A GUIDELINE TO FORENSIC FUNDAMENTALS

Identifying the Underpinning Science of Human Based Forensic Science Disciplines

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INTRODUCTION

Increasing importance is being placed on the characterisation of the empirical foundations underpinning forensic science techniques. While many definitions may exist, the purpose of validation is to provide objective evidence that a method is fit for purpose and that the results obtained can be relied upon.[1] Given that the application of evidential forensic techniques is in the judicial system, these validation requirements are crucial for a court to assess the reliability of any evidence that may arise within a given case.

Forensic science has been under heightened scrutiny over the past decade and there has been an international call for more research into the underpinning science of forensic science disciplines.[2,3] The purpose of this document is to provide an overview of the requirements for a forensic technique to be considered scientifically valid, and able to withstand questions relating to the science underlying both the methods used and the resulting opinions. This document has been developed through consultation with forensic science practitioners and subject matter experts from across Australia and New Zealand.

While many of the considerations contained within this document are applicable to all forensic science techniques and even scientific techniques in general, the work arising from this document will focus on human based forensic disciplines. These human based forensic disciplines, also referred to as pattern comparison or cognitive forensic disciplines, are the ones for which the human is the instrument. That is, there is no analytical instrument that will perform an analysis and generate a result; rather comparison of features by an expert informs the result obtained. Therefore, the validation of these techniques requires consideration of the nature of the feature set under examination and how reliably an expert can interpret the significance of observed similarities and differences. It is anticipated that this document could be used by forensic managers, researchers and practitioners to assess the validity of current methods and opinions and to consider the suitability of new techniques being considered for implementation in forensic casework.

[1] *Guidance – Validation.* 2014. FSR-G-201 Issue 1. Birmingham: The Forensic Science Regulator.

[2] *Strengthening Forensic Science in the United States: A Path Forward.* 2009. The National Academies Press. Washington: National Academy of Sciences.

[3] *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison* Methods. 2016. The US President's Council of Advisors on Science and Technology (PCAST).

METHODS AND OPINIONS

Before defining the character of the science underpinning a forensic technique, it is important to distinguish methods and opinions. The scientific method is the process that is undertaken to generate a result. For example, in DNA analysis the method covers the multiple steps taken to generate a DNA profile. The method is only considered valid for use when the reliability and accuracy of the test method has been determined. In addition, it is expected that there would be a significant body of published literature outlining the basis, the limitations and error rates associated with the scientific methodology. Human opinion however, is the cognitive interpretation of the meaning of the result obtained. In the case of DNA analysis, it may be the conclusion that two DNA profiles match each other. This extends beyond the method and the validity of the opinion will be determined by work undertaken to identify under what criteria two DNA profiles can be concluded as originating from the same source with the associated probability of a match. This distinction is important because a validated method does not mean that all opinions derived from the results are based on sound underpinning science. For example, the opinion that a strong DNA profile has originated from direct contact extends beyond the validity of the DNA profiling technique unless specific studies have been performed to identify the point at which this opinion can be substantiated.

FEATURE SET ASSUMPTIONS

The application of human based forensic disciplines is based on underlying feature set assumptions which should be quantified and assessed as they form the basis of all methods and opinions that are derived. These assumptions relate not only to the nature and frequency of the feature set, but also to whether they can be used as a means to distinguish between groups or individuals. Consideration should be given to the following:

1. How the features originate and whether they are random or ordered.
2. The persistence of the features.
3. The transference of the features.
4. The potential for something foreign/unrelated to be mistaken as a feature.
5. The dependence or independence of the subcomponents of the feature set.
6. Whether unrelated items have the potential to resemble one another.
7. Population studies to determine the level of variation and frequencies of variants.
8. Whether there are established databases to determine the frequency of concurring features.

Where the means of human observation involves some form of enhancement (e.g. microscopy) or transformation (e.g. photography), the process used should preserve the feature set in sufficient detail to enable the human to differentiate meaningful differences and not introduce potential artefacts that could be mistaken as part of the feature set. The validation process should utilise empirical testing to identify any potential for this to occur.

ELEMENTS

In order to adequately identify the underpinning science of a forensic discipline, each technique must be broken down into its individual elements. These individual elements may refer to an assumption or process which underpins the entireity of a method, or may be related to the formation of an opinion that arises from the results of any testing or comparison performed. For human based forensic disciplines, the elements are likely to relate to whether the method of observing the characteristics is sufficiently sensitive to distinguish meaningful differences and whether the thresholds used in the comparison to formulate opinions are sufficient enough to distinguish between highly similar but unrelated features. For example, in the case of fingerprints, an element that underpins the method is the assumption that fingerprints differ between individuals. On the other hand, an element that relates to an opinion arising from the comparison is that once an expert identifies a number of common features, two fingerprints can be concluded as a match. For the discipline of microscopic hair examination, an example of an element would be the opinion that the presence of a certain feature on the root end of a hair provides evidence that it was forcibly removed. In this way each technique can be broken down into its individual elements and the underpinning science would need to be identified for each separately, to ensure that both the method and the opinions can be considered scientifically valid and reliable.

UNDERPINNING SCIENCE CONSIDERATIONS

In order to assist in the identification of the underpinning science of forensic techniques, a number of considerations have been identified. It is important to note that each of these considerations, if applicable, should exist for each of the individual elements whether they are related to the method or the opinion.

RELEVANT EMPIRICAL STUDIES (EXTERNAL)

Once the specific element has been identified, a review of the empirical studies available in the literature should be conducted. A good published scientific validation study would include the following:

- explanation of the methodology and the opinions that can be derived
- publication in a recognised, peer reviewed scientific journal
- use of ground truth known experimental materials
- use of a statistically significant sample size.

RELEVANT EMPIRICAL STUDIES (INTERNAL)

After reviewing the literature external to the laboratory, consideration should be given to the work that has been or may need to be performed within the laboratory. A good internal scientific validation study would include the following:

- explanation of the methodology and the opinions that can be derived
- internal peer review process with external consultation, where appropriate
- use of ground truth known experimental materials
- use of a statistically significant sample size.

EXPERTISE

Where the human is the instrument for a forensic technique, it is important to identify the level of expertise required to perform the analysis. This may be carried out using appropriately designed competency instruments which cover the full spectrum of tasks the practitioner is required to perform in casework. The most effective way to demonstrate the existence of expertise however, is to compare the expert opinion to layperson opinion on casework related tasks.

TRAINING

In addition to the identification of relevant expertise, evidence of a structured training program relevant to task elements should be demonstrated through evidence of:

- competency based training programs that are not solely dependent on the length of time spent in training
- compliance with national guidelines and training standards, where available
- accreditation and certification, where applicable.

VALIDITY

The underlying method on which the element is based should be validated. The testing performed should be applicable to the method, ideally using ground truth known examples under casework relevant conditions. It is important to note that acceptance in court does not provide confirmation that a method is scientifically valid. The appropriate experimental design is important to ensure that the correct processes are validated. Some examples of the types of factors to be tested are:

- accuracy
- precision
- specificity
- sensitivity
- reliability
- reproducibility.

The test materials should be prepared based on studies of how closely unrelated items may resemble one another. Experimental design should include an equal mixture of randomly presented test materials that include:

- items that are related
- items that are unrelated with the highest degree of similarity.

The ground truth of test items should be known.

LIMITATIONS

An acknowledgement of the limitations of the element is crucial to ensure that the evidence provided can be appropriately assessed by the Court. Consideration should also be given to the need in both science and law to disclose these limitations in any scientific report that is prepared. Some examples include:

- element or general discipline specific limitations
- case specific limitations, where appropriate
- applicable error rates that may exist.

ASSUMPTIONS

It is important to acknowledge any assumptions that have been made on which the element is based. As in the case of limitations, consideration should be given to the need in both science and law to disclose these assumptions in any scientific report that is prepared. Some examples include:

- underlying principles of the feature set on which the basis of the analysis is being performed
- case specific assumptions required to perform the analysis, where appropriate.

IMPLEMENTATION CONSIDERATIONS

Even though the underpinning science may have been defined for each element, there are additional process considerations for the implementation or ongoing use of a forensic technique which may impact on its validity and reliability. While some of these may be at the organisational level or specific to the practitioner, it is still worthwhile to address these additional considerations for each of the discipline processes being reported.

PROFICIENCY TESTING

Proficiency testing is an important element of a laboratory's quality program, and is used to continually test the overall casework examination processes. Participation in externally manufactured and managed testing is ideal wherever possible. In the absence of available external proficiency testing programs, an internal proficiency program may be considered, as well as participation in collaborative trials. A sound proficiency testing program should contain the following:

- blind testing specific to the element
- scenarios and testing materials that are consistent with those encountered in casework
- a range of quality and difficulty that emulates casework scenarios.

Ideally, the tests will be produced by an accredited body which reports or publishes the results. An effective error management process should also be in place to address non-conformances highlighted from the analysis of proficiency testing results.

ACCREDITATION

Accreditation is a practical way to demonstrate that the processes associated with the individual elements are performed in accordance with available standards. If the testing performed is of a class that can be accredited, consideration should be given to the following:

- national standards, where they exist, should be adhered to
- international standards that may exist and should be adhered to.

PRESENTING OPINIONS

In order to appropriately convey the result of the analysis, consideration should be given to the way in which it is presented. Transparency in reporting is essential and can be achieved through:

- the statement of all propositions considered in the formation of opinions
- the acknowledgement that the results are based on the opinion of the practitioner
- ensuring that the opinion has considered all of the tests reasonably available
- the acknowledgement that there may be alternative conclusions which could be reached.

REPORTING SCALES

To assist in the presentation of the evidence, it may be appropriate to utilise a reporting scale. While there are a number of reporting scales available, when identifying the appropriate one, consideration should be given to:

- laboratory standards and consistency in reporting across disciplines
- testing performed assessing the use of the scale for the technique
- whether the reporting scale could be understood by a lay person.

It is also important that the scale is provided and referenced in the scientific report.

PROPOSITIONS

In most forms of forensic analysis there are identifiable competing propositions which are under test. Consideration of the logical framework under which the result is formulated can be undertaken in the following ways:

- development of generic or case specific propositions, where appropriate
- acknowledgement of alternative propositions, where possible
- consideration of the use of evaluative reporting.

PEER-REVIEW

The peer-review of work performed is an important part of the forensic analysis process. Whether considered a verification or peer review, good practice would involve an independent assessment of the analysis including:

- independent comparison with a limit to the amount of marks from the original analysis by the first practitioner
- limited access to the case notes with only the required information provided, where possible
- staged approach to reduce the potential for bias.

A documented disagreement resolution process should also be available to address differences arising from the peer-review process.

HUMAN BIAS

Consideration should be given to developing processes which limit the potential influence of human bias on the evaluation and reporting of results. There are a number of points which can be considered:

- carry out investigations within disciplines to identify sources of potentially biasing information or processes
- redesign processes to allow for the assessment of risk around different types of potentially biasing information or processes
- introduce procedures designed to correct for biased processes, and manage potentially biasing domain irrelevant information reaching examiners

Consideration should also be given to acknowledging the attempts made to reduce the impacts of bias in the scientific report, to allow assessment of the potential influence by the court.

CONCLUSION

Forensic science evidence has served the Courts well for many years and its continued success will be dependent on ensuring that there is empirical support for the validity and reliability of the underlying science. It is anticipated that if each of the considerations presented in this document can be satisfied, for each of the elements identified within a given forensic science discipline, a sound scientific basis will be available for the Court to assess the strength of the forensic evidence appropriately.

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