NOWA KODYFIKACJA PRAWA KARNEGO Tom LIX
AUWr No 4038 Wrocław 2021

https://doi.org/10.19195/2084-5065.59.9

Myths about fingerprint evidence: Basic facts countering miscarriage of justice. Part 2

Saleh Mansour

ORCID: 0000-0002-4111-4704
Faculty of Criminology, Lebanese University
Beirut, Lebanon

Shital Zade

ORCID: 0000-0003-1976-8477
International Forensic Science Pvt. Ltd
Pune, Maharashtra, India

Shipra Rohatgi

ORCID: 0000-0003-0532-9908
Amity Institute of Forensic Sciences, Amity University
Noida, India

Slobodan Oklevski

ORCID: 0000-0002-1116-5631
Ministry of Interior, Republic of North Macedonia

Abstract

This is the second part of the study that aims at highlighting twenty-four myths about fingerprint evidence. In this paper, the authors are going to explicate and clarify the difference between the scientific facts and the wrongful concepts that negatively affect the justice system and the effective usage of fingerprint evidence starting from the initial investigation at the crime scene until the final trial at the courtroom.

Keywords: fingerprint aging, constituents, skin anatomy, processing techniques, delicate surfaces, fingerprint sensitivity, evidence interpretation, ACE-V methodology, AFIS

Introduction

Myths about fingerprint evidence are conceptions acquired by law enforcement officers, investigators, prosecutors, judges, and even the public about issues related to fingerprints concerning their constituents, sensitivity against environmental factors – such as sunlight, airflow, temperature, water flow, humidity, etc. – their ability to be developed, and the influence of the time passed after the deposition on their constituents.

Currently, the preconceptions and confusion related to fingerprints lead to negative results regarding the investigation process, human rights issues, as well as criminal justice. For instance, admitting that a fingermark is demolished as a consequence of time and/or environmental factors tends to dismiss developing these fingermarks, which deprives the investigators of fundamental information about the crime scene, allowing the possibility to wrongfully proceed against an innocent person, and leaving the real perpetrator excluded.

As will be shown, there are also other myths which have a highly negative impact on the criminal investigation process as a whole.

1. Fingermarks deposited on surfaces touched by many people are highly sensitive to pollution

The most famous cases representing this myth involved fraud using bank checks without the provision fund, where the check leaf was touched by the perpetrator, the victim, the employees at the company, and the employees in the bank. In the majority of these cases the prosecutors as well as the investigators have not considered processing the fingermarks as an effective way to solve the crime, and consequently, they refrained from asking for that.

However, the check leaf substrate is paper-based, hence it is made up of cellulose, which is good for preserving amino acids for a long time, as mentioned in the previous part of the article.[1] Additionally, due to the psychological aspect and the automatic nervous system response,[2] when the perpetrator becomes highly excited, their various gland secretions multiply beyond the normal levels and penetrate the substrate texture, unlike the secretions from other persons who have touched the substrate, as the amount of their deposited materials is smaller than that of the criminal.

Even though the biological traces are highly sensitive to pollution, because the DNA analysis will show mixed components from different people, and this would negatively affect the biological evidence, the shape of the fingerprint itself is not sensitive to pollution, even when the surface has been touched by many individuals.

2. Developing a fingermark from a textile fabric substrate is impossible

Textile materials include items such as clothing, underwear, bedclothes, furniture, and curtains. Clothing evidence is typically found at crime scenes of physical violence such as murder attempts and sexual assault cases, hence visualizing identifiable fingermarks as well as finger and palmar flexion crease details will be an essential clue to solve such crimes.[3]

However, textile substrates have been excluded from consideration by prosecutors and investigators a long time ago, based on incorrect convictions about the delicate texture of fabrics and textiles. The majority

---

[1] Police Technique et Scientifique (PTS), Division des Etudes des Liaisons et de la Formation, Centre Nationale de Formation, *Révélation Des Traces Papillaires Par Les Procédés Physico-Chimiques*, Ecully, 2011.

[2] M. Richter, R. Wright, "Autonomic nervous system", [in:] *Encyclopedia of Behavioral Medicine*, 2012, https://www.researchgate.net/publication/280650893_Autonomic_nervous_system (accessed: 16.06.2020).

[3] J. Fraser et al., "Visualisation of fingermarks and grab impressions on fabrics. Part 1: Gold/zinc vacuum metal deposition", *Forensic Science International* 208, 2011, pp. 74–78, https://doi.org/10.1016/j.forsciint.

of fabrics are porous surfaces, with different softness and porosity levels depending on their type and texture fabrication. For example, cotton and wool under microscopic level examination shows evident porosity and roughness, whereas synthetic fibers such as nylon and polyester are non-porous and have a more regular fractious texture. However, fibers usually contain dyes and stain-resistant substances. These factors give advantage to the visualization process and raise the chances of obtaining clear details of fingermark ridges – and if not, the examination could assist in locating the touched areas for DNA swabbing and affording contextual indication confirming push/grab scenarios.[4]

All things considered, visualization of fingermarks with clear ridge details from fabrics can be negatively influenced by other factors, for instance if:

– the fabric has a weave of fewer than three threads per mm;
– the fabric surface has been worn against the skin in warm environments, during physical activity, and/or for prolonged periods.[5]

In the same fashion, vacuum metal deposition is the most appropriate technique for processing fingermarks from natural fiber substrates (such as cotton and wool), whereas for synthetic fiber substrates the appropriate techniques are both VMD (gold/zinc and silver/zinc) and superglue fuming. IR reflection can effectively boost the fingermark contrast with the substrate after VMD.[6] Accordingly, powder dusting, DFO, ninhydrin, and physical developer are unsuitable for enhancing fingermarks from fabrics.[7]

[4] The Home Office Centre for Applied Science and Technology (CAST), *Fingermark visualisation manual*, 2014, http://www.officialpublicationsonline.co.uk.libproxy.abertay.ac.uk/publications/download/9781782462347.

[5] Ibid.

[6] GoEvidence Forensic Laboratories, "Vacuum Metal Deposition (VMD)", http://www.goevidence.com/vacuum-metal-deposition-vmd (accessed: 21.06.2020); J. Fraser et al., op. cit.; University of Abertay Dundee, Scottish Police Services Authority, *Fingerprints lifted from fabric: A new twist on old school forensics lets investigators lift prints from fabrics*, https://www.cnet.com/news/police-researchers-lift-fingerprints-from-fabric/ (accessed: 21.06.2020); University of Abertay Dundee, "Forensic breakthrough: Recovering fingerprints on fabrics could turn clothes into silent witnesses", *ScienceDaily*, 2.02.2011, https://www.sciencedaily.com/releases/2011/01/110131073141.htm (accessed: 21.06.2020).

[7] The Home Office Centre for Applied Science and Technology (CAST), op. cit.

Fraser et al.[8] studied the influence of various factors on visualizing fingermark ridge details and flexion of the palm print on different fabric types and found that the potential of developing ridge details identified on the shiner tighter weave nonporous textiles such as nylon and polyester, is higher than on rough porous textiles such as cotton and wool, even though grab-impressions can still show. However, they reported that the fingermark age and donor characteristics are influencing factors on the clarity and reliability of fingermarks developed from textiles. Despite earlier development of samples that may allow us to better visualize details, old fingermarks can give another detail such as ridge or palmer flexion crease as well as allocate the touched area for DNA swabbing.

3. It is impossible to retrieve a fingerprint from human skin

Human skin, similarly to any other surface, can receive the deposited materials of the ridged skin which form the shape of the fingerprint. There are six main ways to reveal fingerprints from human skin: cyanoacrylate, the iodine-silver plate transfer method, magnetic powder, Dakty-foil, RTX (ruthenium tetroxide) process, and the X-ray method.[9] These could be refined by two secondary methods, namely the application of laser radiation and of photographic paper lift technique.[10] All these processes have already been tested and proven to have excellent outcomes.[11]

In physical violence crimes and sexual assaults, human skin can be a surface of deposited fingermarks, which is delicate due to its roughness, high flexibility, continuous secreting mechanism which will continue for several minutes after death, as well as hair presence, along with the level of deformation that can occur during contact. These are factors that make developing clear ridge details less likely and result in a very poor sig-

[8] J. Fraser et al., op. cit.

[9] C. Champod et al., *Fingerprints and other ridge skin impressions*, Boca Raton-London 2004.

[10] M. Trapecar, J. Balazic, "Fingerprint recovery from human skin surfaces", *Science and Justice* 47, 2007, no. 3, pp. 136–140.

[11] H.J. Hammer, "Methods for detection of latent fingerprints from human skin", *Forensic Science International* 16, 1980, no. 1, pp. 35–41, https://www.ncbi.nlm.nih.gov/pubmed/7399379.

nal to noise ratio.[12] However, hairless smooth skin areas are the most favorable for good fingermark recovery.[13] Despite these complications, certain cases, such as manual strangulation, would indicate the presence of fingermarks on the neck of the victim.[14]

Although laboratory experiments highlighted the influence of time elapsed after deposition on visualizing clear prints from live persons and cadavers and indicted that only fresh prints (< 15 min) can be consistently detected, many researchers reported successful visualization of fingermarks from cadavers: Delmas (1988), Hamilton and Dibattista (1985), Misner et al. (1993), Mashiko et al. (1991), Mashiko and Miyamoto (1998), Dolci (1992), Donche (1994).[15]

4. Eye biometrics represented by iris or retina biometrics is more important in human identification than the fingerprint

The iris is the annular region of the eye bounded by the pupil and sclera (white part of the eye), unique and immutable. Iris patterns are formed during the first period of fetal formation, and the iris is pigmented in the two years following the birth. However, the formation of its patterns is not related to any genetic factors, unlike the eye color, so the pattern in which the iris is formed is an individual and unique one. Even identical twins have different iris patterns. Besides, the iris is persistent – its unique characteristics remain stable throughout the life of adult individuals, which makes it highly acceptable as a biometric measure for identifying individuals and personal identification.[16]

Iris biometrics is an automated process of identifying individuals based on their unique iris pattern by comparing their iris digital templates against the ones stored in the database. Its main implementation fields are: immigration systems, passports, visas, ID issuing, passenger control

[12] C. Champod et al., op. cit.

[13] S.M. Bleay, R.S. Croxton, M. de Puit, *Fingerprint development techniques, theory, and application*, Hoboken, NJ 2018.

[14] C. Champod et al., op. cit.

[15] Ibid.

[16] P. Sevugan et al., "Iris recognition system", *International Research Journal of Engineering and Technology* 4, 2017, no. 12, pp. 864–868, https://www.researchgate.net/publication/322222447_IRIS_RECOGNITION_SYSTEM.

at the airports and other border checking points, providing positive identity assurance for larger transactions at live teller machines which lower the risk of losses due to identity theft, and all other areas where asserting an identity is necessary.[17]

On the other hand, retina recognition relates to the individual blood vessel pattern on the thin nerve on the back of the eyeball which processes light entering through the pupil. Similarly to the iris, each eye has its unique pattern of blood vessels, and this applies even to the eyes of identical twins. This distinctive pattern remains stable throughout an individual's life, but it can be affected by some diseases, such as increased pressure inside the eyeball which causes gradual loss of vision (glaucoma), diabetes, high blood pressure, and autoimmune deficiency syndrome.[18]

A point often overlooked is that physical evidence retrieved from the crime scene has two main roles: proving that a crime was committed and identifying the criminal. Nevertheless, the main question about iris and retina identification of criminals is whether iris or retina traces could ever be found at the crime scene. Hence, iris and retina recognition methods are considered particularly important in terms of securing border crossing points and various institutions relying on personal identification, but they are ineffective for investigating the crime scene.

5. A specific number of features should be used to reach a conclusion

Unlike DNA identifications, features within a fingerprint do not happen at a constant rate, making it impossible to establish a frequency distribution.[19] Even a large number of features does not necessarily prevent an error – the clarity and rarity of the features are vital.

---

[17] M. Singh, D. Singh, P. Kalra, "Fingerprint separation: an application of ICA", *Proceedings of the SPIE, Mobile Multimedia/Image Processing, Security, and Applications* 6982, 2008.

[18] F. Sadikoglu, S. Üzelaltınbulat, "Biometric retina identification based on neural network", *Procedia Computer Science* 102, 2016, pp. 26–33. https://doi.org/10.1016/j.procs.2016.09.365.

[19] Committee on Identifying the Needs of the Forensic Sciences Community, National Research Council, *Strengthening forensic science in the United States: A path forward*, Washington, D.C. 2009, p. 140, http://www.nap.edu/catalog/12589.html; J. Polski et al.,

Positive identification within the empirical approach of friction ridge requires an assessment of the presented information or empirical standards, which varies between states (usually between 8, 12, and 16),[20] as well as the validation of this information and the final conclusion of the comparison process.[21] In contrast, the holistic approach requires disseminating three levels of details. The first one is the overall pattern, which could be used only for exclusion. The second level relates to the ridge flow and other features such as flexion creases, the number and sequence of ridges, and the type and location of ridge characteristics. The third one includes the microscopic details of ridge edges (edgeoscopy), the number, shape, location, and distribution of the pores (poroscopy) as well as flexion lines, wrinkles, and scars. The last two-level details are used in correspondence with each other.[22]

Hence, the empirical approach needs a threshold of a minimum number of friction ridge details, whereas the holistic approach does not need such a threshold.

6. Fingerprints are the most certain form of identification

All epithelial skin is equally unique (retina, iris, lips, etc.). Fingerprints are collected more often from crime scenes because they are deposited there more often.

The general requirement to arrive at a conclusion regarding identity based on fingerprint evidence is to find a sufficient number of matching ridge characteristics in the questioned fingerprint and the known reference fingerprint. These ridge characteristics, for example, may be ridge endings or bifurcations. It is also required that there are no unexplainable differences between the two impressions. For instance, what to a lay-

---

Report of the International Association for Identification, Standardization II Committee, 2011, https://nij.ojp.gov/library/publica tions/ (accessed: 28.06.2020).

[20] H.M. Daluz, *Fingerprint analysis laboratory workbook*, Boca Raton 2018.

[21] Interpol European Expert Group on Fingerprint Identification II, *Method for Fingerprint Identification*, part 2. *Detailing the method using common terminology and through the definition and application of shared principles*, Lyon 2004, http://www.latent-prints.com/images/ieegf2.pdf.

[22] Ibid.

person may appear as differences may simply be due to a natural skin distortion at the time the fingerprint was deposited. However, a difference in ridge count between two minutiae would be grounds for concluding that the two impressions are not from the same source. The methodology accepted by the international fingerprint community is referred to by the acronym ACE-V.[23]

– Analysis: the initial information-gathering phase in which the fingerprint examiner studies the questioned fingerprint to assess the quality and quantity of ridge details present.

– Comparison: the side-by-side observation of the two marks (the questioned fingerprint and the reference fingerprint) to determine the agreement or disagreement in the ridge detail.

– Evaluation: assessment by the examiner of the agreement or disagreement in the ridge detail observed during the analysis and comparison phases and the formation of a conclusion.

– Verification: an independent re-examination by a second examiner, preferably without the second examiner knowing the outcome of the first examination.

According to the Scientific Working Group on Friction Ridge Analysis, Study and Technology,[24] the current practice is that there are only three possible outcomes from applying this methodology.

– Individualization: there is a sufficient number of features in agreement to conclude that the two areas of friction ridge impressions originated from the same source and the likelihood that the impression was made by another (different) source is so remote that it is considered a practical impossibility.

– Exclusion: there is a sufficient number of features in disagreement to conclude that the two areas of friction ridge impressions did not originate from the same source.

– Inconclusive: the corresponding information in the latent and exemplar prints is inadequate to allow a conclusion. Typically, the exa-

[23] Scientific Working Group on Friction Ridge Analysis, Study, and Technology, *Standards for examining friction ridge impressions and resulting conclusions*, https://www.nist.gov/system/files/documents/2016/10/26/swgfast_examinations-conclusions_2.0_130427.pdf (accessed: 28.06.2020).

[24] Ibid.

miner provides no additional information regarding the chances that the two prints did or did not share a common source.

Some of the early guidelines were established around 100 years ago and there is no better example than the work published by dr. Edmond Locard, the scientist responsible for the Locard Exchange Principle (from 13 December 1877 to 4 April 1966). Concerning the comparison of a latent mark with a reference fingerprint, he stated in 1914 that:

> 1. If more than 12 concurring points are present and the fingerprint is sharp, the certainty of identity is beyond debate.
> 2. If 8 to 12 concurring points are involved, then the case is borderline and the certainty of identity will depend on the sharpness of the fingerprint, the rarity of its type, the presence of pores, etc. and,
> 3. If a limited number of characteristic points are present, the fingerprints cannot provide certainty for an identification, but only a presumption proportional to the number of points available and their clarity.[25]

However, the official position of the International Association for Identification, effective August 21, 2009, is as follows: "There currently exists no scientific basis for requiring a minimum amount of corresponding friction ridge detail information between two impressions to arrive at an opinion of single-source attribution."[26]

7. Overlays are a good way of verifying a conclusion

The skin is flexible. Overlaying images will *never* result in an exact match. It mainly occurs in latent fingerprints lifted from crime scenes.[27] When the same location of a surface is touched by two fingers at different times, the developed latent image may contain overlapped fingerprints. Overlapping may also occur in live-scan fingerprint images when the surface of fingerprint sensors contains residue of preceding fingerprints.

The overlapped fingerprints constitute a serious challenge to the current generation of fingerprint recognition technology. Manually marking features in overlapped fingerprints is also very difficult even for experi-

[25] C. Champod et al., op. cit.

[26] J. Polski et al., op. cit.

[27] A.K. Jain, J. Feng, "Latent fingerprint matching", *IEEE Transactions on Pattern Analysis and Machine Intelligence* 33, 2011, no. 1, p. 99.

enced fingerprint experts. Although the basic Fourier domain band-stop filtering technique can be used to remove overlapping repetitive lines in latent images,[28] separating overlapped fingerprints, which are not straight lines, is much more complicated. Therefore, it is necessary to develop a technique that can automatically separate overlapped fingerprints into individual ones.

Forensic scientists have proposed separating overlapped latent fingerprints using gold nanomaterial during the latent development stage.[29] While this technology is very interesting, it is not convenient and only works for some types of overlapped latent fingerprints. A more universal solution would be to develop an image processing algorithm to perform the separation task. Such an algorithm would not only benefit fingerprint recognition systems, but also simplify manual feature marking. Its aim would be to separate overlapped fingerprints based on image enhancement using manually marked orientation field. Nevertheless, it is very tedious and time-consuming for the user to manually mark the orientation field of each component fingerprint in the overlapped fingerprint image,[30] and morphological component analysis is used to separate overlapped fingerprints. However, there is an experiment showing that this algorithm can only separate the component fingerprint which dominates the overlapped image.[31] Independent component analysis (ICA) can also be used to separate overlapped fingerprints.[32] Unfortunately, no details are provided on how to apply ICA to separating overlapped fingerprints.

---

[28] S. Bramble, P. Fabrizi, "Observations on the effects of image processing functions on fingermark data in the Fourier domain", *Proceedings of SPIE* 2567, 1995; W.J. Watling, "Using the FFT in forensic digital image enhancement", *Journal of Forensic Identification* 43, 1993, no. 6, pp. 573–584.

[29] H. Tang et al., "Gold nanoparticles and imaging mass spectrometry: Double imaging of latent fingerprints", *Analytical Chemistry* 82 (5), 2010, pp. 1589–1593.

[30] Chen F., Feng J., Zhou J., "On separating overlapped fingerprints", *IEEE 4th International Conference on Biometrics: Theory, Applications and Systems (BTAS)*, 27–29 September 2010, Washington, D.C.

[31] R. Geng, Q. Lian, M. Sun, "基于形态学成分分析的指纹分离 (Fingerprint separation based on morphological component analysis)", *计算机工程与应用* (*Computer Engineering and Applications*) 44, 2008, no. 16, pp. 188–190.

[32] M. Singh, D. Singh, P. Kalra, op. cit..

8. Touching surfaces while wearing gloves will not leave fingerprints

The skin consists of three main layers: the epidermis, the dermis, and the hypodermis. Combined, the layers play crucial roles: providing the body with a protective barrier, regulating body temperature, sensation, various secretions, immunity, blood storage, and synthesis (vitamin D).[33]

Papillary ridges' formation

The outer layer of palms and soles consists of prominent papillae and recesses in the form of furrows, canals, or valleys. Papillary ridges are formed in the dermis or the inner skin layer, and these ridges have tiny niches known as sweat pores that connect to the sweat glands scattered under the surface of the skin with channels through which secretions pass. Additionally, papillary ridges begin to develop in the fetus starting at the sixth and seventh week of estimated gestational age (GA), and ends at about the seventeenth week. The friction ridge pattern itself is established between the tenth and fourteenth week of GA, when these ridges are separate cells that soon grow, multiply, and stick together to form the final shape in which they appear since there are accurate porous holes in the middle of these ridges that allow the secretion of the sweat glands.[34]

The roots of the papillary ridges and the separating furrows which are located on the outer layer of the skin are attached to and firmly rooted in the dermis, in which the primary and secondary ridges are formed. The primary ridges are below the ridges, while the secondary ridges are under the furrows. All of the aforementioned ridges are intertwined and interlocked with the dermis to provide support and strength to the outer

[33] A.V. Maceo, "Anatomy and physiology of adult friction ridge skin", [in:] National Institute of Justice, *The fingerprint sourcebook*, pp. 2-1–2-26, https://www.ojp.gov/pdffiles1/nij/225320.pdf; S.Z. Li, "Encyclopedia of biometrics", [in:] *Encyclopedia of biometrics*, New York 2009, pp. A25–A27, F462, F514, F538, S1225–S1226, https://doi.org/10.1007/978-3-642-27733-7.

[34] A.V. Maceo, op. cit.; S.Z. Li, op. cit.

skin layer, and the sweat glands extend from the primary hills to concentrate in the dermis or the inner skin layer.[35]

However, the average ridge thickness in the epidermis skin is 0.8–1.44 mm, whereas in other skin layers it is 0.07–1.12 mm[36], compared with the average thickness of the latex gloves which is between 0.1028, 0.1285, 0.1542, and 0.1799 mm for various brands.[37] Accordingly, papillary ridges are thicker than gloves when the ridged skin exceeds 0.18 mm, where the gloves play the role of an additional layer of the five consecutive epidermis layers, which depicts the same shape of the ridge pattern and is able to transfer this shape to the touched articles.

Hence, snug-fitting latex gloves act as another layer of skin and one can easily leave very clear fingerprints while wearing them. Leather gloves, on the other hand, can leave prints of the cowhide patterns.[38]

9. The error rate of fingerprint identification when implementing ACE-V methodology is zero

No research has ever indicated this or has stated the specific details of the tested ACE-V methodology. Researchers may have asked the examiner to use a certain method, but there has been no testing to indicate whether this method was used or not.

However, fingerprint identification includes human intervention which involves human bias, which negatively influences the conclusions. ACE-V methodology helps to minimize this bias in its narrower scope, but the accurate implementation of the methodology is still under question. In the same fashion, some fingerprint departments have standard operation procedures (SOP) which include rigid measures of blind verification as well as the independent intervention of higher qualified fingerprint experts to revise the whole identification process and validate it.

---

[35] A.V. Maceo, op. cit.; University of Abertay Dundee, Scottish Police Services Authority, *Fingerprints…*

[36] Ibid.

[37] S.M. Bleay, R.S. Croxton, M. de Puit, op. cit.

[38] N.E. Archer et al., "Changes in the lipid composition of latent fingerprint residue with time after deposition on a surface", *Forensic Science International* 154, 2005, no. 2–3, pp. 224–239, https://doi.org/10.1016/j.forsciint.2004.09.120.

Equally important is the execution of the microscopic third-level details, which leads to additional checking of similarities and dissimilarities. There is also the condition of involving a minimum number of three fingerprint examiners to have a solid conclusion, where each applies the concerned methodology in blind verification. All these procedures play a significant role in decreasing error rates and overcoming human bias. Nonetheless, avoiding human bias and achieving the zero-error rate is still an unachievable goal in fingerprint identification.

10. Fingerprint identification is always solid evidence against the suspect

Missing the interpretation phase as well as bad interpretation of the fingerprint identification evidence can lead to wrong conclusions and accusing an innocent person of the crime. The interpretation phase must be conducted by three parties: the investigator, the prosecutor, and the laboratory technician for further clarifications.[39]

David Ashbaugh,[40] among others, has noted that fingerprint individuality – and therefore fingerprint identification – rest on four premises.

1. Friction ridges develop in their definitive form in fetuses.
2. Friction ridges remain unchanged throughout life except for permanent scar.
3. The friction ridge pattern and its details are unique.
4. The ridge patterns vary within certain boundaries that allow the patterns to be classified.

The primary limitation of fingerprint analysis is that there must be a known print to be compared with the collected print. Unless there is a suspect or the perpetrator's print is found in one of the many databases around the world, the collected prints will likely only be used to exclude individuals from the investigation.

---

[39] S.L. Cooper, "Challenges to fingerprint identification evidence: Why the courts need a new approach to finality", *Mitchell Hamline Law Review* 42, 2016, no. 2, http://open.mitchellhamline.edu/mhlr/vol42/iss2/8.

[40] D.R. Ashbaugh, *Ridgeology: Modern evaluative friction ridge identification*, Ottawa 1989, https://onin.com/fp/ridgeology.pdf.

Another limitation is that there is no scientific way to determine the time a latent print was deposited on a surface. An examiner cannot tell how long a print has been on a surface or under what circumstances it was placed there. For example, if a suspect's print is found in the kitchen of a murdered acquaintance, the print may or may not be tied to the murder, especially if the suspect claims to have visited the victim's house fairly recently.

11. The fingerprints of identical twins might be identical

There are three levels of fingerprint comparison: the first is the type of the print (loop, whorl, arc), the second – the Galton details, and the third – the microscopic details. Since the first level represents the general shape of the fingerprint, there can are many similarities and, consequently, no identification can be made at this level. In the second level, there are also some similarities between the characteristic points such as ridge beginning, ending, and bifurcation, but in the empirical approach of the fingerprint comparison, the incident of having a sufficient amount of these similarities from the same types at the same places is impossible. In the third-level details, represented by edgeoscopy and poroscopy, the similarities become extremely rare. This level is used mainly in difficult traces, when there are fewer second-level details, or in very serious cases such as terrorism.

Furthermore, in each fingerprint there are between forty to one hundred minutiae of second-level details[41] where not one of these points is identical with the others, even though similarities may occur, namely with most frequently repeated details such as bifurcation and ridge ending. If they do occur, the third level provides the expert with the microscopic clarity that demonstrates the differences.

Lin et al.[42] concluded that "although fingerprints [of identical twins] may have a high degree of similarity […] variations in minutiae distribu-

[41] R. Bansal, P. Sehgal, P. Bedi, "Minutiae extraction from fingerprint images – a review", *International Journal of Computer Science Issues* 8 (5), 2011, no. 3.

[42] C.H. Lin et al., "Finger-print comparison I: Similarity in fingerprints", *Journal of Forensic Sciences* 2, 1982, no. 27, pp. 290–304.

tion still permit their differentiation", and the National Forensic Science Technology Center has stated that no two fingerprints have ever been found to be identical, from different sources, and this includes identical twins.[43]

12. It is impossible to determine sex from a fingermark

One of the most widespread myths is that determining sex from a fingermark is beyond the capacity of science. However, the perpetrator's sex can be established if there is a sufficient amount of biological traces within the constituents of the fingermark. A recent study based on a scientifically proven analytical method – which depends on Matrix Assisted Laser Desorption Ionization Mass Spectrometry Profiling mode as a forensic diagnostic tool to perceive and map molecular data of fingermarks, Partial Least Square Discriminant Analysis, and the employment of extensive statistical modelling – succeeded to determine a model with the highest sex predictive accuracy. The main negative effect on this accuracy is represented by the presence of polymers as external contaminants in natural fingermarks. To overcome this problem, the concerned study proposed using a specific type of scoring system with 86.1% predictive power to differentiate male and female fingermarks.[44] The major significance of the study is to provide the investigators and criminal intelligence analysts with critical intelligence information, which positively influences the effectiveness of criminal justice.

13. A fingerprint will disappear when it is exposed to direct sunlight

The sun emits a wide range of wavelengths in the form of visible and invisible electromagnetic radiation. In fact, invisible ultraviolet radiation blocks the short-wavelength UVC radiation as much as the atmosphere,

[43] National Forensic Science Technology Center, *A simplified guide to fingerprint analysis*, 2013, http://www.forensicsciencesimplified.org/prints/Fingerprints.pdf.

[44] C. Heaton et al., "Investigating sex determination through MALDI MS analysis of peptides and proteins in natural fingermarks through comprehensive statistical modelling", *Forensic Chemistry* 20, 2020, https://doi.org/10.1016/j.forc.2020.100271.

and the earth receives the two other longer wavelength UVB and UVA. However, indoor exposure to these types of UV radiation has a lesser effect, as window glass plays the role of an additional filter. The infrared wavelength extends beyond 2000 nm, which has a considerable effect since it warms the substrates that absorb a significant dose of these wavelengths.[45]

Despite the fact that the sunlight speeds up the evaporation process of water and water-soluble molecules, as mentioned above, it will have a very small effect on solid and non-evaporative materials, even if these are fingermark traces of very tiny quantities that cannot be seen by the naked eye. Furthermore, the thermal process of fingerprint development from many surfaces has distinctive results whether the surface is made of textiles, paper, cotton, banknote, or any other materials. The Thermal Fingerprint Developer TFD-2 is used to develop fingerprints from different surfaces just by heating, i.e. without using any reagents, and it provides satisfying results. Hence, the fingerprint deposited on a thermal paper will be developed automatically when it is exposed to sunlight or warm air. Nevertheless, when the deposited surface is exposed to sunlight, fingerprint development specialists at the forensic laboratory have to study all the influencing factors of the case and identify all the relevant conditions to design the proper plan for fingerprint development.

14. The fingerprint will disappear when it is exposed to water flow, rain, or humidity

In fact, water is a major ingredient of sweat glands secretions that has the potential to evaporate immediately after the deposition, unlike other ingredients such as amino acids and lipids. Hence, for this kind of fingermarks water plays a critical role in determining the other insoluble ingredients, assuming that low humidity levels accelerated the drying process, whereas high humidity levels extended the water preservation.[46] However, Barnett and Berger studied the influence of humidity, temperature, and time on the clarity of fingerprints. They stored finger-

---

45 S.M. Bleay, R.S. Croxton, M. de Puit, op. cit.

46 Ibid.

marks with humidity ranging between 32 and 93% and found that its influence on determining the fingermark clarity was minimal. They also concluded that the main influencing factor affecting the fingermark is the primarily originated print quality and not humidity and temperature. Additionally, they experimentally proved the persistence of fingermarks for weeks in rather extreme storage conditions, and their development still gave detectable results.[47]

The non-soluble contents of eccrine sweat, sebaceous, and apocrine glands as well as other contaminating materials are less affected by water and humidity. For instance, sebum, triglycerides, and fatty acids need direct effort and/or detergents to be swiped from non-porous substrates, contrary to the porous and semi-porous substrates, which absorb the majority of fingermark compositions and motivate amino acids to adhere with the cellulose molecules of paper-based substrates.[48] However, extreme rain or water immersion may cause corrosion on metal substrates and the dissolving of water-soluble constituents, causing their collapse.

Heavy rain conditions might have an impact on some components of the fingerprint, but the question remains who can confirm whether the fingermark has disappeared or not. The crime scene investigator has no right to assume that the fingerprints have disappeared – this myth may lead to dismissing important evidence which might solve the crime and strongly support the investigation. It is easy to develop a fingerprint in normal conditions, but in such challenging cases the procedures are different and the interference of a laboratory technician is crucial. At the same time, the small particles reagent (SPR) is an ideal way to reveal fingerprints from wet surfaces, even after rain, knowing that the rain has less effect on the fatty components as well as others, such as sebum, squalene, or oleic acid.

[47] P.D. Barnett, R.A. Berger, "The effects of temperature and humidity on the permanency of latent fingerprints", *Journal of the Forensic Science Society* 16, 1976, no. 3, pp. 249–254.

[48] K. Wertheim, "Fingerprint age determination: Is there any hope?", *Journal of Forensic Identification* 53 (1), 2003, pp. 42–49.

A new experimental study by Kapoor et al. involved submerging objects of eight different substrates for a different period of time, ranging from 0.5 up to 120 hours. The results showed the efficacy of using the brushing method of Robin powder blue and silver magnetic dual powder, which gave notable clarity of fingermarks. Accordingly, the authors emphasize the importance of enhancing fingerprints from recovered items regardless of the time they spent underwater.[49]

Conclusion

To summarize, the fingerprint evidence procedures consist of nine essential and complementized steps: collection, development, analysis, comparison, evaluation, verification, reporting, quality control, and interpretation. However, the interpretation step is the most critical and crucial one as it evaluates the whole adopted procedure and presents the real meaning of the evidence, not the superficial meaning that might contradict the facts. As a result of wrongful ideas about fingerprint evidence, some scientists have claimed the fingerprint science is unreliable, instead of admitting the fact that what leads to wrong results are preconceptions and individual mistakes. This, however, does not make forensic science itself unreliable. Knowing the scientific side of these myths is likely to result in a perfect interpretation of the fingerprint evidence – and accordingly, ignoring those facts may lead to a bad interpretation of the fingerprint evidence, due to which an innocent person will be convicted and the criminal will walk free.

Ultimately, as much as forensic scientists should conduct more in-depth research on fingerprints, crime scene technicians, investigators, prosecutors, and judges also ought to change their preconceived ideas and cooperate more with forensic scientists and specialists. In this way, the justice system can benefit from the new developments, techniques, advances, and innovations that are occurring in fingerprint science.

[49] N. Kapoor et al., "Development of submerged and successive latent fingerprints: a comparative study", *Egyptian Journal of Forensic Sciences* 9, 2019, https://doi.org/10.1186/s41935-019-0147.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Acknowledgements

The authors would like to gratefully acknowledge Madame Michele Triplett, the Forensic Operation Manager of King County Regional AFIS Program, for her worthiest support and contribution to this paper by providing twelve of the mentioned myths, and her precious comments, as well as Madame Caroline Gibb from Forensic Biometric Traces unit of the Netherlands Forensic Institute for her precious comments and support.

References

Archer N.E. et al., "Changes in the lipid composition of latent fingerprint residue with time after deposition on a surface", *Forensic Science International* 154, 2005, no. 2–3, https://doi.org/10.1016/j.forsciint.2004.09.120.

Ashbaugh D.R., *Ridgeology: Modern evaluative friction ridge identification*, Ottawa 1989, https://onin.com/fp/ridgeology.pdf.The Home Office Centre for Applied Science and Technology (CAST), *Fingermark visualisation manual*, 2014, http://www.official publicationsonline.co.uk.libproxy.abertay.ac.uk/publications/download/978 1782462347.

Bansal R., Sehgal P., Bedi P., "Minutiae extraction from fingerprint images – a review", *International Journal of Computer Science Issues* 8 (5), 2011, no. 3.Barnett P.D., Berger R.A., "The effects of temperature and humidity on the permanency of latent fingerprints", *Journal of the Forensic Science Society* 16, 1976, no. 3.

Bleay S.M., Croxton R.S., Puit M. de, *Fingerprint development techniques, theory, and application*, Hoboken, NJ 2018.

Bramble S., Fabrizi P., "Observations on the effects of image processing functions on fingermark data in the Fourier domain", *Proceedings of SPIE* 2567, 1995.

Champod C., "Locard, numerical standards and 'probable' identifications", *Journal of Forensic Identification* 45, 1995, no. 2.

Champod C. et al., *Fingerprints and other ridge skin impressions*, Boca Raton-London 2004.

Chen F., Feng J., Zhou J., "On separating overlapped fingerprints", *IEEE 4th International Conference on Biometrics: Theory, Applications and Systems (BTAS)*, 27–29 September 2010, Washington, D.C.

Cooper S.L., "Challenges to fingerprint identification evidence: Why the courts need a new approach to finality", *Mitchell Hamline Law Review* 42, 2016, no. 2, http://open.mitchellhamline.edu/mhlr/vol42/iss2/8.

Daluz H.M., *Fingerprint analysis laboratory workbook*, Boca Raton, FL 2018.

Fraser J. et al., "Visualisation of fingermarks and grab impressions on fabrics. Part 1: Gold/zinc vacuum metal deposition", *Forensic Science International* 208, 2011, https://doi.org/10.1016/j.forsciint.

Geng R., Lian Q., Sun M., "基于形态学成分分析的指纹分离 (Fingerprint separation based on morphological component analysis)", *计算机工程与应用* (*Computer Engineering and Applications*) 44, 2008, no. 16, pp. 188–190.

Hammer H.J., "Methods for detection of latent fingerprints from human skin", *Forensic Science International* 16, 1980, no. 1, https://www.ncbi.nlm.nih.gov/pubmed/7399379.

Heaton C. et al., "Investigating sex determination through MALDI MS analysis of peptides and proteins in natural fingermarks through comprehensive statistical modelling", *Forensic Chemistry* 20, 2020, https://doi.org/10.1016/j.forc.2020.100271.

Interpol European Expert Group on Fingerprint Identification II, *Method for Fingerprint Identification*, part 2. *Detailing the method using common terminology and through the definition and application of shared principles*, Lyon 2004, http://www.latent-prints.com/images/ieegf2.pdf.

Jain A.K., Feng J., "Latent fingerprint matching", *IEEE Transactions on Pattern Analysis and Machine Intelligence* 33, 2011, no. 1.

Kapoor N. et al., "Development of submerged and successive latent fingerprints: a comparative study", *Egyptian Journal of Forensic Sciences* 9, 2019, https://doi.org/10.1186/s41935-019-0147.

Li S.Z., "Encyclopedia of biometrics", [in:] *Encyclopedia of biometrics*, New York 2009, https://doi.org/10.1007/978-3-642-27733-7.

Lin C.H. et al., "Finger-print comparison I: Similarity in fingerprints", *Journal of Forensic Sciences* 2, 1982, no. 27.

Maceo A.V., "Anatomy and physiology of adult friction ridge skin", [in:] National Institute of Justice, *The fingerprint sourcebook*, https://www.ojp.gov/pdffiles1/nij/225320.pdf.

National Forensic Science Technology Center, *A simplified guide to fingerprint analysis*, 2013, http://www.forensicsciencesimplified.org/prints/Fingerprints.pdf.

National Research Council, *Strengthening forensic science in the United States: A path forward*, Washington, D.C. 2009, p. 140, http://www.nap.edu/catalog/12589.html.

Police Technique et Scientifique (PTS), Division des Etudes des Liaisons et de la Formation, Centre Nationale de Formation, *Révélation Des Traces Papillaires Par Les Procédés Physico-Chimiques*, Ecully, 2011.

Polski J. et al., *Report of the International Association for Identification, Standardization II Committee*, 2011, https://nij.ojp.gov/library/publications/ (accessed: 28.06.2020).

Richter M., Wright R., “Autonomic nervous system”, [in:] *Encyclopedia of Behavioral Medicine*, 2012, https://www.researchgate.net/publication/280650893_Autonomic_nervous_system (accessed: 16.06.2020).
Sadikoglu F., Üzelaltınbulat S., “Biometric retina identification based on neural network”, *Procedia Computer Science* 102, 2016, https://doi.org/10.1016/j.procs.2016.09.365.
Saini M., Kapoor A.K., “Biometrics in forensic identification: applications and challenges”, *Journal of Forensic Medicine* 1, 2016, no. 2, https://www.omicsonline.org/open-access/biometrics-in-forensic-identification-applications-and-challenges-2472-1026-1000108.php?aid=76775.
Scientific Working Group on Friction Ridge Analysis, Study, and Technology, *Standards for examining friction ridge impressions and resulting conclusions*, https://www.nist.gov/system/files/documents/2016/10/26/swgfast_examinations-conclusions_2.0_130427.pdf (accessed: 28.06.2020).
Sevugan P. et al., “Iris recognition system”, *International Research Journal of Engineering and Technology* 4, 2017, no. 12, https://www.researchgate.net/publication/322222447_IRIS_RECOGNITION_SYSTEM.
Singh M., Singh D., Kalra P., “Fingerprint separation: an application of ICA”, *Proceedings of the SPIE, Mobile Multimedia/Image Processing, Security, and Applications* 6982, 2008.
Tang H. et al., “Gold nanoparticles and imaging mass spectrometry: Double imaging of latent fingerprints”, *Analytical Chemistry* 82 (5), 2010.
Trapecar M., Balazic J., “Fingerprint recovery from human skin surfaces”, *Science and Justice* 47, 2007, no. 3.
University of Abertay Dundee, “Forensic breakthrough: Recovering fingerprints on fabrics could turn clothes into silent witnesses”, *ScienceDaily*, 2.02.2011, https://www.sciencedaily.com/releases/2011/01/110131073141.htm (accessed: 21.06.2020).
University of Abertay Dundee, Scottish Police Services Authority, *Fingerprints lifted from fabric. A new twist on old school forensics lets investigators lift prints from fabrics*, https://www.cnet.com/news/police-researchers-lift-fingerprints-from-fabric/ (accessed: 21.06.2020).
“Vacuum Metal Deposition (VMD)”, GoEvidence Forensic Laboratories, http://www.goevidence.com/vacuum-metal-deposition-vmd (accessed: 21.06.2020).
Warhekar S.A. et al., “Thickness, Permeability and Tactile Perception of Commercial Latex Examination Gloves Used in Dental Practice”, *Journal of Indian Association of Public Health Dentistry* 13, 2015, no. 3, https://doi.org/10.4103/2319-5932.165314.
Watling W.J., “Using the FFT in forensic digital image enhancement”, *Journal of Forensic Identification* 43, 1993, no. 6.
Wertheim K., “Fingerprint age determination: Is there any hope?”, *Journal of Forensic Identification* 53 (1), 2003.