

**MARKS EVIDENCE AND PATTERN RECOGNITION IN FORENSIC SCIENCE -  
FROM FINGERPRINTS TO BALLISTICS**

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Marks evidence encompasses the examination of any item where a mark or impression has been made during criminal activity with the purpose of associating the mark with the object or implement that made it. It encompasses a wide range of disciplines that include fingerprint identification, bullet and cartridge case comparisons, tool mark examinations, shoe prints, bite marks and even handwriting and signature examinations can be regarded as marks evidence.

The underpinning methodology in marks examination is pattern recognition. A finger contacting a surface leaves the ridge pattern, a bullet passing down the barrel of a firearm has rifling marks and imperfections impressed on it and a tool cutting a wire will leave characteristics of the blade on the cut surface. The pattern of ridges in the case of a fingerprint or the pattern of striation lines in the case of tool marks or ballistics examinations provides the evidence used to associate the crime scene mark with an individual, a firearm or a tool.

In pattern recognition sciences there are two levels of identification referred to as class and individual characteristics. Class characteristics are features that associate the mark with a particular type of implement, a fingerprint with a group of people or a cartridge case with a type of firearm. Individual characteristics are the features that allow the mark to be associated with a specific tool, firearm or individual. Fingerprints and firearms provide very good examples of marks and pattern recognition in quite different applications.

In fingerprints the class characteristics are the patterns formed by the friction ridges on the fingers, the most common being loops and whorls. The individual characteristics are the various ridge formations. All fingerprint ridge patterns contain these features and it is the relative location of them that provides individual identification. The challenging and interesting aspect of fingerprint identification is the detection of what are termed latent fingermarks. These are the invisible marks composed of body sweat that left at a crime scene when a surface is touched. There have been considerable advances over the last twenty years in the detection of latent marks and there are a wide range of physical and chemical processes available to detect these marks. The processes aim to exploit the various components in a fingerprint deposit to form a visible image that contrasts with the substrate. Identification of the developed crime scene mark can also be challenging as they may only be a fragment of the mark or have suffered distortion. Thus fingerprint detection and identification is an interesting combination of chemistry with pattern recognition.

The great strength of fingerprint evidence is the consistency of dealing with the same types of individual characteristics on all marks. In addition fingerprints remain virtually unchanged through a person's life making it a highly reliable individual identification parameter. The reliability of fingerprint identification is further underpinned by over one hundred years of success as an identification tool throughout the world.

When a firearm is discharged a range of materials are released which can provide evidence to assist an investigation. Chemical products, known as gunshot residues (GSR) are derived from the primer and propellant and can be deposited on the person firing the weapon and on the target. The residues deposited on the firer can provide evidence of association with a firearm and the distribution of residues on the target can provide an indication of the range of the shot. The detection of GSR on the firer requires complex analytical instrumentation involving scanning electron microscopy combined with x-ray spectroscopy. Detection of target residues to determine range involves application of chemical reagents that produce coloured products with the firearms residues.

The important physical materials expelled from a firearm are the projectile (bullet) and cartridge case. Cartridge case ejection at a crime scene is usually only associated with automatic and semi-automatic weapons. Both items will bear characteristic markings due to intimate contact with the firearm. In the case of the bullet the manufacturers rifling grooves, known as lands and grooves, will be imprinted into the surface. The lands and grooves are the class characteristics and combined with the bullet geometry provide an indication of the type and calibre of weapon used. Individual characteristics can exist within the rifling marks that have been imparted during manufacture by the rifling tool or have developed during use of the firearm. These are known as striations and have the appearance of scratches on the surface of the bullet that require the use of a microscope with appropriate illumination of the surface for visualisation. The crime bullet can be compared with a test fired bullet using a comparison microscope which allows the striations from the two bullets to be aligned. The cartridge case will bear an impression made by the firing pin and in the case of automatic and semi-automatic weapons shows marks from the ejection mechanism. The firing pin marks can also be compared with those on a test fired cartridge using a comparison microscope. Thus in a similar way to fingerprints firearms examinations can involve an interesting combination of analytical chemistry and pattern recognition.

One of the major problems faced by firearms examiners is that crime scene bullets can often be badly damaged, fragmented or distorted making comparison with a suspect firearm difficult or even impossible. Cartridge cases therefore often provide a more reliable source of firearms identification. This is an important point for all marks evidence. A perfect fingerprint or pristine cartridge case are ideal but as the marks become weathered, distorted or fragmented is an increase in unreliability with a corresponding increase in subjective judgement.

One of the challenges in marks evidence of all types is determining the value of a mark. In the case of fingerprints automated fingerprint identification systems (AFIS) have been the major development. Most countries around the world including Australia have large AFIS databases and crime scene fingerprints can be searched against the database to potentially identify an offender. All AFIS identifications are confirmed by a trained examiner. There has been similar progress in the case of firearms with the rapid improvements in imaging and computing technologies automated systems

are now available. The integrated ballistics identification system (IBIS) is used widely. For reasons stated above it has greater success with cartridge case examinations than bullets. A data base of marks images can be accumulated allowing multiple crime scenes to be linked and then associated with a firearm when found. As with fingerprints all identifications are confirmed by a trained examiner.

One of the challenges facing marks evidence is being able to place a quantitative value on a positive comparison. This is largely as a result of the massive growth in the application of DNA profiling technology to forensic science investigations. DNA, because of its genetic links, is able to provide a statistically based interpretation to the value of a DNA profile and courts are now familiar with probabilistic expressions for DNA evidence. It is common for values of one in a billion to be quoted for the probability that the DNA profile is not from a suspect making it in effect an individualisation based on an objective test. This has resulted in questions being asked of the traditional forensic science disciplines such as marks evidence about the value of a "pattern match". Providing DNA type statistics however is very difficult if not impossible. In the case of tool marks or bullet comparisons an experienced examiner will instinctively know that the comparison is showing a strong link between the mark and the weapon or tool. However it is not a satisfactory scientific outcome when the strength of a comparison does not connect individual expertise with a scientific measure. Data bases such as exist with AFIS and IBIS are assisting in providing an indicator of individuality but cannot provide meaningful numerical weight to comparisons.

Marks evidence in all its forms will remain a valuable and important forensic science tool. This presentation will discuss marks evidence in its totality and show that the various disciplines can be strongly linked by an underpinning scientific and analytical philosophy. The value of marks evidence in its various forms will be evaluated relative to the probability based conclusions of DNA profiling.