

The Current Position of Fingerprint Evidence - a Literature Review

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Acting on the instructions of Senior Counsel to the Fingerprint Inquiry - Scotland, Gerry Moynihan QC, we have conducted a literature review that seeks to address 'the current status of fingerprinting as a forensic science, and possible causes of error'. In particular, we have considered current academic and professional knowledge and opinion regarding:

- the scientific basis of fingerprint identification
- the numeric -v- the non-numeric standard for fingerprint identifications
- sources and causes of error in analysis and error rates in fingerprint identifications
- the probabilistic approach to fingerprint evidence

In conducting this review we have limited our research to material that is in the public domain and that has been published in peer reviewed journal, largely within the last 10 years.

Abstract

In what follows we review various aspects of the current literature related to fingerprint evidence and examination, with the intention of conveying the current discourses surrounding certain aspects of this particular sub-discipline of forensic science. Although fingerprint evidence continues to play a prominent role in criminal investigations, it has recently been subject to considerable criticism, with questions being raised over the scientific basis of the underlying assumptions of the technique, particularly from scientific and legal scholars. Much of this criticism has sought to raise questions over the admissibility of fingerprint evidence in relation to the *Daubert* ruling in the US, and hence a considerable amount of literature exists in relation to this particular topic. This review provides an overview of the main arguments of these critics, as well as summarising the justifications put forward by proponents of fingerprint examination for the continuing adherence to the principles of uniqueness and individualisation which are associated with this and certain other forms of forensic evidence. We show how this debate exposes differing notions of 'validity' and 'reliability'. We also survey work which has addressed the issues of error and proficiency testing, before moving on to describe how the advent of DNA profiling has prompted attempts to apply probabilistic frameworks to fingerprint examination, although it must be stressed that such attempts remain at a preliminary stage. We conclude with a consideration of other developments that may have a bearing on the professional practice of fingerprinting.

Advocating the validity of fingerprint identification

Ashbaugh (1999)¹ provides a historical account of scientific work which he argues forms the basis of a scientific understanding of the variance of friction skin ridges. Ashbaugh argues that an understanding of the formation of friction ridges via developmental studies provides the necessary justification for the assumption of uniqueness of fingerprints. At approximately three weeks of life the fetal epidermis is one cell thick. At this point epidermal cells begin to divide and proliferate, and

¹ Ashbaugh (1999) *Ridgeology: Modern Evaluative Friction Ridge Identification*, Royal Canadian Mounted Police Document.

at 12-13 weeks, ledge-like formations begin to develop on the bottom of the epidermis next to the dermis, where cells then begin to develop rapidly. These ledges, known as primary ledges, constitute the origins of surface friction ridges. Each primary ledge initially forms as an individual unit, each developing a pore. As the ridge units grow, they fuse together. The units form at various times, and at different locations on the volar surface. The differential series of processes creates a series of pressures which affect ridge alignment and shape. According to Ashbaugh, a combination of genetic and physical factors affect the formation of friction ridges, although each individual ridge forms in a roughly random manner. By the fourth month, primary ridges have proliferated sufficiently so that cells accumulate at the surface to form friction ridges. Relatively little is known about the precise behaviour of these random processes, although algorithmic models have been advanced which have sought to replicate these processes² including the use of computer-generated images.³

Ashbaugh reviews a number of previous studies which have sought to investigate the development of fingerprint characteristics in populations. For example, Okajima (1967) compared the occurrence of certain basic minutiae between twins in various populations.⁴ Higher correlations on the number of minutiae were found for monozygotic twins in comparison to dizygotic twins. More minutiae were observed on prints from males than females, although Okajima's results did not suggest any bilateral difference, e.g. right vs left.⁵ Other work has focused on the relationship between the number of minutiae and pattern area and type, with other studies finding a correlation between the number of minutiae and specific fingers (Loesch 1973, Dankmeijer et al 1980).⁶ Despite the interest in the use of minutiae-led methods, there has been relatively little work carried out which has focused on the variability of minutiae within specific populations. More recently however, Gutierrez et al (2007) have investigated the relative variability of minutiae in a sample of the Spanish population.⁷ This study reported statistically significant differences in the prevalence of the 14 minutiae characteristics used by the Spanish police in terms of the sexes, and within general patterns (i.e. whorls, loops, arches etc). Singh et al (2005) have described a novel approach which seeks to match single fingerprints with hands and fingers on the basis of certain characteristics involving the flow of apex ridges, degree of rotation of centrally circular ridges, angle between core and delta, other ridge features and the position of perpendiculars drawn between the core and delta.⁸

² Sherstinsky, A. and Picard, R.W. (1994) 'Restoration and Enhancement of Fingerprint Images Using M-Lattice – A Novel Non-Linear Dynamical System', *Proceedings of the International Conference on Pattern Recognition*, Jerusalem, pp.195-200.

³ Capelli, R., Erol, A., Maio, D., and Maltoni, D. (2000) 'Synthetic Fingerprint-Image Generation', *Proceedings of the International Conference on Pattern Recognition*, Barcelona, pp.475-478.

⁴ Okajima, M. (1967) 'Frequency of epidermal-ridge minutiae in the calcar area of Japanese twins', *American Journal of Human Genetics*, 19, pp.660-673.

⁵ Champod, C., Lennard, C., Margot, P. and Stoilovic, M. (2004) *Fingerprints and Other Ridge Skin Impressions*, Boca Raton, FL: CRC Press, p.8.

⁶ Loesch, D.Z. (1973) 'Minutiae and Clinical Genetics', *Journal of Mental Deficiency Research*, 17, pp.97-105; Dankmeijer, J., Waltman, J.M., De Wilde, A.G. (1980) 'Biological foundations for forensic identifications based on fingerprints', *Acta Morphologica Neerl-Scand.*, 18, pp.67-83.

⁷ Gutierrez, E., Galera, V., Martinez, J.M., Alonso, C. (2007) 'Biological variability of the minutiae in the fingerprints of a sample of the Spanish population', *Forensic Science International*, 172, pp.98-105.

⁸ Singh, I., Chattopadhyay, P.K., Garg, R.K. (2005) 'Determination of the hand from single digit fingerprint: a study of whorls', *Forensic Science International*, 152, pp.205-208.

ACE-V

In the early 1990s a generic 'methodology' known as ACE-V (Analysis, Comparison, Evaluation, Verification) was defined to encompass the fingerprint identification process.⁹ In what follows we briefly outline the four key stages, drawing in particular on the detailed account of ACE-V given in Champod et al (2004).¹⁰

Analysis

The degree of visual information that can be derived from fingerprints is often conventionally divided into three levels: Level 1, 2 and 3.¹¹ *Level 1* refers to the pattern types which are formed from the flow of friction ridges on the volar surface. The work of early pioneers such as Galton (1892) and Henry (1900) led to the characterisation of patterns including arches, loops and whorls. In addition to this schema, some other measurements have been classified as Level 1, including ridge counting and tracing.¹² *Level 2* features refer to instances of characteristic ridge path deviations, known as *minutiae*. Common forms of minutiae include ridge endings, bifurcations and dots, although the nomenclature is not standardised and differences may be found amongst jurisdictions.¹³ Other features such as the presence of warts, scars or wrinkles are also classed as Level 2. Finally, *Level 3* refers to the study of features intrinsic to ridge formations, such as the alignment of ridges or the shape of their edges.¹⁴ This level also encompasses the consideration of pores found within ridge units, namely aspects of pore shape and their relative position.

During the analysis stage the examiner is expected to categorise all the features that are visible in the mark in line with the Level 1-3 schema, to assess their reality and to consider the conditions under which the mark was left. Hence the examiner should record where visible the type of ridge flow patterns observed, the minutiae and the form and position of ridge edges and pore features. Together this information is regarded as providing a means of assessing a mark's ability to define a unique source.¹⁵

Comparison

The comparison stage involves an iterative assessment of successive Level 1-3 features between the unknown mark and a known print from a suspect, and taking into account the tolerances dictated by the quality of the mark. In order to maximise the objectivity of the process, the examiner should ideally avoid any prior knowledge of the known print under examination. The comparison stage should in theory be focused on features that have been previously identified during an independent assessment of the mark. The comparison should always start with the use of a control measure, i.e. an observed feature in the mark that is then tested against the known print.

⁹ Op cit.1.

¹⁰ Op cit.5.

¹¹ Op cit.1

¹² Op cit 5, p.17.

¹³ Op cit.6

¹⁴ Op cit.11

¹⁵ Op cit.5, p.16.

Evaluation

At the evaluation stage, the examiner is obliged to make some form of inference about the identity of source. In theory at least, just one significant dissimilarity should be enough to declare an exclusion, yet this presents the practical problem of determining precisely what constitutes a significant difference.¹⁶ The relative clarity of the mark is regarded as playing a significant role in this instance, and hence any assessment may become more problematic given a poorly defined mark. If no significant differences can be ascertained however, the value of a match then has to be assessed. A considerable amount of discussion has focused on the processes by which individualisation can be seen to occur. Champod et al (2004) criticise what they regard as an overly simplistic binary approach which makes a distinction between so-called 'class' and 'individual' characteristics, arguing that the issue be better framed as a matter of *selectivity*, a measure which is best regarded as existing on a continuum.¹⁷ They also criticise the use of terms such as 'unique', 'identical', 'same' and 'identity', in constructing terms which can be seen to be statements of the obvious: 'every entity is unique' no two entities can be "identical" to each other because an entity can only be identical to itself...to say that "this mark and this print are identical to each other" is to invoke a profound misconception: the two may be indistinguishable, but they cannot be identical'.¹⁸ Subsequently they argue that the central question for fingerprint examiners to address is not 'Is this mark and that print identical?', but 'Given the detail that has been revealed and the comparison that has been made, what inference might be drawn in relation to the propositions that I have set out to consider?'. Their argument downplays enduring locutions such as 'nature never repeats itself' in favour of considerations of the selectivity of a high-quality mark in relation to the variability of latent marks which may exhibit varying degrees of completeness, distortion or clarity. Hence Champod et al conclude that the ultimate question concerns the number of similarities required to conclude to an identification.¹⁹ Discussions concerning this issue have featured in the literature for almost as long as fingerprints have been used in criminal investigations. In what follows we present an overview of these discourses.

Views on the manner by which fingerprint identification should proceed generally correspond to two distinct positions. The first reflects a view that identification should be based on solely quantitative criteria, with thresholds determined in relation to a certain number of concordant minutiae between the mark and a known print. A second position advances a more holistic view of identification criteria, in which there is a combined assessment of quantitative and qualitative features.²⁰ Yet Champod et al argue that these two positions are not mutually exclusive, and that improvements in transparency will eventually lead to the adoption of quality standards which will render the 'empirical' vs 'holistic' debate irrelevant. However, until such a moment presents itself, it is still worthwhile to consider each position in turn.

The empirical position is generally favoured in European countries, whereby a fixed numerical standard relates a minimum number of minutiae needed to establish an identification. The precise

¹⁶ Op cit.5, p.23; Thornton, J.I. (1997) 'The General Assumptions and Rationale of Forensic Identification', in Faigman, D.L., Kaye, D.H., Saks, M.J., Sanders, J., *Modern Scientific Evidence: The Law and Science of Expert Testimony Vol 2*, St Paul, MN: West Publishing, pp.1-49.

¹⁷ Op cit.5, p.24

¹⁸ Ibid.

¹⁹ Op cit.5, p.25.

²⁰ Op cit.5, p.27.

