OSAC RESEARCH NEEDS ASSESSMENT FORM

Title of research need: Assesment of Criteria for Meaningful Differences in Trace Materials Comparative Data

Keyword(s): Trace evidence, comparison criteria, meaningful differences

Submitting subcommittee(s): Materials/Trace **Date Approved:** 9/24/18

(If SAC review identifies additional subcommittees, add them to the box above.)

Background Information:

1. Description of research need:

In trace evidence comparisons, the forensic examiner analyzes the evidence and resulting data, forms an opinion, and summarizes the findings in a written report. The examiner shall also interpret and report the overall meaning of those findings.

Most of the trace examinations involve a series of analytical steps to identify physical and chemical features that may indicate the compared items are dissimilar in their measured properties. Often, each of these examination stages involves a binary decision to determine whether or not the compared samples can be discriminated based on the measured data.

The data derived from the analysis can be qualitative (i.e., texture, color, identification of compounds from a chemical spectrum, location, and shape of a spectral peak), semi-quantitative (e.g., relative ratios of components in a mass spectra), or quantitative (e.g., concentration of chemical compounds, refractive index).

Criteriamust first be established to define if there is a "meaningful difference." For a difference to be meaningful, the feature or property of a sample should not fall within the variation exhibited by the comparison sample, considering the limitations of the sample or technique. When meaningful differences are found, they often support the proposition that the two samples do not share a common origin.

Examiners make use of validation studies to determine the instrumental variations and to set up quality control thresholds, survey studies to determine how discriminating the compared characteristics are, and reference collections and databases to assess the rarity of observed features based on within-sample and between-sample variations. Replicate measurements of the known and question samples are also needed to arrive at a decision.

Several of these studies have helped to establish comparison criteria in trace comparisons. However, the binary decision process does not always involve the formal application of statistical tests, and the decision of exclusion/association is often made based on cumulative knowledge and expertise of the examiner. This expertise is critical, but it will also benefit from complementary statistical support.

For instance, infrared analysis is one crucial step in the forensic examination and comparison of paint evidence. During the examination, the examiner acquires multiple measurements of each paint layer of the known sample and the questioned sample. First, the examiner interprets the FTIR spectra to identify the main components present in the paint layer (e.g., pigments, fillers, and binder). Then, the examiner compares the relative location and shape of the spectral peaks from the multiple measurements to determine if there are "meaningful differences." This step is often conducted by the overlay of the spectra in a computer, but the examiner ultimately decides if there is a difference. The examiner's expertise is critical to determine if the differences are within expected variations of the manufacture of the material or if they are anticipated based on the appearance of the items during the prior microscopical examination of the evidence. Still, it is a subjective decision, especially when the differences between samples are minor.

Some comparison algorithms have been developed for database searching of IR spectra (e.g., PDQ database, Bio-Rads'

KnowItAll Informatics System) but are not widely applied in crime laboratories to compare known/question spectra.

There is a need for more objective models of comparison of some trace evidence data to assist the examiners in the decision process of finding meaningful differences. Therefore, it is necessary to develop universal, practical and automated statistical approaches to support the examiner's opinion during the comparison of data.

2. Key bibliographic references relating to this research need:

Aitken, C. G. G., Roberts, P. and Jackson, G. (2010). PRACTITIONER GUIDE NO 1: Fundamentals of Probability and Statistical Evidence in Criminal Proceedings - Guidance for Judges, Lawyers, Forensic Scientists and Expert Witnesses, Communicating and Interpreting Statistical Evidence in the Administration of Criminal Justice. Prepared under the auspices of the Royal Statistical Society's Working Group on Statistics and the Law.http://www.rss.org.uk/Images/PDF/influencing-change/rss-fundamentals-probability-statistical-evidence.pdf

European Network of Forensic Science Institutes (ENFSI) (2015) ENFSI Guideline for Evaluative Reporting in Forensic Science (Approved Version 3.0, March 8) http://www.enfsi.eu/sites/default/files/documents/external_publications/m1_guideline.pdf

Aitken, C.G.G, and Taroni, F. (2004) Statistics and the Evaluation of Evidence for Forensic Scientists. Wiley.

Lavine, B. K., White, C. G., Allen, M. D., Fasasi, A., & Weakley, A. (January 01, 2016). Evidential significance of automotive paint trace evidence using a pattern recognition based infrared library search engine for the Paint Data Query Forensic Database. Talanta, 159, 317-329.

Loudermilk, J. B., Himmelsbach, D. S., Barton, F. E., & de, H. J. A. (January 01, 2008). Novel Search Algorithms for a Mid-Infrared Spectral Library of Cotton Contaminants. Applied Spectroscopy, 62, 6, 661-670.https://www.osapublishing.org/as/abstract.cfm?uri=as-62-6-661&origin=search

C Muehlethaler, G Massonnet, P Esseiva.The application of chemometrics on Infrared and Raman spectra as a tool forthe forensic analysis of paints.Forensic science international 209 (1-3), 173-182

Cyril Muehlethaler, Geneviève Massonnet, Tacha Hicks. Evaluation of infrared spectra analyses using a likelihood ratio approach: A practical example of spray paint examination Science and Justice 56(2):61-72

Mehltretter, AH, Wright, DM, and Smith, MA. (2017) "Variation in duct tape products over time: Physicalmeasurements and adhesive compositional analysis by Fourier transform infrared spectroscopy." *Forensic Chemistry*, Vol. 4, 1-8.

Mehltretter, AH, Wright, DM, Dettman, JR, and Smith, MA. (2015) "Intra-Roll and Intra-Jumbo Roll Variation of Duct Tapes." *Journal of the American Society of Trace Evidence Examiners (ASTEE)*, Vol. 6, Issue 1, 21-41.

Wright, DM, Bradley, MJ, and Mehltretter, AH. (2013) "Analysis and Discrimination of Single White Layers of Architectural Paint." *Journal ofForensic Sciences*. 2013, Vol. 58, No. 3: 358-364. DOI: 10.1111/j.1556-4029.2013.x

Mehltretter, AH, Bradley, MJ, and Wright, DM. (2011) Analysis and discrimination of electrical tapes: Part II. Backings, *Journal of Forensic Sciences*, 2011, Vol. 56, No. 6. DOI: 10.1111/j.1556-4029.2011.01873.x

3a. In what ways would the research results improve current laboratory capabilities?

Crime laboratories require the development of standardized criteria to determine when differences in the observed or measured features of compared samples are found to be "meaningful." This type of research will help in the harmonization and standardization of interpretation of trace evidence.

There is a vast amount of existing data derived from validation studies, surveys, and databases that could serve as a valuable source of data for the validation of comparison algorithms and models. **A close collaboration between practitioners and statisticians is strongly recommended to optimize the outcomes of such research.**

3b. In what ways would the research results improve understanding of the scientific basis for the subcommittee(s)?

At the subcommittee level, this type of research would provide additional support to the instrumental guides for all material types as well as interpretation and report writing guidelines that are being developed for trace materials in general.

3c. In what ways would the research results improve services to the criminal justice system?

The development of universal and automated statistical approaches for the comparison of data will enhance the scientific foundations of the interpretation of trace evidence materials. Ideally, the proposed statistical approaches could be expanded in the future to other forensic disciplines.

4. Status assessment (I, II, III, or IV): I

	Major gap in current knowledge	Minor gap in current knowledge
No or limited current research	I	III

is being conducted		
Existing current research is being conducted	II	IV

This research need has been identified by one or more subcommittees of OSAC and is being provided as an informational resource to the community.

Approvals:

Subcommittee Approval date: 9/24/18

(Approval is by majority vote of subcommittee. Once approved, forward to SAC.)

SAC

1. Does the SAC agree with the research need? Yes [x] No [ ]
2. Does the SAC agree with the status assessment? Yes [x] No [ ]

If no, what is the status assessment of the SAC: [ ]

Approval date: 12/19/18

(Approval is by majority vote of SAC. Once approved, forward to NIST for posting.)