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Introduction

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Forensic scientific evidence can help us to establish:

- that a particular person was at a given place at a given time;
- that a particular person carried out an activity, such as signing a cheque or breaking a window;
- that something was done with a particular instrument, for example, a door was forced with a particular tool, a shot fired from a particular weapon, or a call made from a particular telephone;
- a relationship between two people, for example, in paternity disputes and incest or immigration cases.

There is a whole range of techniques used for forensic purposes, and new methods are continually being added to the arsenal of the forensic scientist. Our purpose is not to discuss the technical details of these methods, which rapidly become dated. We propose to concentrate on how such evidence should be interpreted and incorporated into the court process.[1]

1.1 Three 'principles'

Traditionally, several ideas have been proposed as principles for forensic science:

(i) Locard's 'Principle': A perpetrator will either leave marks or traces on the crime scene, or carry traces from the crime scene. This is often misquoted as 'every contact leaves a trace' but Locard never actually claimed this.
Edmond Locard (1877–1966) was a French forensic scientist. He proposed that we should always consider whether traces of the victim or crime scene can be found on

[1] We use evidence here in the sense of observations (that are certain) that influence our degree of belief in the truth of things we cannot be certain about, such as those listed here. We do not limit evidence to information that has been designated as such by a court.

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the accused and whether traces of the accused can be found on the crime scene or victim. After an assault, for example, we might find skin and blood under a deceased's fingernails and infer that they come from the attacker. We might arrest a suspect on the basis of other evidence and find, on him or his clothing, fibres which might come from the deceased's clothes, blood which might come from the deceased or soil and plant material which might come from the scene.

(ii) 'Principle' of individuality: Two objects may be indistinguishable but no two objects are identical.[2]

The combination of these two ideas together might seem to have enormous potential value to the forensic scientist. If every contact provides ample opportunity for the transfer of traces, and every trace is different that seems to be cause for optimism. However, if no two objects are identical, then, for example, no two fingerprint impressions will be identical even if they are taken from the same finger; no two samples of handwriting by the same author will be identical. The question is whether two marks have the same source, and how much our observations help us in answering that question.

We describe these two statements as proposed principles rather than laws because neither meets the standard definition of a law of science. The philosopher Karl R. Popper (1902–1994) said that for a law to be regarded as scientific it must be potentially falsifiable, that is, it must be possible, at least in theory, to design an experiment which would disprove it.[3] It seems to be impossible to design an experiment to refute the first of these principles. If an experiment fails to find an impression after two objects have been in contact, it may be that all that is revealed is the limitations of the detection process. The proposed principle that no two objects are identical does not require proof, since two objects that would be identical in every way would – by definition – be one object. Unfortunately, it does not follow from the uniqueness of every object that we can correctly point out its unique source.

(iii) Individualisation 'Principle': If enough similarities are seen between two objects to exclude the possibility of coincidence, then those objects must have come from the same source.

This 'principle' has a long history in forensic science, as can be seen from the following quotes that span the 20th century:

> *The principles which underlie all proof by comparison of handwritings are very simple, and, when distinctly enunciated, appear to be self-evident. To prove that two documents were written by the same hand, coincidences must be shown to exist in them which cannot be accidental.*[4]

> *When any two items have characteristics in common of such number and significance as to preclude their simultaneous occurrence by chance, and there are no inexplicable differences, then it may be concluded that they are the same, or from the same source.*[5]

[2] Wittgenstein: 'Roughly speaking, to say of two things that they are identical is nonsense, and to say of one thing that it is identical with itself is to say nothing at all' (*Tractatus*, 5.5303).

[3] Popper KR, *Conjectures and Refutations: The Growth of Scientific Knowledge*, 5th ed (Routledge and Kegan Paul, London, 1989).

[4] Osborn AS, *Questioned Documents*, (Rochester, New York, 1910), p. 211.

[5] Huber RA, Expert witnesses, (1959), 2, *Criminal Law Quarterly*, 276–296.

> *… we look for unique characteristics in the items under examination. If we find a sufficient number of characteristics to preclude the possibility or probability of their having occurred by coincidence in two different objects, we are able to form a conclusion of individualization. It's as simple as that.*[6]

This popular so-called principle, while simple, is fraught with problems. The possibility of a coincidence can never be completely excluded, which precludes categorical statements of individualisation. There is no general criterion possible for the number of coincidences needed to decide an individualisation; whatever level is chosen is purely arbitrary. How certain we would want to be for a decision would depend on the gravity of the crime involved (e.g. capital murder versus shoplifting). How certain we could be would also depend on other evidence and information in the case. Clearly, such issues and decisions are not up to the forensic scientist but rather the trier of fact. The role of the forensic scientist is not to decide the issue, but to describe what the evidence is worth. This 'principle' should therefore not be used.

1.2 Dreyfus, Bertillon, and Poincaré

In 1894, Alfred Dreyfus (1859–1935), an officer in the French army, was charged with treason in what was to become one of the most famous criminal trials in history. The charges were espionage and passing information to Germany. The espionage had definitely taken place and one of the central items of evidence was the comparison of the handwriting in an incriminating note with Dreyfus's own handwriting. A prominent witness for the prosecution was Alphonse Bertillon (1853–1914).

Bertillon was a Paris police officer who rose to found a police laboratory for the identification of criminals. He was well known for proposing a system of anthropometry, which became known as Bertillonage. Anthropometry simply means the measurement of humans. Bertillonage required taking a photograph and recording a series of measurements of bone features which were known not to change after adolescence. Later, fingerprints were added to the features recorded. The basis of the system was that it would be unlikely that any two people would have the same measurements over the whole range of features.

Bertillonage suffered from a number of problems. The method was slow and expensive and was far from error free. The officers taking the measurements had to be specially trained; this involved more expense, and even then, at the levels of accuracy called for, no two would take the same measurements from the same series of features. Nor could the system be applied to juveniles.

The purpose of the system was to determine whether or not a person had the same measurements as a person who had earlier been arrested. This can be very useful, for example, when someone is arrested on suspicion of failing to attend court or when a person being sentenced denies that previous convictions relate to him. However, Bertillonage could not help investigators by providing evidence that a particular person had been, for example, at the scene of a crime.

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[6] Tuthill H, *Individualization: Principles and Procedures in Criminalistics* (Lightning Powder Company, Salem, Oregon, 1994) p. 27.

Although fingerprints were later taken as one of the Bertillonage measurements and Bertillon himself solved a crime using fingerprints in 1902, there was no formal classification system for them. Once such systems were developed (by Galton and Henry in England and India, and Vucetich in Argentina) it was possible to quickly exclude the majority of the fingerprint collection (i.e. the other classes) on each search. Fingerprints became a far quicker and simpler method of identification than anthropometry. In the first full year of operation by the London Metropolitan Police, fingerprints identified 3 times as many persons as anthropometry and, 2 years later, 10 times as many. Not only were fingerprints far simpler and cheaper to obtain and record but they could also help investigators identify the perpetrators of crimes. Bertillonage was dropped.

Bertillon gave evidence in the Dreyfus case as a handwriting expert and claimed that Dreyfus had written the incriminating document. His evidence referred to certain similarities and multiplied together the probabilities of each of the similarities occurring by chance to arrive at a very low probability of them occurring together by chance. His evidence was subjected to devastating critique by a number of people including Poincaré, an eminent mathematician.[7] Poincaré made three important points about Bertillon's evidence. The first was that Bertillon had simply erred in that the figure he produced was the probability of getting the four similarities amongst four examined characteristics. There were far more characteristics examined, and so the chances of finding four similarities were actually much greater than Bertillon's figure. The second point Poincaré made was that events that have actually occurred might be seen beforehand as highly improbable. The example he gave was the drawing of a particular number or set of numbers in a lottery. The probability that any particular set of numbers will be drawn is extremely low. Once it has been drawn, however, that low probability does not mean that the draw has been dishonest.

Most importantly of all, Poincaré discussed what is called the inverse probability problem, the difference between calculating in advance the probability of an effect and calculating after the event the most probable cause of an effect:

> *As an example of probability of effects, we usually choose an urn containing 90 white balls and 10 black balls; if we randomly draw a ball from this urn, what is the probability for this ball to be black; it is evidently 1/10.*
>
> *The problems of probability of causes are far more complicated, but far more interesting.*
>
> *Let us suppose for example two urns of identical exterior; we know that the first contains 90 white balls and 10 black balls, and the second contains 90 black balls and 10 white balls. We draw arbitrarily a ball from one of the urns, without knowing from which, and we observe that it is white. What is the probability that it came from the first urn?*
>
> *In this new problem, the effect is known, we observed that the ball drawn was white; but the cause is unknown, we do not know from which urn we made the draw.*
>
> *The problem that we are concerned with here is of the same nature: the effect is known, the indicated coincidences on the document, and it is the cause (forgery or natural writing) that is to be determined.*[8]

[7] Taroni F, Champod C, and Margot P, Forerunners of Bayesianism in early forensic science, (1998), 38, *Jurimetrics*, 183–200.

[8] Poincaré H, Darboux G, Appell P (1908) Rapport de MM. les experts Darboux, Appell et Poincaré, In *Affaire Dreyfus; La révision du procès de Rennes; Enquête de la chambre criminelle de la Cour De Cassation* vol. 3, p. 502. Paris: Ligue française pour la défense des droits de l'homme et du citoyen.

Poincaré identifies a crucial point for forensic science and, indeed, all reasoning about evidence in court. This is a central theme of this book and will be explained in the following chapters. Courts are not concerned with the probability that some observation would be made. They are concerned with what can be inferred from the fact that the observation has been made. The question for the court then is what inferences can be drawn as to the guilt of the accused.

Poincaré went on to make the point that single items of evidence enable us to alter our assessment of the probability of an event but they cannot determine the probability of an event on their own[9]:

> *To be able to calculate, from an observed event, the probability of a cause, we need several data:*
>
> 1. *we need to know what was à priori, before the event, the probability of this cause.*
> 2. *we then need to know for each possible cause, the probability of the observed event.*

1.3 Requirements for Forensic Scientific Evidence

Photographs are still used to help identify criminals and are recorded with the details of their convictions. They have a number of advantages: they can be transmitted and reproduced easily and can enable people to be recognised at a distance. In most cases, a photograph will settle a question of identity. Where this is seriously challenged, however, a photograph is of questionable value, particularly if much time has passed since it was taken.[10] Similarly, physical descriptions can be broadcast on police radios and even the most rudimentary description will eliminate a large proportion of the population. However, when identity is seriously challenged, descriptions and even eyewitness identification are of questionable value, perhaps because the question has become whether the perpetrator was the accused or someone else of similar appearance.

The limitations of Bertillonage prompt us to consider the features of an ideal scientific system for identifying people. These would include:

- that it uses features that are highly variable between individuals;
- that those features do not change or change little over time;
- that those features are unambiguous so that two experts would describe the same feature the same way;
- that those features can be transferred to traces at a crime scene; and
- that it is reasonably simple and cheap to operate.

Inevitably, few systems will satisfy all these requirements and in particular there may be a trade-off between the last requirement and the others. Each of the systems that we examine later will satisfy some of these requirements but not all.

[9] Poincaré pointed out that in the example he gave, before we draw the ball, we intuitively assess the probability that the urn chosen was the one with 90 white balls and 10 black balls as 0.5, or odds of 1 to 1. The problem would be changed if there were 11 urns to choose from and we knew that 10 of them had 90 white balls and only one had 90 black balls.

[10] At the trial in Israel of the alleged Nazi concentration camp guard Demjanjuk various techniques were used to try to show that the defendant in 1989 was the person in a photograph on a 50-year-old identity card. Conversely, methods of altering photographs, either to implicate or exculpate a person, are now readily available.

If we can establish features that help distinguish between individuals or groups, it becomes useful to maintain a database of observed features of known individuals. Large databases of DNA profiles have now been established, as happened with fingerprint collections over the last century. In investigations, such databases allow police to search for individuals that could have left a crime scene trace.

If a suspect has been identified and the observed features of this known person are, for example, similar to those of the traces from the crime scene, we need to evaluate what those observed similarities are worth. If the suspect had nothing to do with the crime, what would be the probability of finding those similarities? That probability can be assessed with the help of databases of features that are representative of some population. It does not require the contributors to the database to be known.

As we have seen, evidence should not be expected to give certainty. This does not make evidence 'unreliable' or inadmissible. Lawyers often tend to ignore evidence that does not claim to provide certainty, but by doing so, they lose relevant and probative evidence.[11] Uncertainty is inherent to the limited amount of information that can be extracted from traces, which may be minute, old and contaminated. Poincaré did not tell us to simply discard such evidence, but to assess the probability of the observed effects for the possible causes.

It follows that a scientific witness will not, in principle, be able to say that two samples came from the same person. The evidence can only lead to an assessment of the probabilities that the evidence would be found if the prosecution case was true and if the defence case was true. The legal system has not been successful in dealing with this kind of evidence, and our purpose is to explain how such evidence should be given and integrated into the case.

1.3.1 Reliability

Rather than think rigorously about these problems, the legal system has been prone to ask questions such as 'how reliable is this evidence?'. This question is difficult to answer since 'reliable' appears to have no fixed meaning. We discuss its different possible meanings and the consequences of each in Chapter 5.

1.4 What We Will Cover

We adopt a structure different from that of most other books on forensic scientific evidence. Those intended for scientists are usually built round the different techniques available. Those for lawyers are often structured round rules such as the Basis Rule, the Field of Expertise Rule, the Qualifications Rule and the Ultimate Issue Rule. That such a structure is unsatisfactory is shown by the extent to which these 'rules' are intertwined. Courts sometimes refer to one, sometimes to another. Cases that are decided on the basis of one rule are often explicable by reference to another. In this book, we

[11] As the New Zealand Court of Appeal said in respect of fingerprints in *R* v *Buisson* [1990] 2 NZLR 542, 548.

- explain the fundamentals of logical reasoning about evidence and show how these principles apply to all forms of evidence in court cases. These principles explain how individual items of evidence should be thought about (Chapters 2 and 3);
- consider what kinds of questions forensic scientific evidence can answer (Chapter 4);
- discuss how the strength of evidence can be explained (Chapter 5);
- show how to combine evidence with the case as a whole (Chapter 6);
- look in more detail at how forensic scientists evaluate evidence and the methods they use (Chapter 7);
- discuss the analysis of some specific types of scientific evidence to show how the principles apply to particular problems (Chapter 8);
- discuss various misleading and fallacious styles of presentation of evidence, some of which are still in common use (Chapters 9 and 10);
- examine some of the more traditional legal questions in the light of our analysis and make recommendations for reform (Chapter 11).