



### B174 Estimating the Probability of Randomly Acquired Characteristics (RACs) Locations on a Shoe Sole

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**Learning Overview:** After attending this presentation, attendees will better understand the process of comparing the shoes of a suspect with prints left at a crime scene and the importance of faults on the shoe sole, known as RACs—especially their spatial distribution—in determining the findings' evidential value. Novel methods for estimating the probability of a RAC appearing at a given location on a shoe sole will be explained, as well as the impact of this information on the likelihood of a match.

**Impact on the Forensic Science Community:** This presentation will impact the forensic science community by developing a greater expectation that forensic evidence have a solid scientific basis.

In recent years, forensic methods have been criticized for their shortcomings in providing courts with objective and quantitative answers to the question of whether a sample from a suspect matches a sample found at the crime scene. Unlike DNA that is used routinely to link suspects to crime scenes because of its scientific objectivity and accessible documentation, the evaluation of other types of evidence, such as shoeprints, tire tracks, tool marks, and the like, has not reached this gold standard. Both the 2009 National Research Council (NRC) Report, *Strengthening Forensic Science in the United States: A Path Forward*,<sup>1</sup> and the 2016 President's Council of Advisors on Science and Technology (PCAST) Report to President Obama, *Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods*, have called for the strengthening of the scientific basis of forensic procedures.<sup>1,2</sup>

Here, shoeprint comparison is considered. The identification of footwear impressions is based on the comparison of a print found at the crime scene with a print made from a suspect's shoe. The analysis of shoeprints by experts is done in two broad stages. First, the pattern, size, and wear of the shoe sole are compared to the crime scene print. If these do not fit, the analysis is stopped, and the pair is classified as a non-match. In the second stage, the forensic expert examines whether RACs on the shoe sole, such as scratches or holes, match the RACs on the print from the crime scene. These RACs may have various characteristics; for example, location, shape, and orientation. However, the distribution of RAC characteristics has not been investigated thoroughly. New statistical methods are presented for estimating the probability of a RAC at a given location on the shoe sole. RACs are assumed to follow a 2D point process, the intensity function of which governs the probability of their appearance at different locations. A smooth intensity function based on pixel data is first estimated using a logistic regression and natural cubic splines. This approach fully exploits the data, but may be problematic as the definition of location is ambiguous. An alternative approach is presented, which uses a piece-wise constant intensity function in regions defined by forensic experts. It is shown that RACs are likely to appear at certain locations, corresponding to the foot's morphology.

The findings of this study take us a step forward in assessing the evidential value of shoeprint comparison. As RACs in certain locations are rarer than in others, they carry more weight in determining the rarity of the shoe sole, or in other words, the probability of a match between the crime scene print and the suspect's shoe.

#### Reference(s):

1. National Research Council (NRC), Committee on Identifying the Needs of the Forensic Science Community. (2009). *Strengthening Forensic Science in the United States: A Path Forward*. Washington, DC: The National Academies Press.
2. President's Council of Advisors on Science and Technology (PCAST). *Report to the President: Forensic Science in Criminal Courts: Ensuring Scientific Validity Of Feature-Comparison Methods*. (2016). Washington, DC: Executive Office of the President of the United States.

#### Footwear Impression, Randomly Acquired Characteristics, Shoeprints