The impact of the principles of evidence interpretation on the structure and content of statements

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The Forensic Science Service (FSS) has devoted appreciable effort to developing the application of the principles of evidence interpretation. Much of the work has been reported in previous papers in this journal, in particular those that develop a model for Case Assessment and Interpretation (CAI). The principles of interpretation are restated and the implications for structure and content of statements are described.

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Introduction
A successful forensic science operation depends on a wide range of technical procedures and skills that will lead, in any individual case, to a set of observations. The crucial element that the scientist brings to any case is the interpretation of those observations. This is the heart of forensic science: it is where the scientist adds value to the process. Any technology-based organisation can set itself up to carry out the purely technical aspects of a forensic examination. The position of a successful forensic science organisation in a Criminal Justice (CJ) system should be characterised by the quality of the scientific inference that it offers over and above the purely technical procedures.

Classically, the statement has been seen as something that the scientist writes at the culmination of the work on a case (or, at least, on completion of a phase of the work in a complicated case), so the scientist’s ideas in relation to the interpretation of the evidence have only focused at a late stage in processing the case. However, this view has been challenged and substantially revised in recent years through the Forensic Science Service (FSS) Case Assessment and Interpretation (CAI) project – see Cook et al [1].

The CAI project has been devoted to improving the value for money offered by the FSS to its customers. It has promoted the idea of a customer/contractor partnership for ensuring that resources are expended economically and effectively. The immediate consequence of this is an emphasis on thinking about the interpretation of the case at the very outset. This enables a meaningful dialogue with the customer about costs and expected outcomes.

CAI fosters the view that interpretation and assessment must be at the forefront of the scientist’s mind throughout the case. If this view is sustained then the interpretative issues will have been resolved before the statement is written.

Interpretation is, of course, a part of everyday life and it is possible to visualise a kind of spectrum. At one extreme there is pure intuition, which defies rational analysis. At the other extreme is pure logic. Scientific judgement cannot be based on pure intuition or “hunch”. Experience is very important, nevertheless the scientist should, as far as possible, be able to rationalise the opinion that is presented. The opinion might be supported by data: there is, indeed, a kind of data spectrum ranging from the case where the opinion rests largely on an established data collection to the case at the other extreme where there are no data and the opinion is entirely based on experience. In any case, the expert opinion is necessarily subjective, but it should always conform to logical principles. Those principles are furnished by considering probability theory as a means of reasoning under uncertainty: this leads to the Bayesian view of evidence interpretation, which will be discussed further in the next section.

It is also important that scientists communicate their findings effectively. In most cases, in the UK, the forensic scientist does not attend court proceedings and so the statement is the main medium of communication. Often the statement will be read to the court by a lawyer who cannot be expected to have anything more than a nodding acquaintance with the technicalities and scientific nuances of the subject matter. Therefore the statement has to stand on its own and if it is not easy to read then there is a real danger that the impact of the scientist’s contribution will be vitiated. The FSS is working continuously to improve and refine the language and structure of its statements.

After the next section, which explores the principles of interpretation, the structure and composition of statements are covered in some depth.

Overview of the theory of interpretation
The first recorded instance of Bayesian reasoning in the context of a legal trial was recently discovered in the documents associated with the Dreyfus trials by Taroni et al [2]. Its application within forensic science expanded rapidly during the 1990s and an excellent introduction to the subject is provided by Robertson and Vignaux [3].

Elements of interpretation
Surrounding the incidents that a scientist is asked to address, there are items of information relating to time, location, actions, eyewitness statements and so on. This body of information forms a framework of circumstances within which the scientific examination is carried out. It is important to emphasise that the framework will contain elements that are uncertain, unreliable or even erroneous. Furthermore, the framework is liable to change, perhaps many times, between inception of the investigation and subsequent court proceedings.

Within that framework, and subject to agreement with the customer, the scientist carries out searches, examinations and analyses that lead to observations. The role of the scientist is to apply a particular kind of expertise to the interpretation of those observations. It is common practice to refer to the observations as “evidence”. There is a school of thought that the observations do not become evidence until a court of law decides to admit them as such. However, this appears to be a minority view and, following widespread custom, observations and evidence will be taken to be synonymous in this paper.

Within the framework of circumstances, various claims and allegations will be made by investigators, advocates and witnesses. The scientist will be asked to consider some of these but they are often couched in vague terms. In general, it will be necessary for the scientist to formalise them in order to address them. Such a formalised allegation is referred to in this paper as a proposition.
**Principles of interpretation**

The Bayesian model represents the application of probability theory to reasoning under uncertainty. The model reveals the central importance of the likelihood ratio, the formulation of which crystallises three key principles for the interpretation of forensic science evidence.

1. Interpretation of scientific evidence is carried out within a framework of circumstances. The interpretation depends on the structure and content of the framework.

2. Interpretation is only meaningful when two or more competing propositions are addressed.

3. The role of the forensic scientist is to consider the probability of the evidence given the propositions that are addressed.

No matter how complex a case becomes, these principles should always be at the forefront of the scientist's mind. Adherence to the principles will serve to promote logical reasoning and clarity of thought.

Other contributors to the legal system—lawyers, police officers and judiciary—will, in general, not be aware of these principles. Thus, questions will often be put to the scientist that are incompatible with a logical framework. The scientist can assist by clarifying the classes of questions that are meaningful and those that need to be left to others, particularly the jury. The question “what is the chance that this blood is that of the suspect?” has a beguiling simplicity but the scientist should not yield to the temptation to respond, as is explained later, in the section on the transposed conditional.

**Pre-assessment**

Although the interpretation section comes at the end of the statement, it is not good practice to delay thinking about interpretation until that section is being written. On the contrary, interpretation should start when the scientist first meets the case. It is at that stage that the scientist thinks about the questions that are to be addressed and the outcomes that may be expected. More formally, the scientist should attempt to frame propositions (see below) and think about the weight of evidence that is expected. Ideally, this process should inform a discussion with the customer before any substantial expense is incurred. There is a formal model for this process, described by Cook et al [1].

**Hierarchy of propositions**

No scientist should ever be focused solely on one proposition to interpret observations. That is particularly true for the forensic scientist, who must at all times be impartial. Whenever observations are to be interpreted then they must be viewed from at least two perspectives. In the adversary system these will reflect the scientist's understanding of the respective positions of prosecution and defence. Of course, either position might change as a case proceeds, even up to the last minute outside the court and in the witness box.

This is why it is important for the scientist to be as clear as possible about the alternative propositions that were considered at the time of writing the statement.

It is convenient to visualise a “hierarchy of propositions” and this is described by Cook et al [4]. The notion is also in line with the work of Schum [5]. In summary, the hierarchy has three levels, though the distinctions between levels can be blurred and, in some cases, non-existent. The highest level, level 3 represents Offence level propositions such as:

- Mr Smith raped Ms V
- Some other man raped Ms V

In general, these are the propositions that the jury will consider and forensic scientists will most often prefer to retreat to level 2 or Activity level propositions. For example:

- Mr Smith had sexual intercourse with Ms V
- Some other man had sexual intercourse with Ms V

To address propositions at this level, the scientist will need to take account of information in the framework of circumstances. This is particularly the case when issues of transfer and persistence arise.

In some cases, there is insufficient information in the framework for the scientist meaningfully to address level 2 propositions, when it is necessary to retreat to level 1 or Source level propositions, such as:

- The semen came from Mr Smith
- The semen came from some other man

With the rapid development of DNA profiling technology, particularly the enormous improvements in sensitivity that have taken place, another issue is becoming increasingly important. It is now possible to visualise situations where it is not necessarily the case that a particular profile actually came from what was observed as a discernible region of staining. In such cases, it might be necessary to address what might be termed “sub-level 1” propositions of the kind:

- The DNA came from Mr Smith
- The DNA came from some other person

A consequence of moving away from level 3 propositions is that more of the interpretative issues must be left to the court. The scientist may help by explaining the nature of those issues and also the difficulties in addressing them from a scientific standpoint.

Although much has been written on the subject, it is still true that the framing of propositions is often the most difficult part of interpreting evidence. Because it is difficult, there is a temptation to avoid it but it is a temptation that should be resisted.

Scientists should be aware of the distinction between formal propositions—that are generated, at least in part, by the case
circumstances – and less formal explanations. The distinction is discussed, with examples, by Evett et al [6]. Explanations can be useful as a kind of exploratory tool and they play an important part in reconstruction. In different terms, but along lines that are not incompatible with this view, De Forest [7] describes the processes of cogitation and hypothesis development. Reconstruction will normally contribute to the investigative phase and reports at that stage from the scientist to the investigator may be quite different in form and structure from the guidelines discussed here. When it comes to the phase of preparing a statement for the court the interpretation should be based on propositions that are framed within the context of the case circumstances.

**Likelihood ratios**

It is necessary to consider the probability of the evidence given each of the two propositions. Very often it will not be possible to do this quantitatively: this does not matter as long as the underlying concept is adhered to. If the scientist considers the evidence to be more probable if the prosecution proposition is true than if the defence proposition is true then the prosecution proposition is supported. On the other hand, if the evidence is more probable given that the defence proposition is true, then that proposition is supported. In both cases the extent of the support depends on the magnitude of the likelihood ratio.

This concept underpins all of forensic science inference and a given magnitude of the likelihood ratio represents the same weight of evidence whatever evidence type is under consideration. This means that numerical values of the likelihood ratio can underpin a verbal scale for reporting weight of evidence.

**Verbal scale**

In the FSS, weight of evidence is communicated by the use of the word supports together with an appropriate qualifier, chosen from the list: limited, moderate, moderately strong, strong, very strong. The equivalence between numbers and words is a matter to be settled by consensus among scientists from all disciplines. At the present time the verbal convention followed by the FSS is as follows:

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<tr>
<td>&gt;1 to 10</td>
<td>Limited evidence to support</td>
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<tr>
<td>10 to 100</td>
<td>Moderate evidence to support</td>
</tr>
<tr>
<td>100 to 1000</td>
<td>Moderately strong evidence to support</td>
</tr>
<tr>
<td>1000 to 10000</td>
<td>Strong evidence to support</td>
</tr>
<tr>
<td>&gt;10000</td>
<td>Very strong evidence to support</td>
</tr>
</tbody>
</table>

The table is given for likelihood ratios in excess of one, that therefore represent support for the prosecution proposition. The scale works in a directly comparable way for likelihood ratios less than one, when the evidence represents support for the defence proposition.

Of course, the divisions in the table cannot be seen as arbitrary discontinuous steps. It would be ludicrous to claim that a likelihood ratio of 999 is materially different in its impact from one of 1001: but that kind of precision is rarely realistic in forensic science and the scale is no more than a guide to the judgement of the scientist.

In the ranges of very large likelihood ratios – such as those reported in DNA profiling cases – then the verbal scale becomes inadequate. It is difficult to find words that convey greater emphasis than very strong. Nevertheless, it is accepted practice to use the phrase extremely strong for likelihood ratios of one million and more. Aitken and Taroni [8] have recently proposed a new approach to the problem of conveying weight of evidence by means of the logarithm of the likelihood ratio.

In contrast, likelihood ratios in the region of one also need special attention. In numerical terms, a value of exactly one represents evidence that is perfectly neutral: neither proposition is supported in favour of the other. Of course, as we have said, the assessment of the evidence is not numerically precise, nevertheless there will be cases in which the examiner believes that the likelihood ratio does not differ sufficiently from one to express an opinion of support. In such cases, some care is needed in expressing the opinion. To say "there is no evidence to support proposition x" is in danger of being mistakenly interpreted as meaning that there is evidence to support the alternative proposition y. To avoid such a problem it is desirable to use something along the lines of:

> The evidence is just as likely given either proposition and therefore does not provide any guidance as to which of them is correct.

Variations to the verbal scale may be made from time to time, in accord with consensus across all disciplines within the FSS.

**The transposed conditional (the prosecutor’s fallacy)**

Although the Bayesian approach to evidence interpretation is quite an old idea, its take up in forensic science has only become widespread over the last 10 years. Through most of the 20th century, forensic scientists were either ignorant of the principles of logical interpretation or chose to disregard them. Thus it became fairly widespread practice to invoke the notion of probability in a manner that cannot be defended logically. This is the practice of expressing an opinion in the form of a probability for the truth of a proposition. For example:

> In my opinion, there is a strong probability that Mr Smith wrote the questioned handwriting.

> In my opinion, it is unlikely that the footwear mark was made by another shoe.

However, the key principle of evidence interpretation is that the scientist should always express opinions in relation to
the probability of the evidence given the proposition. The job of assessing the probability of the truth of the proposition given the evidence is the province of the jury. To go from the former probability to the latter either involves taking account of other non-scientific evidence (which is not generally considered to be the role of the scientist) or simply taking the illogical step of "transposing the conditional" or committing the prosecutor's fallacy. This subject has been dealt with by several authors, including Evett [9], Thompson and Schumann [10] and Robertson and Vignaux [11].

Categorical opinions

Another practice, that is as old as forensic science, is that of giving opinions of certainty. The classic example of this is the "fingerprint identification". When a fingerprint expert says "in my opinion, this mark and this print were made by the same person" then he/she is saying that he is certain of that proposition.

Viewed from the Bayesian perspective, an opinion of certainty of the truth of a proposition represents an infinite likelihood ratio. It amounts to saying, "no matter whatever weight of other evidence there is to the contrary, I have no doubt of the truth of the proposition."

This kind of opinion cannot be rationalised logically. It incorporates a partially psychological process that Stoney described as a "leap of faith" [11]. Nevertheless, such opinions have long been accepted by courts as extremely helpful and valuable evidence. They are permitted in relation to any evidence type, with the exception of DNA profiling. There the scientist is, by the rulings in Doheny and Adams [12], not permitted to express an opinion of personal certainty.

Statement writing: some general points

Scientists of the first and second resorts

Classically, there has tended to be a distinction between "prosecution" and "defence" experts but that view is gradually changing. Whereas the government forensic scientist was, at one time, seen to be someone who worked "for the police", the FSS has come to be seen as an organisation that provides services to customers. True, by far the largest part of FSS business comes from police forces, but the policy of the Service is to be equally accessible to requests from all sectors involved in the legal process – whether criminal or civil.

When a police investigator needs the services of a forensic scientist then the FSS, if approached, will respond by providing the "scientist of the first resort". If a case against one or more individuals is subsequently brought to court then that scientist will most probably be called as a prosecution witness. In which case, defence may well choose to retain another scientist to advise them, who could then be termed the "scientist of the second resort". The fact that one is called by the prosecution and one by the defence does not make these scientists any different from the viewpoint of integrity, impartiality and professional standards. It may happen that both scientists are members of the same organisation, reflecting what is long established practice among barristers in Great Britain.

The role of the scientist of the second resort is, in general, quite different from that of the scientist of the first resort. His/her function will be that of providing a searching critique of the work of others. This means that the form of the report/statement will be largely determined by what has gone before and so the format will vary considerably from case to case.

The guidelines given here are for statements written by the scientist of the first resort, where the format is expected to vary less and where there are certain mandatory requirements that must be met.

Words/phrases of nebulous meaning

There are certain phrases that are quite widely used by lawyers and police officers that serve poorly for conveying opinions about weight of evidence.

The phrase "consistent with", when used in the context of "the evidence is consistent with this shoe having left the mark" is a potential source of confusion. Also it is not balanced, unless the other proposition is addressed. Perhaps it might be equally true to say "the evidence is also consistent with any other shoe of the same model and size having left the mark". At worst, the use of this phrase lays one open to the criticism of partiality. At best, it does nothing to convey an assessment of the weight of evidence in favour of one or other of the stated propositions.

The following examples are of the use of words in a manner that tends to obscure, rather than clarify:

1. "There is evidence of a link between the drug deal and the dwelling of Mr Smith".
2. "There is evidence that Mr Smith has been associated with the firearm X."
3. "There is evidence that Mr Smith was involved in the incident."

Each of these is unsatisfactory in its own way. In no case is the nature of the association clear and each sentence is capable of various interpretations. In each case, the scientist should have made clear just what propositions were being addressed.

The word "contact" is an important part of the vocabulary of the forensic scientist, but there is a danger of using it in a manner that tends to obscure meaning. For example, "in my opinion, Mr Smith had been in recent contact with broken glass" could mean all sorts of things.
Support or refute
It has become quite widespread practice among forensic scientists to use this phrase in the context "I have considered whether the evidence supports or refutes the proposition that...". However, the word "refute" is not the true converse of "support". The latter permits of degrees of support, whereas the former is categorical in nature. The verbal scale is symmetrical about likelihood ratios of one so "supports" can always be employed for opinions that corroborate and in such situations "refute" is not needed.

Thus, whereas it may be appropriate to use "refute" to convey a categorical rejection of a proposition, it is less appropriate to employ it as the converse of "supports".

Statement structure
Mandatory requirements
There are several aspects of the statement that are governed by law, precedent and good practice, such as disclosure and listing of items. The exact requirements will depend on the jurisdiction in which the scientist operates and will therefore not be discussed further in this paper. The remainder of the statement should flow from, and reflect, the logical thought processes, and their application to the examination of items, that are encouraged by the application of the CAI model. The FSS has a menu of section headings that reflect the natural stages of the model and these will now be described.

Framework of circumstances
The three ways in which the framework of circumstances will influence the evaluation of the scientific evidence at court may be summarised as follows.

1. By contributing to the formulation of the propositions that are addressed.
2. Given the propositions, aspects of the framework will condition the scientist's judgement of the probability of the evidence. Information about times and actions, for example, will inform judgements about transfer and persistence in some cases. In a DNA case, to give another example, a physical description of the offender will inform a decision about which database to use.
3. Other aspects of the framework will influence the judgement of the jury in relation to the prior odds in favour of one or other of the propositions.

The scientist may have been told many items of information relating to the crime(s), suspect(s), witnesses, and so on. It is something of a judgement call to decide on which items of information are relevant to the interpretation of the observations that have been made. Those that have a bearing on the first two of the above should clearly be included; those that serve only to influence the third should clearly be omitted.

The framework of circumstances is not a collection of "facts". Much may depend on witnesses who are later shown to be unreliable. This is why it is important to explain how the framework appeared to the scientist at the time of the examination. It is also advisable to give a signal that, should the framework change in any way, it will be necessary to review the interpretation.

Purpose
This is no more than a brief explanation, in general terms, of why the examination was undertaken, the techniques applied and items considered. Discretion is needed here, because it often happens that the examination followed a different course than that originally envisaged by the customer. For some time, there has been a view that there should be a strong relationship between this section and the conclusion, but this view can be unnecessarily restrictive.

Note that the customer's view of the purpose might be rather different from that of the scientist. Thus the customer might see the purpose to be "to seek evidence to put Mr Smith at the scene of crime". The scientist, being impartial would present this differently, for example "to seek evidence to help address the issue of whether or not Mr Smith was at the scene of the crime".

In those cases in which the scientist has examined only a selection of the items submitted, the reasons for the selection might best be made clear at this point.

Technical issues
It is necessary to explain sufficient of the details of any techniques that have been employed to aid the comprehension of the court. This is a far from easy undertaking. DNA profiling, for example, has a technical complexity that can be bewildering even to scientists from other disciplines. Yet the scientist has a duty to give an explanation in simple terms of the principles of what is involved.

Fortunately, it is usually possible to select appropriate macros for inclusion in the statement. Careful judgement should be employed, however. There is little point, for example, in describing the techniques of fibres comparison in a case where no fibres were actually found!

Examination and results
This section will often require careful structuring. It is necessary to record all relevant observations and sometimes the pattern of evidence will be very complicated. So there are conflicting demands: it is difficult to describe comprehensive detail, yet at the same time maintain an interesting and comprehensible narrative. There is a school of thought that favours the use of tables as an aid to summary. This is fine as long as the scientist can be confident that the tables will be copied for the jury. Otherwise, it is rather difficult to read out a table!

Interpretation
This is where the scientist must make every effort to convey his/her interpretation of the observations in a logical and
clear manner. The key to this process is a specification of the propositions that have been addressed. It might be necessary to explain why a particular set has been chosen. For example, if level 1 propositions have been addressed then it might be useful to explain why it was not possible to address level 2 propositions.

Next should come an explanation of the scientist’s assessment of the probability of the evidence given each of the propositions. This naturally leads to an opinion about which of the propositions is supported by the evidence and an assessment of the strength of that support.

In the event of there being uncertainty about salient features of the framework of circumstances, it may be helpful if the scientist here explored the sensitivity of the assessment to possible changes in the circumstances.

**Conclusion**

Whether or not a separate conclusion section is necessary is a moot point that may depend on the complexity of the case. If there are several strands to the evidence and a number of different sets of propositions then this may be the place to attempt to draw them together.

It is understandable that our customers may ask to have a brief conclusion containing a simply stated “bottom line”. But we can easily see that this is a simplistic view. For example, our “bottom line” might be strong support for a level I proposition. A hurried prosecutor may not sense the issues that need to be addressed in considering the level 3 propositions that will be before the court.

**Appendix**

The purpose of the Appendix is to isolate the more esoteric technical information and results from the main body of the statement. Information presented in this way is provided for completeness and to avoid the use of jargon in the main part of the statement. The Appendix is for reference purposes and is not intended for reading out in court. It is principally for the use of specialists who are assigned to scrutinise the work that has been done.

**Complex cases**

The foregoing has tended to concentrate on the simpler kind of cases, otherwise it would have been difficult to expose the central principles of interpretation and statement writing. Nevertheless, it is possible to continue to abide by those principles whatever the complexity of the case. The challenges there come from marshalling all of the material and presenting some kind of narrative.

When there are several strands to the evidence there is always a need at some stage to attempt to draw them together but there are few simple rules for doing this. There is one principle that should be borne in mind – it is not possible to combine level I propositions. If the interpretation is based on a set of level 1 propositions then they can only be brought together through addressing level 2 propositions. This is discussed in more detail in Evett et al [6].

It might be helpful to provide a separate Summary section, according to the discretion of the scientist. When two or more reporting officers have prepared statements in the same case then it may be appropriate for one of them to provide summarising comments. In some cases it may be more appropriate for this to be done as a separate statement.

**Discussion**

The breadth of disciplines within forensic science continues to expand and the range of techniques and subject matter within statements is extremely broad. Thus it is unrealistic to be prescriptive in laying down standards for interpretation and statement writing. This is where the creativity of the individual scientist has its greatest opportunity of expression and this should not be shackled by unrealistic rules and regulations. Nevertheless, it is highly desirable that guidelines for good practice should exist and be followed. This paper has concentrated on general principles in a manner that should inform all disciplines.

The nature and philosophy of forensic science will undoubtedly continue to evolve and the practices that have been discussed here will also be refined as the years pass. These are not tablets of stone neither are they intended to be a set of shackles to discourage imaginative innovation: it is hoped, however, that they provide a firm foundation for constructive expansion.

**References**