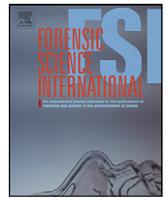




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Forensic identification: From a faith-based “Science” to a scientific science

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ABSTRACT

This article reviews the fundamental assumptions of forensic identification (“individualization”) science and notes the lack of empirical evidence or theory supporting its typical strong claims. The article then discusses three general research strategies for placing these fields on firmer scientific ground. It concludes by suggesting what forensic identification science experts can do while awaiting that scientific foundation.

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1. Introduction

The purpose of this article is to suggest research directions in which the forensic identification sciences might proceed in order to place their work on firmer scientific ground. The larger scientific world is taking notice and insisting upon real science in forensic identification (e.g. [1]).

First, however, we should remind ourselves of the core assumptions that underlie conventional forensic identification, and realize that they are based more on faith than on empirical evidence, so that we can appreciate the need for improved research and theory. These shortcomings are shared by all of the forensic “individualization” sciences, certainly including forensic odontology. Thus, the discussion in this brief paper can be conducted at a fairly high level of generality, although the specific research within each subfield will need to concern itself with the particulars of its subject: dentition, fingerprints, writing, firearms, footwear, and so on.

Forensic identification begins with the recognition that the fine physical features of objects and the marks they leave vary, even for the same types of object (bitemarks or toolmarks, for example). But rather than measure that variability, and systematically and rigorously assess the degree to which it reduces the pool of objects that could have been the source of the questioned evidence, systematically and rigorously taking into account the quality and amount of the questioned mark, each of the traditional forensic sciences quickly adopted a belief in uniqueness: that no two

objects could leave indistinguishably similar markings. Much rides on this belief. If true, it eliminates the need to collect systematic data to assess variability. It leads to the belief that if two marks are indistinguishable they must have originated from the same object “to the exclusion of all others in the world.” And, by a more obscure route, it has led many forensic examiners to believe that the possibility of error borders on (or is) zero.

Where did the notion of uniqueness come from? Initially, from Lambert Adolphe Jacques Quételet (1796–1874), the father of social statistics, who hypothesized that “nature never repeats,” offering the product rule of probability theory to suggest the great odds against such repetition. Alphonse Bertillon (1853–1914), a police records clerk, applied the idea to the classification of prisoners and invented anthropometry. Though never proven empirically, and impossible to prove statistically, generations of forensic scientists have repeated the mantra, passing it down through generations. The founders of each forensic identification subfield invoked the product rule (e.g. [2–5]). Thus, forensic identification science has taken a fundamental insight (variability produced by random effects) and exaggerated it into an unfounded but strongly held faith in uniqueness and (virtual) freedom from error.

Various scientists and other commentators have from time to time reminded forensic science of these and other shortcomings. In the 1940s, Cummins and Midlo undertook an extensive effort to prove that no two fingerprints could be indistinguishably alike, but in the end conceded failure: “[I]t is impossible to offer decisive proof that no two fingerprints bear identical patterns.” Speaking of the futility of relying on probability theory, they wrote: “It is unfortunate that this approach carries the implication that a complete correspondence of two patterns might occur...” [6]. More recently, Stoney has asked, “what made us ever think we

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could individualize using statistics?” [7]. Elsewhere, Stoney has pointed out that, “The criteria for absolute identification in fingerprint work are subjective and ill-defined. They are the product of probabilistic intuitions widely shared among fingerprint examiners, not of scientific research.” [8]. As to certainty of forensic identifications, Bunch has noted: “[I]t must be observed that there is no rational or scientific ground for making claims of absolute certainty in any of the traditional identification sciences, which include fingerprint, document, firearms, toolmark, and shoe and tire-tread analysis.” [9] (For historical reviews, see [10,11]. For a more detailed treatment of the fallacy of individualization, see [12].)

Writing more broadly, reviewers of various subfields have pointed to the lack of any research foundations for some of the most fundamental claims made by those fields. Examples include odontology (“This article presents a discussion of the scientific basis for human bitemark analyses.” . . . “The review revealed a lack of valid evidence to support many of the assumptions made by forensic dentists during bitemark comparisons” [13]), handwriting [14–16], and fingerprints [17].

Despite such cautionary statements, the various forensic identification sciences generally proceed as if their faith-based assumptions were true. A number of factors seem to be converging to impel identification science toward a paradigm shift to quantitative empirical science [18]. These include changes in the law of admissibility of expert evidence (in much of the U.S.) which subject experts to greater scrutiny, findings about the causes of the erroneous convictions in DNA exoneration cases [19], research on the performance of forensic examiners, and advances in biometrics from industry and academia.

Consideration of the errors in the original trials that led to erroneous convictions in DNA exoneration cases suggest that errors by forensic scientists were second only to eyewitness errors in producing false convictions [19]. Similarly, consider the results of proficiency studies. That there are any errors at all calls into question the claim of zero error rates among many forensic scientists. But for some subfields, and for some tasks within fields, the error rates are high. One of the highest such error rates has been found in some testing among board certified forensic odontologists [20] (Also see compilations of documented errors, such as Cole’s study of fingerprint misidentifications [21]).

In addition, a number of tragic erroneous convictions have been highly publicized. One such case was that of Ray Krone, convicted of rape and murder in Arizona in 1992, based in large part on forensic dental testimony asserting that he was a perfect match to a bitemark found on the victim. Krone was sentenced to death. Fortunately, he was still alive 10 years later when DNA testing excluded him and inculpated someone else [22]. Krone became the 100th person in the United States in recent times who had been sentenced to death and later was determined to have been innocent.

Regrettably, changes in law and growing public skepticism seem to promote more interest in improvement of forensic science than the lack of sound theory or data. One would hope it would have been the other way around, and that forensic science would not wait to be forced to further develop itself. But that has not been the case. Giannelli and Imwinkelried have noted that, “All the areas of forensic science [discussed in their article and the present one] share two common denominators: in each area little rigorous, systematic research has been done to validate the discipline’s basic premises and techniques, and in each area there is no evident reason why such research would be infeasible” [23]. The journal *Science* has editorialized disapprovingly that the U.S. National Institute of Justice “has regularly resisted including comprehensive evaluations of the science underlying forensic techniques” [24], though that might change in the wake of the NRC Report [1].

2. Two stages of forensic identification and their error risks

Forensic identification consists of two major steps. First, a determination must be made as to whether the questioned and the known marks are indistinguishably alike. The second step is to evaluate the meaning of their appearing indistinguishably alike.

The first step might seem straightforward, but it is fraught with error risks [25]. In forensic odontology, skin might be temporarily stretched or compressed at the time a bite is inflicted, and examiners must try to account for whether and how much that altered the appearance of a bite. Examiners must avoid mistaking class characteristics for so-called individualizing characteristics. They must distinguish differences that are real (“unexplained”) from those that are artifactual (differences are always present; examiners must decide what to make of them). These and other problems are explained in greater detail by Bowers [20]. For most areas of forensic identification, all of this is entirely subjective, which means that there are no objective standards to guide these judgments. Solutions to these problems can be found. For example, research is being conducted in an effort to make the evaluation of DNA profiles in electropherograms more data-based and objective (see the work of Dan Krane, Jason Gilder, and colleagues).

One of the greatest threats to the accuracy of conclusions about questioned and known marks is what is termed context effects or observer effects. Simply put, perception and judgment are affected by expectations, beliefs, and motivations. This phenomenon has been studied in a wide array of scientific fields and has led to widespread adoption of blind testing, or masking procedures, to prevent errors – except in forensic science [26]. An examiner exposed to inculpatory information about evidence or allegations or investigative theories in a case, but which information is extraneous to the examination the examiner must perform, will tend to perceive or to interpret what he or she is examining in a direction consistent with the other information in the case. Such context effects are thought to have played an important part in the FBI’s well-known error in identifying the source of fingerprints in the Madrid train bombing case in 2004 [27].

An experimental demonstration of the context effect shows how powerful it can be. Dror et al. presented five experienced British fingerprint examiners with pairs of latent and known prints [28]. Each examiner was given a pair that he or she had positively identified 5 years earlier “as a clear and definite match.” But Dror et al. told each examiner that these were, instead, the latent and file prints which the FBI had famously misidentified. Nevertheless, each examiner was asked to examine the prints and reach his own conclusion. The results were that only one of the five examiners reached the same conclusion as he had originally. (Three now declared the prints to be from different persons, and a fourth was unable to reach a conclusion.)

To protect forensic examiners from such risks, “sequential unmasking” protocols have been suggested [29]. Additionally, the use of “evidence lineups” in conjunction with masking would greatly enhance error-avoidance [26]. Such procedures would also go quite far in preventing the problem of fraud and fabrication, which appears to be surprisingly frequent, at least among American examiners [18,30]. In the context of a properly conducted blind evidence lineup, even an examiner who wanted to deliberately inculpate a suspect regardless of the forensic evidence would be unable to do so.

Once it is properly determined that a questioned and a known are indistinguishably alike, the second step is to evaluate the meaning of that finding. Many forensic identification examiners skip the second step entirely, simply assuming that finding a match at the first step in and of itself establishes their common source. Rather than calculating the frequency of such matches in the relevant population or sub-population, based on data, examiners

simply assume identity. This is where the assumption of uniqueness substitutes for science. The flaw in this assumption is shown by morphometric studies of simulated bitemarks which demonstrate that as many as 15% of participants could generate bite patterns that were indistinguishable from each other [31]. DNA typing provides the analogy which all of identification science could emulate, as will become clear in the next section.

3. Three research strategies

At least three research strategies could be adopted to move forensic identification science forward onto more secure ground, which can be termed the DNA model, the black box model, and the basic research model.

3.1. The DNA model

DNA typing has provided the most defensible approach to forensic identification yet developed. Physical attributes of the objects of interest are measured, data are collected on the variation of these attributes in a reference population, and the probability of a coincidental match is determined and reported. No assumption of uniqueness is necessary and none is employed. Objective data are collected and used to guide judgments about the relative rarity of the questioned and known samples. DNA typing thus provides a model for how the rest of forensic identification science could and should carry out its work [32]. Difficulties concerning measurement of complex patterns will have to be surmounted, requiring the help of fields which deal with such problems. While none of this obviates problems at the first stage (comparison), those too can be and are beginning to be studied and standards developed to reduce or remove problematic subjectivity from the comparison process.

3.2. The black box model

Another model is to leave the process of judging similarity and drawing inferences of its improbability to the examiner using conventional subjective methods, but to harness those human “black boxes” to a program of serious research. By systematically presenting examiners with different problem tasks within their various domains (e.g., for handwriting examiners: signatures, cursive writing, hand printing, with different degrees of writing complexity, intra-writer variation, and so on), a “map” can be drawn that describes which examination tasks can be performed at what level of accuracy. By systematically varying the adequacy of the questioned evidence (e.g., for fingerprint examiners: the completeness of the latent print, the quality of the latent), the level of accuracy associated with that amount and quality of evidence can be estimated, and limits can be defined beyond which an opinion ought not be ventured.

3.3. The basic research model

Each subfield of forensic identification is rich with beliefs about the nature of the evidence and the process of examining and drawing inferences. These beliefs can be regarded as hypotheses that need to be tested. Specific studies can be designed to test them. If forensic identification is like other fields – as varied as medicine or arson investigation – many of the hypotheses will turn out to be correct and many will turn out to be incorrect. It is important to learn which are which.

Some traditional fields have taken steps along the lines of the above models. For example, a movement within the field of firearms examination has begun to develop what in effect are empirically based statistical floors of accuracy. By comparing the

frequency of consecutive matching striae in pairs of bullets that are known matches versus pairs that are known non-matches, minimum consecutive matching striae can be stated. This is somewhat of a hybrid approach, crossing the DNA model with the basic research model [33].

4. What to do while waiting for the science

What can forensic scientists do while waiting for a serious body of research to evolve that illuminates their particular subfield? The short answer is: honesty and humility.

Confine reports and testimony within the bounds of the empirically tested findings of the field, intelligently understood (meaning: not relying excessively on any single study of a limited aspect of a phenomenon and not overgeneralizing). If very little is based on empirically tested findings, simply say so, while stating conclusions in a way that recognizes and respects the limits of the available knowledge. What one believes or hopes about a field and what one can know on existing research are not the same. Refrain from exaggerating what actually is known at the present stage of the field's development. Remain within the bounds of actual knowledge. Abandon claims of uniqueness and absoluteness. Recognize that forensic identification is a probabilistic endeavor. Abandon the use of misleading terminology, such as “match” or “identification” or “scientific certainty.” Offer descriptions and opinions with clarity and candor. Offer conclusions with modesty, unless and until a body of serious empirically based knowledge allows more. Resist the culture of exaggeration. Strive for science-based, not faith-based, forensic science.

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