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Fingermark ridge drift

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ABSTRACT

Distortions of the fingermark topography are usually considered when comparing latent and exemplar fingerprints. These alterations are characterized as caused by an extrinsic action, which affects entire areas of the deposition and alters the overall flow of a series of contiguous ridges. Here we introduce a novel visual phenomenon that does not follow these principles, named *fingermark ridge drift*. An experiment was designed that included variables such as type of secretion (eccrine and sebaceous), substrate (glass and polystyrene), and degrees of exposure to natural light (darkness, shade, and direct light) indoors. Fingermarks were sequentially visualized with titanium dioxide powder, photographed and analyzed. The comparison between fresh and aged depositions revealed that under certain environmental conditions an individual ridge could randomly change its original position regardless of its unaltered adjacent ridges. The causes of the *drift* phenomenon are not well understood. We believe it is exclusively associated with intrinsic natural aging processes of latent fingermarks. This discovery will help explain the detection of certain dissimilarities at the minutiae/ridge level; determine more accurate "hits"; identify potentially erroneous corresponding points; and rethink identification protocols, especially the criteria of "no single minutiae discrepancy" for a positive identification.

1. Introduction

Scrutiny of the scientific validity of methods associated with the analysis and interpretation of fingerprint patterns has grown substantially over the past decade. In the United States, this has been prompted in no small part by the 1993 United States Supreme Court decision of Daubert vs Merrell Dow, which established more rigorous admissibility guidelines for reviewing the theoretical basis of scientific methods and the statistical and methodology errors associated with the conclusions [1]. These guidelines all relate to the principles outlined in the scientific method in as much as they require testing hypotheses, implementing standards/controls during experimentation, and associating error with the test results.

The importance of the principles outlined in the scientific method is also a central theme in the National Academy of Sciences (NAS) National Research Council Report Strengthening Forensic Science in the United States: A Path Forward, which examined 'critical issues at the interface of science, technology and the law' [2]. The NAS report was clear that the future of forensic science must be based on high quality research to guide its findings and interpretations of evidence uniqueness. The report contained a number of other recommendations, among them Recommendation #3, that called for peer reviewed research to assess the issues of "accuracy, reliability and validity" of all forensic disciplines, including the sources of human error in forensic examinations.

2. The fingerprint examination process

The availability of automated management platforms for ridge pattern-based evidence that include comprehensive reference databases provides law enforcement agencies with invaluable investigative information. For example, the Integrated Automated Fingerprint Identification System, IAFIS employs computer algorithms for ranking the known source candidates. While these data systems serve to narrow down the number of comparisons made between a known source and evidentiary item, the final determination in rendering a conclusion is based on the assessment of the forensic examiner. As a result, generalizations are developed from a limited number of specific observations. Further, the assessment is susceptible to unconscious bias, potentially

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undermining the impartiality of forensic interpretations and contributing a potential source of error. Cognitive bias may be defined as a deviation in judgment whereby inferences may be drawn in an illogical fashion [3]. The implication is that cognitive bias in forensic interpretations may impact the reliability of the evidence and the conclusions drawn. Several studies report cognitive bias as a potential issue within the justice system [4–6] while high profile cases including false identifications [6–9] have further highlighted the issue. Dror also describes sources of bias that are specific in forensic science examinations [10–18]. Other studies have also examined the role of cognition in fingerprint identification [19–23].

3. The complexity of fingerprint identifications

A major limitation to the source attribution approach resides in the quality and quantity of the friction ridge characteristics. This may be true for the known source, the questioned item, or both. With respect to the questioned item, factors that affect the quality of the impression pattern include substrate features (shape and composition), type of deposition (donor), surrounding environmental conditions, methods of collection [24], and distortion [25], each of which contribute potential sources of error to a comparison analysis. Further, the timeframe from occurrence to recovery may account for degradation effects that preclude a true contemporaneous comparison. Notably, many of these limitations are beyond the control of forensic examiners.

Fingermark distortions have been described in the literature as the result of applying non-uniform pressure during deposition, combined with the inherent elasticity of friction ridge skin and the curvature of the finger [26–28]. There may also be insufficient detail in the pattern that is inherent to the surface bearing the impression, or image deformations due to the documentation techniques (an absence or improper positioning of a measurement scale, position of scale, and/or poor photographic techniques). Given these variables, it is reasonable to assume that no two impressions from the same friction ridge skin surface will be exact duplicates. However, these alterations of the fingermark topography and of the acquired image are usually considered during a comparison process between a latent and an exemplar (inked or scanned) fingerprint in order to discriminate true differences from distortions and other artifacts. One study reports on the extent to which fingermark minutiae can be distorted without affecting false positive and false match rates [25]. Other studies propose deformation models [29] and software tools [30] to account for the effects of distortion.

The Mayfield case illustrates many of the potential sources of error in fingerprint comparison analyses. The U.S. Department of Justice convened a panel of fingerprint experts to review the case and reported the sources of error in the misidentification [6]. In relation to faulty reliance of the fingerprint ridge details, The Office of the Inspector General Report concluded that FBI examiners "apparently misinterpreted distortions as real features corresponding to Level 3 details seen in Mayfield's known fingerprints".

4. Measures to control error rates

Fingerprint pattern comparisons rely on empirical observations and conclusions rendered by experienced examiners. The comparison of a known source with a questioned item of evidence involves the process of inductive reasoning, whereby the questioned item is compared to a limited number of evidentiary items of known origin. Several countermeasures have been proposed to safeguard the forensic scientist from the influence of error [31–36].

In the context of this report, two different "error" concepts are to be distinguished: *misattribution* and *misidentification*. The former denotes cases where a fingermark is correctly associated to a suspect but is inconsistent with the time of crime. The latter refers to cases where an incorrect match is made between the trace and donor because not enough identifiers are present (i.e. poor quality and quantity of necessary ridge detail).

5. The discovery of *fingermark ridge drift*

To shed some light on the challenging issue of *misattributions*, the authors of the present study originally developed an experiment based on a real crime case. In the early morning of 9 May 2011, a restaurant in the city of Esplugues de Llobregat (Barcelona) was burglarized. Among other targets was a slot machine located on the premises, which was forced and emptied. Forensic experts of the *Catalonia Police – Mossos d'Esquadra* successfully developed one latent fingermark located on a polystyrene (plastic) container used for coin collection inside the machine. The impression was developed with titanium dioxide powder. A positive identification followed but the suspect admitted working for the slot machine company 6 months prior to the crime. At that time, forensic specialists were unable to determine the time at which the latent fingermark was deposited, so no charges could be filed.

In the subsequent pilot work published by De Alcaraz-Fossoul et al. [37], researchers were able to qualitatively determine the distinctive indoor aging processes of latent fingermarks from a single individual. Visual analyses on the images were performed and results proved the conceptual feasibility of the method to distinguish specific patterns of degradation over time. As a collateral result of this study, the *drift* phenomenon was unexpectedly observed. In order to confirm such finding, investigators analyzed all images available to ensure the phenomenon was reoccurring and was not accidental. By describing this new feature, the authors attempt to scientifically reason the occurrence of *misidentifications* beyond the aforementioned human error.

It should be noted that the main objective of this article is to describe and set the scientific basis of a future, more extensive and in-depth study. This will include a larger number of latent fingermarks and consider donor differences such as age, race, gender, health conditions, as well as other physical substrates, etc. Ideally, further exploration in this area will provide an improved explanation and more accurate approach to the complex and unresolved issue of *misidentifications* and *misattributions*.

6. Materials and methods

For the present report, the same latent fingermark images were used as in the experiment performed previously by De Alcaraz-Fossoul et al. [37]. Briefly, a total of 310 impressions originating from three different fingers (index, middle and ring) from a single donor were deposited on two non-porous materials (glass and polystyrene) The donor was a Caucasian male in his early 30s with no reported metabolic diseases. Each latent fingermark was prepared as an eccrine-rich or sebaceous-rich deposit, exposed to three ambient light conditions (direct light, shade, and darkness), and aged over a period of 7 days to 6 months. Titanium dioxide powder was used to process all fingermarks prior to documentation with digital photography.

In order to clearly observe the *drift* phenomenon, 90 fingermarks were selected from the total pool of 310 samples for presenting the best ridge quality. The remaining were excluded because they were either too degraded or completely obliterated as result of the natural aging process. A visual comparison of the fresh prints with the aged prints from the corresponding fingers was performed. The specific area of choice for minutiae examination was exclusively the core