

Case Report

Expert Fingerprint Testimony Post-PCAST—A Canadian Case Study

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Abstract: Royal Canadian Mounted Police (RCMP) expert testimony on fingerprint impression evidence was challenged by defense counsel, who called Dr. Simon Cole as an expert witness in the retrial of Timothy Bornyk, who was charged with a residential break and enter. The charge was based on a single fingerprint that was recovered from the crime scene. At the original trial, Justice Funt acquitted the accused, citing reports that were critical of fingerprint practices and perceived troubling aspects of the fingerprint testimony. The Crown's appeal was allowed because the trial judge had relied upon independently researched literature that was not properly tested in evidence, and he conducted an unguided fingerprint comparison.

For the retrial, the RCMP recommended that scientific studies and ongoing standards development work in the fingerprint community since the National Academies of Science (NAS) report should be presented to the court.

The Crown's strategy changed. First, the fingerprint examiner described RCMP policy on proficiency tests, use of the Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST) Quality Table and Sufficiency Graph to assess quality and quantity of the minutiae in the latent print, erroneous identifications, and error rate studies. Second, key scientific publications and international best practices were introduced to the court. Finally, the verifier testified. Ten days later, Mr. Bornyk was found guilty.

This article summarizes the trials, the impact of the President's Council of Advisors on Science and Technology (PCAST) report *Forensic Science in Criminal Courts: Ensuring Scientific Validity of*

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Received February 15, 2018; accepted May 1, 2018

Feature-Comparison Methods on expert testimony, and provides an explanation of an incorrect error rate reproduced by PCAST. As the RCMP learn from this court challenge, potential future changes to RCMP research, policy, and training are discussed.

Introduction

The standard for admissibility of expert evidence in Canadian courts was established in *R. v Mohan* through application of the following criteria: (a) the evidence is relevant to some issue in the case, (b) the evidence is necessary in assisting the trier of fact, (c) the evidence does not violate an exclusionary rule, and (d) the witness is a properly qualified expert [1]. U.S. courts in the 1993 Daubert ruling [2] specified admissibility factors for scientific expertise that have been supplemented by amendments to the *Federal Rules of Evidence*, specifically Rule 702 – Testimony by Expert Witnesses [3], which states,

A witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if: (a) the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue; (b) the testimony is based on sufficient facts or data; (c) the testimony is the product of reliable principles and methods; and (d) the expert has reliably applied the principles and methods to the facts of the case.

The legal community was not alone in trying to define criteria for court acceptance of expert evidence; the forensic science and forensic identification communities were establishing scientific working groups (SWGs) to improve forensic practices through the development of best practices. The SWGs were funded by the U.S. government and involved American and international forensic scientists, practitioners, and researchers who built noncompulsory consensus guidelines [4]. The Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST) worked to develop best practices for fingerprint comparison. These groups have now evolved into the Organization of Scientific Area Committees (OSAC) and are administered by the U.S. government through the National Institute of Standards and Technology where the work is focused on developing enforceable standards [5].

As North American forensic experts adjusted to the new admissibility criteria, several wrongful convictions were unfolding in criminal courts around the world that would result in judicial public inquiries that outlined poor practices in several forensic sciences [6–9]. Two of these reviews related to erroneous identification of fingerprints. The Scottish Criminal Records Office (SCRO) misidentified two latent impressions during a 1997 murder investigation [9], and the Federal Bureau of Investigation (FBI) misidentified a single latent fingerprint during the international investigation into the terrorist bombings in Madrid, Spain, in 2004 [7]. Throughout this paper, these errors will be referred to as the SCRO error and the FBI error.

These erroneous identifications focused public attention on forensic science and prompted the United States Department of Justice to provide a federal grant to the National Research Council Committee of the National Academies of Sciences (NAS) to assess the needs of the forensic science community in the United States [10]. The NAS consists of respected scientists who have been elected by their scientific peers to be members of this body. They come from a range of different scientific disciplines, and the NAS prepares reports that provide scientific guidance to the United States. The NAS report, titled *Strengthening Forensic Science in the United States: A Path Forward*, provided 13 recommendations, which are listed in Table 1.

| NAS Report (2009) Recommendations |
|--|
| 1. Formation of the National Institute of Forensic Science (NIFS) |
| 2. Standard terminology for reporting results |
| 3. Research into accuracy, reliability and validity of forensic science |
| 4. Remove forensic science laboratories from control of law enforcement |
| 5. Research on human observer bias and sources of human error |
| 6. Integrated team approach to standards development |
| 7. Laboratory accreditation and individual certification |
| 8. Routine quality assurance and quality control procedures to ensure accuracy |
| 9. Establish a code of ethics |
| 10. Attract graduate students to multidisciplinary fields |
| 11. Improve medicolegal death investigation |
| 12. Achieve a nationwide fingerprint data interoperability |
| 13. Prepare to analyze evidence from events of homeland security |

Note: The three bolded recommendations are relevant to the expert testimony provided by Dr. Wilkenson in the retrial of Mr. Bornyk.

Table 1
Recommendations from the 2009 NAS report [10].

Researchers interested in fingerprints focused their efforts on addressing recommendations raised by the NAS report, which received significant attention and funding. Recommendation 3, which called for more research into the accuracy¹, reliability, and validity of forensic science, resulted in several black box studies in the fingerprint community that delivered first generation practicewide error rates. However, when the residential break and enter occurred, which is the focus of this article, the results of these studies were yet to be published. By the time the first trial occurred in 2013, they had only recently been published, but they would eventually play a significant role in Canada's first challenge to fingerprint expert testimony. The names of individuals described in this article are part of the public record, which can be accessed through the Canadian Legal Information Institute website² [11–13].

R. v Bornyk (2013)

In July of 2010, Royal Canadian Mounted Police (RCMP) forensic identification employees Corporal (Cpl.) Brad Wolbeck and Civilian Member Erin McGreevy attended a residential break and enter in Surrey, British Columbia, where a single latent fingerprint on a Living Dead Doll box was located and developed with fingerprint powder (Figure 1).

The latent friction ridge impression, R1, was submitted to the Canadian Criminal Real Time Identification Services for search against the automated fingerprint information system (AFIS). The initial coding of the friction ridge features failed to associate the impression with any records in AFIS, but several weeks later, a reverse hit³ was made to Timothy Bornyk. Cpl. Wolbeck subsequently identified R1 to the right ring finger on the set of known standards bearing the name Timothy Bornyk (Figure 2). In preparation for court, Cpl. Wolbeck completed a friction ridge analysis report (FRAR), which described the methodology analysis, comparison, and evaluation (ACE), as well as the final step of verification (V), which was performed independently by a second fingerprint examiner, Staff Sergeant (S/Sgt.) McNaught in this case [14].

¹ Accuracy and other scientific terms used throughout this article are defined in Appendix 1. The source of the definition is shown in parentheses.

² www.canlii.org under British Columbia

³ A reverse hit occurs when a new set of known standards is searched against the records of unsolved latent files and AFIS generates a candidate list of potential matches from which an AFIS technician identifies a specific record.



Figure 1

*Living Dead Doll box showing location of latent friction ridge impression, R1.
(Photo credit: Erin McGreevy, RCMP).*

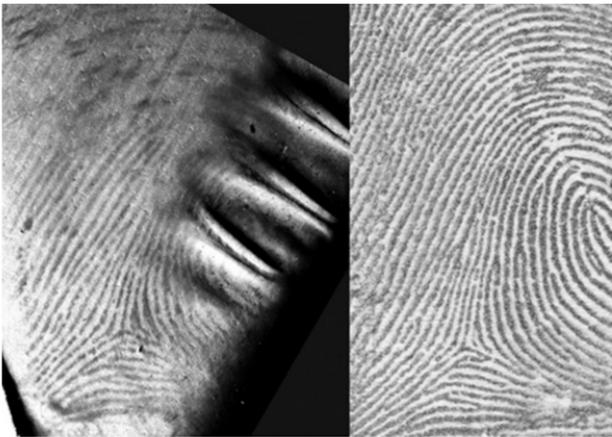


Figure 2

*The latent impression (left image), R1, and the known impression (right
image) from the set of knowns bearing the name Timothy Bornyk.
(Photo credit: Erin McGreevy, RCMP).*

In October of 2013, in the Supreme Court of British Columbia Canada, The Honorable Justice Funt recognized Cpl. Wolbeck as an “expert in the identification, comparison and individualization of fingerprints” [11]. The Crown’s evidence rested on the single latent fingerprint, R1, identified to Mr. Bornyk. Prior to rendering judgment, Justice Funt sent Crown counsel a memorandum listing four articles critical of fingerprint analysis: *National Academy of Sciences Report* [10]; *The Fingerprint Inquiry Report* [9]; *Latent Print Examination and Human Factors: Improving the Practice through a Systems Approach* [15]; and *Certainty, Individualisation and the Subjective Nature of Expert Fingerprint Evidence* [16]. The Crown counsel sent three additional articles for the judge to consider: *Fingerprint Admissibility Challenge in a Post-NAS Environment* [17]; *Performance Study of the ACE-V Process: A Pilot Study to Measure the Accuracy, Precision, Reproducibility, Repeatability, and Biasability of Conclusions Resulting from the ACE-V Process* [18]; and *ACE-V and the Scientific Method* [19]. The fingerprint expert was excluded from commenting on these articles [11].

Subsequently, Justice Funt listed the following troubling aspects with regards to the fingerprint evidence [11]:

(1) Institutional bias

Cpl. Wolbeck had testified, “there’s no errors allowed in fingerprint identification” since he believed that an erroneous identification, according to the RCMP policy in place at the time of the trial, would result in the employee being removed from forensic duties. Justice Funt was of the opinion that strict adherence to this policy could bias the examiner with respect to the reliability of a possible AFIS match. Further, the consequences of an error may bias the verifier into agreeing with the conclusions of the original examiner. An expert must be intellectually free to change his or her opinion without fear of losing his or her position, “... science and scientific thought, like many areas of learning, thrive on the freedom of thought and the challenge of ideas”.

(2) Photocopied versus original

Justice Funt believed that the use of a copy of the set of known standards bearing the name Timothy Dale Bornyk rather than the original might result in reduced quality that could impact the comparison process. “When there is subjective examination of a matter

containing precise and fine detail where a person's liberty is at stake, the use of a photocopy rather than the original should, in my view, only occur in the most exceptional of circumstances.”

(3) Bench notes not in evidence

Although Cpl. Wolbeck's bench notes were provided to Crown, they were not disclosed to defense until the last afternoon of legal argument.

(4) Verifier of Cpl. Wolbeck's conclusion was not called as a witness

S/Sgt. McNaught was the verifier of Cpl. Wolbeck's conclusion and, as was typical, she was not requested to attend court and provide proof of her verification. “The only evidence that the Court has as to the Verification step, and in particular Corporal [sic] McNaught's procedure for verification and her findings, is found in Corporal Wolbeck's report and testimony.”

(5) That which is not seen in a partial print

Justice Funt felt that details could be present in the distorted area of the impression that could lead to an exclusion as indicated by the following quote: “Where there is a partial print, or as in the case at the bar a distorted print, the risk arises that there could be exculpatory information unseen in the highly distorted portion of the latent print.”

(6) Subjective certainty

If the latent fingerprint is individualized⁴ to a known print with absolute certainty, then a second expert would not be necessary. “The subjective certainty of Corporal Wolbeck's conclusion is not made clear.”

(7) 2006 C-2167⁵ evidence

The AFIS search eventually hit to a set of known standards from 2006 that was of better quality than the July 2010 set of known standards, and Justice Funt

⁴ At the time of the first trial, the RCMP policy used the SWGFAST approved term, “individualized”, but in Communique 2015-001 dated 2015-03-13, forensic identification employees were instructed to use the term “identified” in their reports and while testifying.

⁵ C-216 is the name of the RCMP form used to collect a set of known fingerprint standards.

was concerned about the general reliability of this process and why the better quality form was not used for the comparison.

(8) Unexplained discrepancies

Justice Funt performed his own comparison and could not reconcile two breaks in a ridge just to the left of the delta: "... in the area of the latent fingerprint stated to be of 'low tolerance' and 'extremely reliable', two gaps on the latent fingerprint are not visible on the known fingerprint".

The gaps that caused Justice Funt concern are highlighted in blue in Figure 3.

In his final judgment Justice Funt concluded, "While the usable portion of the latent fingerprint and the known fingerprint are quite similar, I have more than a reasonable doubt that there is a match of the latent fingerprint to the known fingerprint. Accordingly, I acquit the accused."



Figure 3

An enlargement of the latent impression, R1, showing the gaps in a ridge that contributed to Justice Funt's decision to acquit Mr. Bornyk. (Photo credit: Erin McGreevy, RCMP).

Appeal and Retrial Preparation (2016)

The crown appealed the decision and upon appeal in her written reasons, The Honorable Madam Justice Saunders concluded,

The judge erred in locating and using material that was in the nature of opinion but was not evidence in the trial. By doing so he effectively assumed the multi-faceted role of ‘advocate, witness and judge’, and so compromised the appearance of judicial independence essential to a fair trial. As fingerprint comparison is an area of forensic science in which expert evidence elucidation is required, the judge erred as well in making his own comparison unassisted by expert evidence. The verdict is set aside and a new trial is ordered. [12]

The retrial was set for January 2017. In the closing months of President Obama’s administration, the President’s Council of Advisors on Science and Technology (PCAST) published a report titled *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods*, which reviewed progress in forensic science since the NAS report and outlined additional efforts that could contribute to strengthening of forensic science in the United States [20]. PCAST assessed feature comparison methods that determine whether an evidentiary sample is or is not associated with a source sample based on similar patterns, impressions, or features. They included simple and complex mixtures of DNA, bitemark, fingerprint, footwear, firearms, and hair analysis. They focused on two aspects of scientific validity for forensic science disciplines: (1) foundational scientific validity, which required the method be shown, based on empirical studies, to be repeatable, reproducible, and accurate at levels that can be measured and are appropriate for the intended use; and (2) validity as applied, which required the method to be reliably applied in practice. The PCAST report concluded, “... latent fingerprint analysis is a foundationally valid subjective methodology—albeit with a false positive rate that is substantial and is likely to be higher than expected by many jurors based on longstanding claims about the infallibility of fingerprint analysis”.

Implementation of the PCAST recommendations with respect to fingerprint comparison would require some fundamental changes to how fingerprint evidence is presented to the trier of fact including (1) awareness that only two black box studies

have been performed that measure examiner accuracy using ground truth data, (2) awareness of the error rates derived from these studies, (3) awareness that these error rates represent the minimum error rate because the examiners knew they were being tested, (4) demonstration that the analysis of the latent was documented prior to the analysis of the known to reduce confirmation bias, (5) disclosure of all contextual information of the case that the examiner had been exposed to that was irrelevant to the fingerprint comparison process, and (6) results of proficiency tests and the manner in which they were administered.

During the preparation for the retrial, the defense requested disclosure of all Integrated Forensic Identification Services (IFIS) policies and procedures, records of all erroneous identifications and exclusions, as well as details of proficiency tests. Fingerprint critic, Dr. Simon Cole, a professor in the Department of Criminology, Law and Society at the University of California, Irving, was called as an expert for the defense. Crown provided the RCMP with a copy of Dr. Cole's expert report *Re: R. v Bornyk* [21]. The RCMP were also given the affidavit of Dr. Emma Cunliffe, an associate professor in the Peter A. Allard School of Law at the University of British Columbia, who has co-authored articles with Dr. Cole on expert evidence.

The RCMP's strategy was to consider the concerns of Justice Funt and to address the criticisms of fingerprints raised by Dr. Cole in a direct and transparent manner within the Canadian context. The authors took the lead in preparing the IFIS response: David Richard prepared an expert witness guide that dealt with the issues raised by Justice Funt and the reoccurring themes from Dr. Cunliffe's published work; Dr. Della Wilkinson prepared a presentation outlining scientific research published since the NAS report that is relevant to Canadian practices in fingerprint identification. At the time, both authors were members of the Canadian Friction Ridge Working Group (CanFRWG), which completed a review of Dr. Cole's published work and the relevance of his criticisms to Canadian legal practice [22]. Eventually, the strategy coalesced into communicating the following main objectives to the trier of fact: (1) the proficiency testing and training of the fingerprint expert, (2) the quality of R1, (3) the reliability and accuracy of ACE, and (4) the recent scientific publications that address recommendations raised by the NAS report. The publication of the PCAST report four months before the retrial provided a template for presenting fingerprint evidence that was adopted by the RCMP.

R. v Bornyk (2017)

On January 23, 2017, Cpl. Wolbeck was recognized by Justice Crawford as an “expert in fingerprints, including the taking, locating, collecting, preserving, analyzing, comparing, and identifying of fingerprints”. During his qualification as an expert, he outlined his initial training to become a forensic identification specialist as well as the ongoing professional development provided by the RCMP, which includes proficiency testing on a three-year cycle to maintain certification.

During Cpl. Wolbeck’s description of the ACE method for fingerprint examination on January 24, 2017, he repeatedly stated that the latent impression should be analyzed before looking at the known exemplar: “We have to understand what we can about the impression before we look at the known, and this is done in every case.” and “One of the steps that’s taken to reduce the bias is to analyze that fingerprint completely prior to looking at any known impressions.” He also made reference to the *SWGFAST Standard for Examining Friction Ridge Impressions and Resulting Conclusions* [14] when describing the quality and quantity of data within R1, specifically referencing the SWGFAST Quality Table (Figure 4) and the SWGFAST Sufficiency Graph (Figure 5). In section 33.44 of *The Fingerprint Inquiry* [9], Justice Campbell raised concerns about the perceived lack of standards for assessing sufficiency in fingerprint comparisons, and many critics of fingerprint evidence continue to raise this concern. Although not completely objective, SWGFAST outlined the decision thresholds for the standardized assessment of quality and the interplay of quality with quantity when fingerprint examiners develop their opinion. Cpl. Wolbeck described the overall quality of R1 as “high” and illustrated a few of the more than 20 minutiae that he observed during his analysis and more than 20 in agreement during his comparison, “. . . I have in excess of 20 ridge characteristics that are in agreement between the latent and the known” [13]. When these two facts are considered in regard to the Sufficiency Graph, the argument was easily made to conclude that the latent and the right ring finger observed on the set of known standards bearing the name Timothy Bornyk originated from the same source.

Cpl. Wolbeck also provided clarification regarding two statements that he had made during the first trial. First, “no errors permitted in fingerprint identification” [23], which understandably raised concern for Dr. Cole in his expert report and testimony [21]. Cpl. Wolbeck explained that he had been

describing what was widely believed to be RCMP policy at the time: that members would be removed from the forensic identification program and reassigned to other police duties if they made an error. Second, Cpl. Wolbeck stated in the first trial, “I’ve never made an error” [23], which he clarified as being based on ground truth exercises from training coupled with the fact that no other examiner verifying his opinion had disagreed with his original conclusion “. . . acknowledging that errors can be made, but I have not been notified in my career, either in training or in practical casework of an error that I have made” [23].

As is customary in Canadian courts, Cpl. Wolbeck provided opinion evidence as follows: “... based on my knowledge and experience, I formed the opinion that the fingerprint marked R1 located on the Living Dead doll’s box and the inked impression of the right ring finger on the C216 fingerprint form bearing the name Timothy Dale Bornyk were made by the same person”. He further stated that the detail in agreement far exceeded anything that he had seen between two different donors.

Under cross-examination, Cpl. Wolbeck was questioned extensively about bias, starting with the fact that the verifier was aware of his opinion that R1 was deposited by Mr. Bornyk. Cpl. Wolbeck agreed that blind verification provides a greater safeguard for complex cases and he explained that, in 2015, the RCMP changed the policy so that the verifier no longer sees the opinion of the original examiner. Removing the original examiner’s decision is not the only component in a blind verification, but it is a step towards a more robust verification process. Another concern for the defense was the fact that Mr. Bornyk’s prior convictions were listed on the set of known standards and that Cpl. Wolbeck could have been biased by knowing Mr. Bornyk had been convicted of other offences. Cpl. Wolbeck stated that he played no role in the investigation other than to compare the fingerprints. He was asked whether he was aware of the high-profile error associated with the Madrid Bombing and the SCRO errors, but when he offered to show the court the images of these low-quality impressions, the defense moved his focus to the apparent dissimilarities within the ridges, as noted in Figure 3. The cross-examination finished with defense asking Cpl. Wolbeck whether the RCMP used ground truth samples in proficiency testing and whether Cpl. Wolbeck had knowledge of statistical models in relation to fingerprint comparison, to which Cpl. Wolbeck made reference to validation studies on the proficiency of fingerprint examiners and that he was aware of research into statistical models but was unaware of the application of such a model in casework.

| Quality | |
|-------------|---|
| High | Level 1 is distinct; Level 2 details are distinct; There are abundant distinct Level 3 details. |
| Medium High | Level 1 is distinct; Most of the Level 2 details are distinct; There are minimal distinct Level 3 details. |
| Medium Low | Level 1 is distinct; Few of the Level 2 details are distinct; There are minimal distinct Level 3 details. |
| Low | Level 1 may not be distinct; Most of the Level 2 details are indistinct; There are no distinct Level 3 details. |

Figure 4
SWGFAST Quality Table [14].

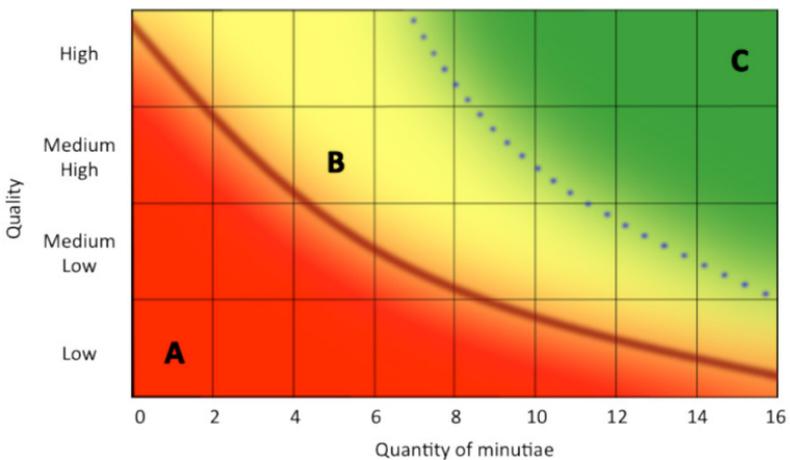


Figure 5
SWGFAST Sufficiency Graph [14].

On re-direct, the Crown asked Cpl. Wolbeck to show Justice Crawford the images of the FBI and the SCRO errors so that the court could appreciate the difference in the quality of the impressions of these high-profile errors compared to R1 (Figure 6).

Cpl. Wolbeck's testimony reflected current practices and ongoing changes within the fingerprint discipline.

Scientific Research Since the NAS Report

Dr. Della Wilkinson, a research scientist and manager of IFIS-Scientific Technical Support, was recognized by Justice Crawford as a fingerprint expert (not to be confused with being an expert in fingerprint examination and comparison). She described research demonstrating that fingerprint experts possess genuine expertise relative to novices who had no fingerprint training, knowledge, or experience [24] (Figure 7). In this study, 37 novices and 37 latent fingerprint comparison experts were presented with 12 fingerprint comparisons (one latent compared to a single known) for each of three conditions: (1) when the latent and known were from the same source (termed "match"), (2) when the latent and the known appeared similar but were from different sources (termed "similar"), and (3) when the latent and known appeared different and were from different sources (termed "not similar"). All participants were asked to rate the likelihood that the fingerprint pairs came from the same source, with a rating of 1 through 6 considered an identification and 7 through 12 an exclusion; no option existed for inconclusive. In all cases, the experts outperformed the novices, but the differences in accuracy were most significant when the latent and the known had a similar appearance but were in fact from different sources. Under this condition, the novices mistakenly identified 55.18% of similar nonmatching pairs and were less accurate than a coin toss. Experts mistakenly identified 0.68% of similar nonmatching pairs. They were significantly better but experts were not infallible.

Dr. Cole has proposed that the fingerprint examiner should only be allowed to describe his or her observations with respect to fingerprint comparison and leave the judge or jury to make the final decision ". . . why should the forensic analyst make the decision, as opposed to some other actor in the criminal justice system?" [25]. This is essentially what occurred in the 2013 Borneyk trial. The Tangen et al. [24] study provides the court with objective data, albeit on a small sample size, supporting the role



Figure 6

Images of the FBI (left image) and SCRO (right image) erroneous identifications.

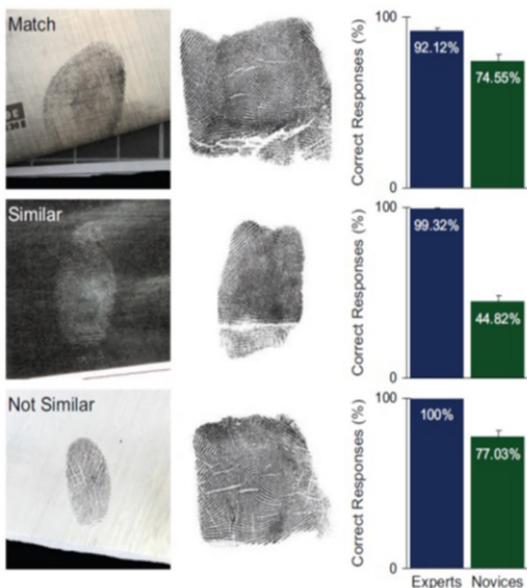


Figure 7

Results from Tangen et al. study showing that fingerprint experts outperformed novices under all conditions but most significantly when the latent and the known had a similar appearance [20]. (Reprinted from Tangen et al., *Psychol. Sci.* 2011, 22, page 996. With permission from SAGE Publishing.)

of the fingerprint expert as being the appropriate professional to provide opinion evidence on fingerprint comparisons.

In accordance with the PCAST recommendations, Dr. Wilkinson described in detail the two black box studies referenced by PCAST. The FBI/Noblis black box study was published in the National Academy of Sciences Proceedings, which is the same scientific body that prepared the 2009 NAS report [26]. The FBI/Noblis researchers asked 169 latent fingerprint examiners to compare approximately 100 pairs of fingerprints (a single latent compared to a single known). There were a total of 3,628 conclusive (identification⁶ or exclusion) decisions where the latent and known pairs originated from different sources and the latent was determined to be of “value for identification”. The results show that six false positives were made from the 3,628 decisions, producing a false positive rate of 0.17% or 1 in 605. The study did not involve verification. Of the six false positives, one impression was erroneously identified by two examiners but with exemplars from different subjects.

The second black box study referenced by PCAST was the unpublished Miami-Dade study funded by the National Institute of Justice [27]. In the Miami-Dade study, the fingerprint examiners were asked to compare a latent to three sets of knowns that involved multiple comparisons for each trial in contrast to the FBI/Noblis study, which involved a single decision. In the Miami-Dade study, the false positive rate was incorrectly calculated as 4.2% or 1 in 24 (Appendix 2: Calculation Error in Miami-Dade Black Box Study).

The authors of the PCAST report chose to represent the potential error rates from these studies using 95% one-sided confidence intervals. Based on the upper bound of the confidence interval for the incorrect false positive rate in the Miami-Dade study, PCAST concludes that “. . . the rate could be as high as 1 error in 18 cases”. It is unfortunate that the incorrect false positive rate in the Miami-Dade study was not discovered by PCAST and that the error was compounded in a confidence interval. We take no issue with using a confidence interval to assess the uncertainty in the estimation of an error rate, nor is there an issue with the technique PCAST used to calculate the one-sided confidence interval; however, people may be easily misinformed by PCAST’s concluding statements about the upper bound. PCAST’s conclusion may lead the reader to believe the upper bound is some sort of “worst case scenario” when in fact it is simply measuring the

⁶ In the FBI/Noblis black box study, the term “individualization” was used.

uncertainty of the estimated error rate. The correct interpretation of the upper bound of a 95% one-sided confidence interval is that if the experiment were repeated many times using the same sampling methodology, then the true error rate would be below the upper bounds about 95% of the time. Providing a two-sided confidence interval, an upper and lower bound as done in the FBI/Noblis black box study, would provide the nonstatistical reader a more realistic description of a confidence interval without an unnecessary and potentially misleading interpretation. The defense counsel in the Bornyk trial questioned Dr. Wilkinson on the fact that she omitted the latter part of the PCAST quote regarding the validity of fingerprints that suggests “. . . a false positive rate that is substantial and is likely to be higher than expected by many jurors”.

Dr. Wilkinson argued that there is fundamental disagreement between the fingerprint community and PCAST on how the latter chose to frame the error rates from these black box studies as one-sided confidence intervals, which could contribute to an undervaluing of fingerprint evidence. She was concerned that the upper bound of the one-sided confidence interval, which was constructed from an incorrect false positive rate, was being interpreted as the potential error rate for the fingerprint discipline. Dr. Cole states that there is no place for claims of zero error rates with respect to fingerprint comparisons and black box studies have offered some improvements [28]. However, they do not provide the court with an error rate relevant to the case at hand, and perpetuating the “1 in 18” false positive rate is flat out wrong and must be challenged before it becomes an urban myth with the potential to mislead the court and result in the understatement of fingerprint evidence.

Statistical research that demonstrates the highly discriminating power of latent fingerprint impressions was presented by Dr. Wilkinson [29]. In a ground-breaking paper submitted to the Royal Statistical Society, researchers with the United Kingdom Forensic Science Service presented a statistical model based on likelihood ratios (LR) that represents both the perspective of the Crown [i.e., that the latent and the known were created by the same individual (numerator)], as well as the perspective of the Defense [i.e., that the latent and the known were created by different individuals (denominator)]. A simplified representation of the LR equation as applied to fingerprints is provided below.

$$LR = \frac{\text{Comparison between latent and known (numerator)}}{\text{Comparison between latent and large database of fingerprints (denominator)}}$$

The relationship between the numerator and denominator is shown in Table 2.

| Numerator vs Denominator | Result of Log_{10}LR |
|--|---|
| Numerator significantly larger than denominator | Latent more similar to known than fingerprints in general $\text{Log}_{10}\text{LR} > 0$ |
| Numerator significantly smaller than denominator | Latent more similar to fingerprints in general than to known $\text{Log}_{10}\text{LR} < 0$ |
| Numerator and denominator are similar | Similarity between latent and known is comparable to similarity between latent and fingerprints in general Log_{10}LR is around zero |

Log_{10} - non-linear scale used to represent large values by reducing the range to a more manageable scale. For Log_{10} each increment represents a factor of ten (i.e., 0=1; 1=10; 2=100; 3=1,000 etc.).

Table 2
Likelihood ratios as applied to fingerprint comparisons.

A validation experiment was reported in the Neumann et al. statistical paper that involved 122 U.K. crime scene impressions with confirmed association to 122 known impressions from U.K. case files [29]. This is referred to as the same source data and is represented by the circles in Figure 8. The 122 U.K. crime scene impressions were searched against the U.S. Integrated Automated Fingerprint Information System database of approximately 600 million fingerprints to generate confirmed close nonmatches. This is referred to as different source data and is represented by the crosses in Figure 8.

The LR model showed good separation of the same source and different source datasets. The experiment showed that as the number of minutiae within a latent fingerprint increased, so did the discriminating power of that fingerprint. The data also showed that the value of fingerprint evidence does not depend on just quantity of minutiae but also the rarity of the minutiae configurations. For example, the 11-minutiae configurations spread over a broad range of LRs, some of which showed no more discriminating power than the 5-minutiae configurations. This demonstrates that there is no statistical basis for a minimum point threshold when deciding whether a latent and known are from the same source. This decision is based on quality of the latent and known (how well can you see the data), quantity (how much data is present), and rarity (how valuable is the available data).

In addition to stating that fingerprint comparison is foundationally valid, PCAST also stated that it must also be shown to be valid as applied, which relates to confirmation and contextual biases. It has been standard RCMP practice to examine the latent

The PCAST report generated many responses from professional groups impacted by its recommendations including the OSAC Friction Ridge Subcommittee (OSAC FRS), of which Dr. Wilkinson is an affiliate member [31]. OSAC FRS addressed several concerns about the PCAST report and the manner in which the black box data has been interpreted by PCAST: (1) the calculation error in the Miami-Dade study could lead to courts underestimating the value of fingerprint evidence – “The OSAC FRS notes that the PCAST failed to detect the calculation error in the false positive rate reported by Miami-Dade.”, (2) the statement that the referenced false positive rates represent incomplete practice (i.e., no verification), and (3) sharing research that shows anonymity can lead to increased errors because participants are not accountable for their responses. This suggests that false positive rates in casework could be even lower than those generated by black box studies and counteracts the PCAST argument that because the examiners knew they were being tested, casework error rates could be higher. It is difficult to prove which of these arguments dominate, but undervaluing of evidence is equally as concerning as overstating its value.

Crown counsel’s final expert witness was the verifier, S/Sgt. McNaught, whom Justice Crawford also recognized as a fingerprint expert in comparisons. S/Sgt. McNaught testified to the fact that she had performed an independent ACE of R1 and concurred with Cpl. Wolbeck’s opinion that it was created by the right ring finger of Mr. Bornyk. She explained that she viewed the role of verification no differently than being the original examiner because her professional integrity was on the line in either case. As a verifier, S/Sgt. McNaught was able to speak to her independence by explaining that on three prior occasions she had reached a different conclusion to the original examiner and she was aware that in at least one of these occasions, the Identification Evaluation Group agreed with the original examiner. S/Sgt. McNaught stated under cross-examination that she had been aware of Cpl. Wolbeck’s conclusion prior to examination of R1.

Dr. Simon Cole was recognized as a fingerprint expert, and his testimony covered some specific concerns about testimony from *R. v Bornyk* (2013) where he felt Cpl. Wolbeck had overstated the evidence by not indicating the possibility of error through statements such as “no errors permitted in fingerprints” and “I’ve never made an error”. In addition to the other concerns addressed throughout this paper, Dr. Cole was concerned about the bias of AFIS searches “because the database search finds

the unfortunate people in the database whose friction ridge skin is most like that of the true source...”. In addition to the AFIS search, the images corresponding to the returned candidate list are assessed by AFIS technicians and further reviewed before being released to the forensic identification specialist.

A significant concern expressed in Dr. Cole’s testimony is the lack of formal rules to determine when a difference in the appearance of friction ridge skin between the latent and known is described as an explainable dissimilarity or an unexplainable discrepancy. Examiners should provide a description of how the friction skin develops in the fetus to explain how the surrounding ridge flow will change for a discrepancy but remain constant for a dissimilarity, which should help to distinguish between the two. This is often sufficient to explain any difference in appearance between the latent and the known.

Dr. Cole has been asking for an external validation of fingerprints for some time “concerns about the need for validation from some external scientific community, rather than relying merely on ‘self-validat[ion]’ . . . by a practitioner community or ‘judicial certification’ by the courts...” [28] In his expert testimony, he recognized PCAST as a nonpartisan, authoritative scientific report. Dr. Cole quoted from the Fingerprint Inquiry that “there is not an objective measurement of sufficiency” [32] but agreed that SWGFAST guidelines are the closest thing to best practices available to the fingerprint community. Most importantly, he agreed that the following quote from the PCAST Addendum [33] does appear to be asserting that validation of fingerprint analysis has been established:

PCAST applauds the work of the friction-ridge discipline, which has set an excellent example by undertaking both (i) path-breaking black-box studies to establish the validity and degree of reliability of latent-fingerprint analysis ... In the case of subjective methods whose validity and degree of reliability have already been established by appropriate empirical studies (such as latent-print analysis), PCAST agrees that continued investment in black-box studies is likely to be less valuable than investments to develop fully objective methods.

On February 10, 2017, 10 days after the defense and Crown delivered their closing arguments, Mr. Bornyk was found guilty on one charge of breaking and entering a dwelling [13].

Current RCMP Forensic Identification Practices

The RCMP has built its forensic identification program on three foundational elements: policy, training, and research. In a healthy system, all three are interconnected, with research informing policy to make evidence-based changes, which training then delivers to the practitioners in a continual learning cycle. Policy, training, and practitioners all provide input to research in this closed-loop system, which allowed the RCMP to provide a comprehensive defense of its practices. Written policies that are reviewed on a set schedule were made available to the defense counsel and are the foundation of any quality control process.

Canadian fingerprint examiners are trained in one of two police colleges, providing a uniform practice for the judicial system. A continual learning cycle, upon which the RCMP relies, informs practitioners about emerging knowledge in a timely manner. Nationally coordinated proficiency testing to maintain certification is another important part of quality control and complements other national RCMP quality control policies applied at the national, divisional, and unit level.

Increased scientific research has been a recommendation common to all reports reviewing forensic science since the 2009 *National Academy of Sciences Report* (recommendation 3) [10], the 2011 *Fingerprint Inquiry* (recommendations 81-84) [9], the 2012 *National Institute of Standards and Technology Report* (recommendation 10.6) [15], and the 2016 *PCAST Report* (recommendations 4-5) quoted below [20]:

The Federal Bureau of Investigation (FBI) Laboratory should undertake a vigorous research program to improve forensic science. . . The program should include:

- (i) conducting studies on the reliability of feature-comparison methods, in conjunction with independent third parties without stake in the outcome;
- (ii) developing new approaches to improve reliability of feature-comparison methods;
- (iii) expanding collaborative programs with external scientists; and

(iv) ensuring that external scientists have appropriate access to datasets and sample collections, so that they can carry out independent studies.

The RCMP has an established research culture going back to the 1960s when Huber wrote the foundational paper describing the philosophy and methodology of ACE in fingerprint comparison [34]. In the 1990s, another RCMP researcher thoroughly described the foundational scientific knowledge upon which fingerprint examinations are based as well as the factors considered during each stage of the identification process including the final stage of verification (ACE-V) [35]. Today, IFIS researchers have developed collaborations with internationally renowned scientists and are undertaking research projects to determine objective thresholds for different quality control processes. This type of research should improve workflow efficiency and ensure that practitioners have the necessary time to dedicate to more challenging fingerprint comparisons and thus contribute to the RCMP mandate of *safer communities*.

In addition, RCMP employees participate in international and national technical committees dedicated to standards development where scientific contributions are expected and technical knowledge is necessary to absorb information of strategic value to the RCMP and the Canadian fingerprint community. CanFRWG has been meeting on an annual basis to discuss emerging knowledge since it was formed in 2011. Its membership consists of practitioners from federal, provincial, and large municipal police agencies from across Canada as well as representatives from the two Canadian police colleges, the Canadian Identification Society, and Crown Attorneys. CanFRWG provides a forum for standards development, and its members have produced a slide presentation to standardize presentation of expert fingerprint testimony to the courts as well as a position paper reviewing the criticisms of Dr. Cole from a Canadian perspective [22] [<https://sites.google.com/site/canfrwg/>].

These elements provided a solid foundation for the RCMP to prepare for the retrial of Mr. Bornyk and contributed to what the RCMP consider to be the appropriate outcome. However, as with any evolving practice, the RCMP will seize upon this opportunity to improve upon its current practice, and in the final section of this article, we describe potential ways to further evolve the Canadian practice of fingerprint comparison.

What Does the Future Hold?

Electronic Bench Notes

One of the first elements of the friction ridge identification process taught at both of the Canadian Police Colleges is the need for bench notes to form part of the objective intelligence gathering process and to be made at the time of the analysis of the latent. As stated previously, they are completed prior to any comparison of the known impression and are later used to complete a FRAR should the expert be called to testify. The Ottawa Police Services have been developing an electronic bench note that creates a date-stamped copy of the analysis of the latent impression before allowing the forensic identification employee to analyze the known fingerprint. The system allows for a blind verification process where details that could identify the original examiner are hidden from the version forwarded to the second examiner. The opinion of the original examiner can also be hidden from the verifier. Another advantage of an electronic bench note is that the basic information captured during analysis automatically populates the FRAR with the option to add further detail as desired. This improves efficiency and helps to reduce errors arising from mistakes made in data entry. Any format of bench notes will help to determine the possible cause of an error, but developing an electronic version embeds best practices into the workflow and will improve transparency.

Color Mapping of Quality

Another approach taught by both Canadian police colleges to reduce confirmation bias is to look for differences when performing comparisons rather than similarities. GYRO is a method to document the quality of data observed in the latent through color mapping and is an acronym of Green Yellow Red Orange [36]. Identifying the range of quality within the latent and the known through colors is a simple way for an examiner to reflect on the value he or she should give minutiae when the selected minutiae are overlaid on the quality color map. The application of GYRO will help standardize documentation and allow for a more thorough root cause analysis should an erroneous identification be made. This would be most advantageous in training where instructors would be able to see the exact data that students select and provide guidance when these minutiae appear in low-quality regions. There is potential for AFIS to be used to produce an objective color map within the flow of casework.

Impartiality Statement and Disclosure of Unavoidable Contextual Information

Canadian police agencies have police officers performing both the crime scene examination and the fingerprint comparison, which could present some challenges when addressing contextual bias during expert testimony. One simple step would be to disclose any unavoidable contextual information that the fingerprint examiner was exposed to during the investigation including any steps that were taken to mitigate contextual bias. Furthermore, development of an impartiality statement to be included in the FRAR that highlights the legal precedent acknowledging that police officers can provide objective and impartial evidence [37] would outline the organizational structure for the courts. An example of such an impartiality statement is:

This report has been prepared in an objective and impartial manner⁷ following policies and guidelines developed by Integrated Forensic Identification Services policy centre which is unrelated to the operational investigative policy centre. Forensic identification (FI) employees are not under the investigative command structure and their role is to report objective findings derived from examination of the physical evidence with only unavoidable knowledge of the investigation. All knowledge of the investigation that could bias the opinion of the FI employee has been disclosed in this report.

Black Box Studies of Noncomplex Comparisons

More objective measures to distinguish between complex and noncomplex comparisons are needed so that appropriate levels of quality assurance can be applied. For example, full mark-up of the latent and blind verification should be required for challenging comparisons but partial mark-up of the latent and standard verification might be all that is required for less challenging comparisons. Research in the form of black box studies should help to establish a threshold below which fingerprint examiners do not make errors, which would objectively define what is meant by less challenging comparisons.

⁷ White, Burgess Langille Inman v Abbott and Haliburton Co., 2015 SCC

Standardized Reporting

The OSAC Physics/Pattern Committee is developing a conclusions document with the objective of providing universal conclusions for the five physical forensic sciences under its remit, which includes bloodstain pattern analysis, fingerprints, firearms and toolmarks, footwear, and questioned documents. Each discipline should be able to use the range or a subset of the conclusions to convey information to the court that is consistent across these types of physical evidence where the output to the court is the subjective opinion of the practitioner. Although a challenging task, this will assist the court by having terms used in a uniform manner by experts from a range of disciplines.

Development of Proficiency Test Based on Ground Truth Data

The RCMP has proficiency tests that are nationally coordinated by the central IFIS Training Section, which is internal to the RCMP and could be seen as a conflict of interest. At present, there is no national organization able to undertake this function for all Canadian police agencies because the use of private proficiency test providers has been controversial, with the tests often being described as too easy. Currently, the RCMP is moving away from using casework impressions and is developing proficiency tests that are based on ground truth data. The next step would be to explore the integration of proficiency tests into the flow of casework. As stated earlier, fingerprint practitioners attend the scene to record and gather evidence, as well as to compare any fingerprints developed through optical, physical, or chemical methods, which creates obvious challenges to embedding proficiency tests within the flow of casework because an examiner will quickly determine when an impression was not one that he or she developed during his or her scene or exhibit examination. The only viable option would be to introduce proficiency testing during the verification stage, which is more easily achieved in larger multiperson units and would require a centrally coordinated verification process for smaller two-person units.

Further Exploration of Statistical Models

There is still much work to be done until a robust statistical model is available for universal application for assigning meaningful probabilities to fingerprint associations. The United States Army has been using FRStat, a model they developed since 2017 [38]. The military criminal justice system is a closed loop, which allows the United States Army to ensure that the prosecutor, defense, and judge all fully understand the terms.

This is a huge advantage when introducing such a significant change in the practice of fingerprint comparison and one not shared by most fingerprint practitioners. AFIS vendors are other participants in the fingerprint community who have all the necessary tools, such as computer scientists, fingerprint databases, and technical knowledge of fingerprints, to develop an objective statistical approach that could be implemented in the current workflow.

Summary

In summary, this article describes a case study regarding an admissibility challenge of fingerprint expert testimony where the RCMP followed the recommendations outlined in the PCAST report. This necessitated addressing the myth of a false positive rate that could be as high as “1 error in 18 cases” for fingerprint comparisons. This error rate myth originates from a calculation error in the Miami-Dade study that produced an incorrect false positive rate of 4.2%. PCAST then calculated an upper bound of a one-sided confidence interval of 5.4% (approximately 1 in 18). This is being viewed as the potential error rate in the fingerprint discipline and cannot pass unchallenged.

Acknowledgments

Preparing for such a trial is a team event and requires much behind-the-scenes support. The authors would like to acknowledge the members of IFIS Program Support: Joe Penney, Martin Lelievre, Mike Wyllie, and Julie Rix, who provided support during the Bornyk trial by reviewing and releasing several versions of RCMP policy going back to the period of time when the initial scene examination occurred. We would also like to acknowledge Erin Pepper and Diana O'Brien, who completed a comprehensive review of all RCMP erroneous identifications and provided details of the quality control measures undertaken to address each one. We would also like to acknowledge the expert testimony of Cpl. Brad Wolbeck during the Bornyk trial.

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Appendix 1

Definitions of Scientific Terms

Accurate - with known probabilities, an examiner obtains the correct results both (1) for samples from the same source (true positives), and (2) for samples from different sources (true negatives) (PCAST [20]).

Reliability - when repeatability, reproducibility, and accuracy are demonstrated (PCAST [20]).

Repeatability - with known probability, a participant obtains the same result when analyzing samples from the same sources (PCAST [20]).

Reproducibility - with known probability, different participants obtain the same result when analyzing the same samples (PCAST [20]).

Validity - a method has shown, based on empirical studies, to be reliable with levels of repeatability, reproducibility, and accuracy that are appropriate to the intended application (PCAST [20]).

Empirical study - test in which a method has been used to analyze a large number of independent sets of samples, similar in relevant aspects to those encountered in casework, in order to estimate the method's repeatability, reproducibility, and accuracy (PCAST [20]).

Black box study - an empirical study that assesses a subjective method by having examiners analyze samples and render opinions about the origin or similarity of samples (PCAST [20]).

Ground truth - definitive knowledge of the actual source of an impression (SWGFAST [39]).

False positive (erroneous identification) - incorrect determination that two areas of friction ridge impressions originated from the same source (SWGFAST [39]).

False positive rate - proportion of comparisons between non-mated pairs that resulted in an erroneous identification (SWGFAST [39]).

Mated pairs - impressions intentionally collected from the same individual and used for measuring error rates (SWGFAST [39]).

Non-mated pairs - impression intentionally collected from different individuals and used for measuring error rates (SWGFAST [39]).

Likelihood ratio - (also known as Bayes' factor) in the statistical interpretation of evidence, this is the ratio of the probability of the evidence, given the prosecution hypothesis, to the probability of the evidence, given the defense hypothesis (Encyclopedia of Forensic Science, Glossary [40]).

Contextual bias - effect of information or outside influences on the evaluation and interpretation of data (SWGFAST [39]).

Confirmation bias - tendency to search for data or interpret information in a manner that supports one's preconceptions (SWGFAST [39]).

Proficiency - ongoing demonstration of competency (SWGFAST [39]).

Competency - possessing and demonstrating the requisite knowledge, skills, and abilities to successfully perform a specific task (SWGFAST [39]).

Appendix 2

Calculation Error in Miami-Dade Black Box Study

| ACE Examination | | | |
|-----------------|-------------|------------------|--------|
| | Same Source | Different Source | Totals |
| Identification | 2,457 | 42 | 2,499 |
| Inconclusive | 446 | 403 | 849 |
| Exclusion | 235 | 953 | 1,188 |
| Totals | 3,138 | 1,398 | 4,536 |

Inconclusive decisions are not considered to be errors in the fingerprint profession. The ACE Examination Table (Table 4 in Miami-Dade Research Study [27]) implies that 42 identifications were made on different source comparisons, resulting in a false positive rate of:

$$[42/(1398-403=995)] \times 100 = 4.22\%$$

| ACE Trials Participant Decisions | | | | | | | |
|----------------------------------|--------------------|----------------|-------------------------|---------------------------|--------------|--------------------|----------------------|
| Source Present | # of Latent Prints | # of Decisions | Correct Identifications | Erroneous Identifications | Inconclusive | Correct Exclusions | Erroneous Exclusions |
| Yes | 56 | 3,177 | 2,457 | 39 | 446 | N/A | 235 |
| No | 24 | 1,359 | N/A | 3 | 403 | 953 | N/A |
| Totals | 80 | 4,536 | 2,457 | 42 | 849 | 953 | 235 |

However, data in ACE Trails Participant Decisions Table (Table 11 in the Miami-Dade Research Study [27]) indicate that the majority of the erroneous identifications occurred on same source comparisons, therefore a false positive could have occurred on any trial in the experiment. This means that different numbers from Table 11 should be used to calculate the false positive rate:

$$[42/(4536-849=3687)] \times 100 = 1.14\%$$

Further on in the report, the authors state, “In assessing these errors, it was noted that in 35 of the 42 erroneous identifications the participants appear to have made a clerical error, but the authors could not determine this with certainty”.

While acknowledging that “. . . it is inappropriate to exclude errors in a *post hoc* manner. . .”, PCAST did re-calculate the false positive rate with the 35 clerical errors removed [20] and removing these clerical errors from the corrected calculation produces a false positive rate similar to the FBI/Noblis black box study:

$$[(42-35=7)/(3687-35=3652)] \times 100 = 0.19\%$$