – the defence are not actually required to say anything at all. Of course, they are rarely so sanguine, but it has happened.) In considering a Bayesian approach to interpreting evidence, it should be remembered that a court case is a test of the prosecution case against ALL other hypotheses, not just whatever one the defence decides to put forward, or that the expert has decided to consider.

Key words Forensic science, management, interpretation, communication, quality.

Although the expert is, in theory, there to assist the court the lawyers for the other side are not sitting awestruck. They're looking for ways to drive a coach and horses through any opinion contrary to their case. The other side's lawyer would like to make the expert go beyond the boundary of what they can reasonably know to make an unreasonable statement that can be easily discredited. Thorough preparation and knowledge minimises the expert's risk in these courtroom games. Preparation entails a consideration and thorough appreciation of the purpose for which the expert is employed: to explain and interpret scientific analyses.

Explanation

The first thing that the expert must consider when explaining something is who is the target and what is the purpose of the explanation. Juries are drawn from the general public, and the general public are not renowned for their perspicacity in scientific matters. Failure of the expert to deal with the gap between their own knowledge and the jury's can have severe consequences. Scientists are torn between the need to explain, and their training that tells them to be accurate; between sounding dumb and sounding erudite and educated. But poor explanations will prejudice testimony.

The Dingo Baby Case

Lindy Chamberlain was accused of murdering her baby [3]. Her husband was accused of being an accessory. She claimed that the baby had been taken by a dingo. The scientific and medical evidence were the major planks in the prosecution case. Two expert witnesses spoke of the damage to the baby's clothes and some blood in the Chamberlain's car. They gave evidence in clear, plain terms. The defence brought two forensic pathologists to counter this interpretation. They argued in such a pedantic way that the jury, according to a juror, could not follow their testimony. Lindy Chamberlain was convicted and condemned to life imprisonment with hard labour. This story ends two years later with a successful challenge to the scientific and medical evidence, the quashing of the conviction and Chamberlain's release. In this case the defence science was correct, but the experts' inability to explain it in a manner understandable by the jury was instrumental in the wrong verdict being delivered.

The expert must consider whether they are speaking the same language as the juror. They must ensure that when terms from chemistry, biology, statistics and medicine are employed the audience, the jury, are receiving the meaning that is intended. Careful choice of words, awareness of the possibilities for misinterpretation, and clarity are the key requirements. The expert witness must consider the perspective and background of the jury rather than their own. Attempts to appear clever or authoritative by resorting to jargon and techno-speak should be resisted.

The use of analogy can be very helpful when explaining complex matters – it should not be forgotten that most scientific models are analogies of the real environment made more or less complex by the needs of the scientists using them – for example, space filling models of complex molecules or orbital models of simple atoms and molecules. There are two key aspects to the use of analogy that should concern the expert witness; the analogy should convey sufficient information to achieve the intended comprehension in the jury, and it should not mislead.

If there are questions of detail, for example about the validity, reproducibility, accuracy, precision, or any one of a number of performance parameters, then it would be appropriate to expand on this description until sufficient data is presented to allow an informed decision – after all that's exactly what the jury are being asked to do in a court case. However, it is rarely necessary to deliver a technical lecture.

Quality of Evidence

Scientists continue to confuse quality with standards of accuracy or precision. One definition of quality is 'Fitness for Purpose'. This implies a need to define the purpose. The first priority, the purpose, of an expert witness is to help the jury in their deliberations. The quality of evidence must not be confused with the standard of analytical accuracy and precision.

To give an example from our laboratory – we were getting complaints from the pathologist that we were taking a long time to deliver alcohol results. In conversation it became clear that the pathologist did not require an alcohol analysis accurate to fractions of a milligram, he was content with knowing whether there was a lot or a little. Of course we could provide this less accurate, but more helpful, result a lot quicker since we did not have to perform the same extensive QA as we do for our Road Traffic Alcohol analysis. The scientist may be correct in the view that the standard of the answer was reduced, inasmuch as we were now making a faster, less precise statement about the evidence – but that was what the pathologist required.

Interpretation

So what are we supposed to be explaining to the jury? Answer: our interpretation of the scientific analyses of the evidence.

Again, in the Dingo Baby case [3], the Chamberlain family, Lindy, her husband Michael and their three children went camping to Ayers Rock. Azaria, the baby, was left alone in the tent. Lindy and another camper heard a baby's cry and she rushed to the tent just in time to see what she claimed was a dingo making off with something in its mouth. There was blood in the tent and the baby was missing.

An inquest agreed that a dingo had made off with Azaria. Then the rumour machine cranked into action. Suggestions were made of religiously fanatical parents sacrificing their baby. The press suggested that the name Azaria meant "sacrifice in the wilderness"; a scientific experiment was performed in Adelaide zoo: a starving dingo decapitated a goat and extracted it from a baby's jumpsuit by opening two snaps. But the damage was significantly different from that found on Azaria's clothes. A pathologist examined the clothes and concluded that Azaria's clothes had not been cut by a dingo, but by scissors or a knife. Based on this information the police reopened the case. A police forensic biologist claimed to have found foetal Hb in the

Chamberlain's car and on a camera bag. Her methods were heavily criticised and she had apparently disposed of her records and samples by the time of the last inquest – only two years after the incident! The case was surrounded by an intense media attention. "Everybody knew" that dingoes didn't attack babies. The parents were convicted of murder.

A Royal Commission eventually heard new scientific evidence that discredited the tests used by the forensic biologist, Aborigine trackers were called as experts to testify that a dingo could have killed a baby, and that urine could have attracted them. Indeed, a witness was called who had shot a dingo that had killed a baby. The conviction was quashed and Lindy Chamberlain was released after serving almost four years, arguably because of poor forensic science on one side, and the inability of experts to properly explain better science to a jury on the other.

Good forensic science is good science, applied properly and explained adequately. Without each of these components it is poor forensic science because the purpose of the effort is to assist a court. If the explanation does not do so, then the court is not helped. If the science is poor then the court is potentially misinformed.

Science

A Scientific Experiment: a scientist has in front of him a flea. He shouts at the flea "Jump!" and it jumps. Again, "Jump" and again it jumps. The scientist delicately pulls all of the legs from the flea. "Jump!" he shouts again. No response. "Jump!", again nothing. Three months later his paper appeared in *Science & Justice* entitled, "Removing the legs from a flea renders it totally deaf…a Bayesian Approach."

Science is as much a way of establishing knowledge as a body of knowledge. That way is by properly constructed controlled experiments that test specific hypotheses. Only when we have done these, or are aware of these, can we consider that our work has a scientific basis.

Let's look at another experiment. Handwriting analysts were asked to look at samples of handwriting and match them to each other and conclude, by matching to controls, whether they had been written by the same person and which of the controls it was [4]. All of the examiners reached the same conclusions. Validation for handwriting analysis? Well, not quite. Unfortunately, they were all wrong. 100% reliable, 0% accurate.

Roland Molineux was charged with the murder of Katherine Adams. He was found guilty and sentenced to death. Eighteen handwriting experts, 14 'professionals', all concluded the same thing; Molineux had written the key documents in the prosecution case. On appeal, 15 experts were called to say the opposite and Roland Molineux was released.

Are things changing? The Molineux case was in 1900 – the double blind experiment was in 1989. The scientific expert must be constantly cognisant of at least the following facts: firstly, never totally discount the possibility that the effect that you observe could have occurred in a different way to what you surmise. Secondly, know the limitations of the tests we use. Few tests have no false positives or false negatives. Be aware that even though these may not be known, it is as well to consider that they probably exist. Thirdly, know the difference between experience and expertise.

Experience and expertise

A technician may have years of experience working with a particular technique or piece of equipment. They may know how to solve some problems through previous trials and errors. They may have done this with no knowledge of how the system actually responds to the repairs or the theoretical knowledge of the technique. They have experience but could only be considered to have expertise in particular aspects of the technology.

A scientific expert then requires special knowledge of science, not just a casual awareness gained through experience. What is science and what makes a conclusion or explanation scientific? A properly constructed and controlled experiment is certainly one thing. Some things wear the cloak of science, but underneath are simply not.

Jack Straw, when UK Home Secretary, apparently wanted to introduce a law to lock up people suffering from Dangerously Severe Personality Disorder (DSPD). A syndrome in which predictive studies have varied in their successful predictions from 36% to 100% accuracy with an average of 70%. Thus you would have to lock up ten people to get seven actually dangerous people. But you would lock them up BEFORE they committed a crime. It is estimated that there are between 300 and 600 people in this category in the UK. This means that we would lock up 90 to 180 people who would not commit a crime – up to 360 if the poorest results applied.

The false negative rate was 40%. That is 40% of people who were diagnosed as unlikely to commit crime actually went on to commit violence. Tossing a coin would be just 10% worse! … and a professor of forensic psychiatry describes these results as "pretty good".

The expert witness

No matter how many professional registers we have, nor how many qualifications we muster, the court, and ethics, will always demand that the defence have the right to call whoever and whatever expertise they consider necessary. The proper way to expose the fraud is in cross examination. It should never be for some closed clique of self-selected experts to decide who can and cannot provide information to the court. It prompts the question "Who decides if the assessors are competent?" or *quis custodiet ipsos custodes*?

You've heard of the prosecutor's fallacy and the defence attorney's fallacy. Well, here's another – it was in *Nature* so it must be true – the Texas Gunslinger's fallacy [6]. Shoot at the barn door, then draw a target around the hole.

On 6th August 1967 Linda Peacock was murdered in Biggar between Edinburgh and Glasgow. This case led to the first case in Scotland where a conviction was secured on the basis of forensic odontology [7].

The crime scene gave little hope for physical evidence. A detective sergeant, the crime scene photographer, noticed marks on the breast of the victim. Although odontology was still a 'murky area' Scotland had its own forensic odontology expert. He concluded that the marks were human teeth marks inflicted just moments after death. Troubling though was the fact that he also concluded that they had to have been inflicted from behind the victim – "It would have taken an act of considerable contortion, but was not impossible". Three thousand local men were interviewed. To a man, they all had alibis!

Conveniently, there was a local Borstal. It was suggested that teeth impressions be taken of all 29 young men. Now notice that outsiders were first interviewed then eliminated, but the Borstal boys were asked to yield impressions first. The expert then examined all of the impressions to judge whether they could have caused the marks found on the body. Conclusion? "Several were useless...so I decided to call in another expert". Despite being examined by "Scotland's leading expert" who could come to no firm conclusion, but favouring impression Number 14, another expert was called. He had performed only seven odontology cases at this time – they may or may not (more likely not?) have featured similar marks to those in the Peacock case. Conclusion? Twenty-nine boys were reduced to five suspects and eventually to one – Number 14. Inconveniently, Number 14 had a cast-iron alibi. The original expert wrote, "apart from the already-discredited Number 14, none of the others fitted at all".

A re-examination using purportedly more sophisticated techniques settled on Number 11. Conveniently, the Chief Superintendent on the case reported that, of all 3028 interviews, the only one he "didn't feel comfortable with" was Number 11's.

There was, apparently, not one piece of incontrovertible evidence other than this suspect science and a hunch to link Number 11 to the crime. Even the Procurator Fiscal (the office responsible for prosecuting criminal cases in Scotland) did not want to proceed without a firm conclusion in the scientific evidence. Practice at that time required the matching of at least five teeth, but only two had a claimed match. Two officials at the borstal had seen suspect Number 11 at 10.00 pm and 10.30 pm (at which time he was in bed). But one inmate had reported that he had seen him return just before 10.30 pm. He thus had half an hour to leave the Borstal, meet the girl, assault and murder her, and return to the Borstal. The accused pleaded not guilty and vehemently denied any involvement in the murder. He was found guilty and sentenced to life imprisonment.

Viewed dispassionately, were these experts forced by the overwhelming scientific case and tests that the mark could only have been caused by Number 11 or just determined to find a match?

Authority

We must be careful of deferring to authority. I would commend the book by Robert Thouless, *Straight and crooked thinking* [9]. In it, he argues strongly that we should not rely on authority alone to convince us of an argument. Mere authority is capable of abuse. That abuse may be well-intentioned and may use the contemporary standards, but that doesn't, *de facto*, make the authority right.

In one case, an eminent pathologist had already concluded from the maggot infestation that the corpse was at least nine days old. He has written that he estimated that the fly's eggs had been laid nine or ten days earlier, and that he added a little more time for the flies to find the body. On this basis he was prepared to say, when asked to consider the possibility of eight days, that "No it isn't and I am ready to stand up to severe cross-examination on the point if it comes to trial". This despite three reliable eye witnesses, including those who knew the victim, declaring that they had seen the deceased the day after the pathologist's estimated time of death. The story goes that the pathologist "was too much of an expert to doubt – even for Quentin Hogg who asked no further questions" [7].

The body in this case was in such a state of decay that the autopsy was done on-site. Despite this the pathologist was able to conclude, but only after the suspect was identified as an ex-soldier, that the blows to the throat might be administered by a man who was an expert in unarmed combat. Again, the Director of Public Prosecutions was unwilling to prosecute without conclusive scientific evidence. On the basis of this "expert" testimony then, a man was sentenced to life imprisonment. An insight into this case can perhaps be gained from the pathologist's own words, "The case was particularly satisfying to me. My insistence on the time of death [would have meant] a public disgrace for me if I had been wrong" [8]. The dispassionate and impartial expert.

Dr Mather was a member of the Royal Society. He diagnosed several people as having a particular set of symptoms that led him to conclude that they were possessed of a certain condition – or syndrome. This was generally accepted at the time. Dr Mather was called in to make the diagnosis of 'bewitched' that condemned several people to be hanged during the Salem witch trials.

The essential point in these cases is that almost all of the principles regarding acceptance of other possibilities, controlled experiments, and above all a dispassionate and impartial approach (regardless of reputations) seem to have been ignored. This is not to underestimate the immense pressure that can be brought to bear on the expert to provide an unequivocal answer. This does not remove however, the professional responsibility to work within the limits of scientific knowledge generally and one's own knowledge specifically.

Junk science

In a recent review of the Lee Clegg Case (a soldier convicted of murder in Northern Ireland) the author appeals for responses

from scientists when they see clearly junk analysis being purveyed as real science and scientific opinion. Recent discussions including articles and correspondence in *Science & Justice*, are perhaps illuminating how far many aspects of fingerprints are from approaching a scientific discipline [10,11].

If the newly launched Council for the Registration of Forensic Practitioners is to have the full effect that it should then I suggest that every one of us has to be constantly vigilant for examples of crafts and arts attempting to cling on to the coat-tails of properly validated and rigorously tested science, as does the Council itself when considering which disciplines to endorse.

I notice that a potential group of registrants is so-called forensic psychiatrists. I have already alluded to several examples from within this so-called practice. I'll just mention recovered memories to drive another nail in that particular coffin. I hear the occasional tale of Criminal Profiling bearing fruit but the failures rarely make the news. I am unaware of any properly constructed study that examines the effectiveness of the range of 'criminal profiling' from individual to geographic that doesn't fall into the Texas Gunslinger trap of fitting the expected result into the actual observation, or just ignoring failures altogether. Even psychics occasionally get it right – but that does not, in any way, validate the procedures as science or even of value. How much time and effort have been wasted chasing the shadows predicted by these practices?

Conclusion

The scientific disciplines, including all aspects of forensic medicine, must not be allowed to be dragged into the mire of the forensic black arts that do not depend on stringent scientific methods and checks. Practitioners must satisfy themselves, and others, that they truly know their science, are performing it to the best of their ability, and continually striving to improve themselves and their science. Practititioners must think about forensic science, think about the people who need to know and understand this science even though those people are not scientists. Think about the practitioner's responsibilities to them and to the people whose lives will depend upon the practitioner's capability to report clearly and accurately the results of their investigation. If forensic science is to achieve and maintain the status it deserves, each of us owes this duty of care to all of those affected by our work.

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