National Institute of Justice

Forensic Science Research and Development Symposium

American Academy of Forensic Sciences 71st Annual Scientific Meeting

Tuesday, February 19, 2019
Baltimore, Maryland

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STRENGTHEN SCIENCE. ADVANCE JUSTICE.

Forensic Technology
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STRENGTHEN SCIENCE. ADVANCE JUSTICE.

NIJ is the federal government's lead agency for forensic science research and development as well as the administration of programs that facilitate training, improve laboratory efficiency, and reduce backlogs. The mission of NIJ's Office of Investigative and Forensic Sciences is to improve the quality and practice of forensic science through innovative solutions that support research and development, testing and evaluation, technology, information exchange, and the development of training resources for the criminal justice community.

Through the research, development, testing, and evaluation process, we provide direct support to crime laboratories and law enforcement agencies to increase their capacity to process high-volume cases and provide needed training in new technologies. With highly qualified personnel and strong ties to the community, NIJ's Office of Investigative and Forensic Sciences plays a leadership role in directing efforts to address the needs of our nation's forensic science community.

Forensic Technology
CENTER OF EXCELLENCE

A program of the National Institute of Justice

RTI International and its academic- and community-based consortium of partnerships work to meet all tasks and objectives for the Forensic Technology Center of Excellence (FTCoE), put forward under the National Institute of Justice (NIJ) Cooperative Agreement No. 2016-MU-BX-K110.

RTI INTERNATIONAL

The FTCoE is led by RTI International, a global research institute dedicated to improving the human condition by turning knowledge into practice. With a staff of more than 5,000 providing research and technical services to governments and businesses in more than 75 countries, RTI brings a global perspective. The FTCoE builds on RTI's expertise in forensic science, innovation, technology application, economics, DNA analytics, statistics, program evaluation, public health, and information science.

This forum is funded through a cooperative agreement from the National Institute of Justice (2016-MU-BX-K110), Office of Justice Programs, U.S. Department of Justice. Neither the U.S. Department of Justice nor any of its components operate, control, are responsible for, or necessarily endorse, this forum. The opinions, findings, and conclusions or recommendations expressed in this forum are those of the presenter(s) and do not necessarily reflect those of the Department of Justice. Any products and manufacturers discussed are presented for informational purposes only and do not constitute product approval or endorsement by the U.S. Department of Justice.

Greetings,

The National Institute of Justice (NIJ) and its Forensic Technology Center of Excellence at RTI International want to welcome you to the 2019 NIJ Forensic Science Research and Development (R&D) Symposium. This event is held in conjunction with the American Academy of Forensic Sciences 71st Annual Scientific Meeting in Baltimore, Maryland. On February 19, hundreds of attendees will join us in person and online to learn about NIJ research awards given to several talented researchers spanning the forensic disciplines.

For more than a decade, NIJ has hosted an annual R&D symposium to showcase great scientific innovations and promote the transition of research into practice. The NIJ supports research to advance efficiency, quality, reliability, and capacity in the criminal justice and forensic science communities; this research focuses on developing new technologies, providing proof for evidence-based practices, and evaluating findings for case investigations and legal proceedings.

This year, members of the NIJ R&D team—including program managers Gregory Dutton, Danielle McLeod-Henning, and Frances Scott—worked to bring you a phenomenal research agenda. The full-day program includes 16 presenters and their researcher partners representing 16 NIJ awards; these awards were received during a 5-year period (2013–2017). The two morning sessions comprise Impression and Pattern Evidence/Trace Evidence and Forensic Biology/DNA; the afternoon sessions cover Controlled Substances/Toxicology and Forensic Anthropology/Forensic Pathology.

We are pleased to have you—both national and international stakeholders of the criminal justice system—join us for this event; we are confident that you will learn valuable information to help guide your research endeavors and impending cases. The research shared with you at this event will help to efficiently identify, gather, and process evidence related to crime and death scene investigations in the future. Thank you and enjoy this program of research and developments in forensic sciences.

Respectfully,

John S. Morgan, PhD
Director
Forensic Technology Center of Excellence
Center for Forensic Sciences, RTI International

Gerry LaPorte, MSFS
Director
Office of Investigative and Forensic Sciences
National Institute of Justice

Directors

John S. Morgan

Dr. John Morgan is Senior Director of the Center for Forensic Sciences at RTI International. His scientific research interests have included optoelectronic materials, chemical/biological agent detection, and mass spectrometry. His background includes public service as a member of the Maryland House of Delegates and Congressional Science Fellow of the American Physical Society. He has served in the U.S. Department of Justice (DOJ) and the U.S. Department of Defense (DoD) as a Senior Executive managing programs that encompass scientific research, public safety, military technology, special operations, information systems, and standards. He received the 2007 Service to America Medal for his work to improve the nation's capacity to conduct DNA analysis. Dr. Morgan is internationally recognized for his work in forensics, body armor, special operations technology, and predictive policing.

Gerry LaPorte

Mr. Gerald (Gerry) LaPorte serves as the Director in the Office of Investigative and Forensic Sciences at the National Institute of Justice (NIJ), whose mission is to improve the quality and practice of forensic science through innovative solutions that support research, development, technology, evaluation, and information exchange for the criminal justice community. His primary duties are to oversee the management of over $400 million in grants and provide expert analysis and advice on agency-wide programs and issues of national impact relating to forensic science. Mr. LaPorte has been employed in various capacities in the forensic sciences since 1993, and prior to joining NIJ, he was the Chief Forensic Chemist at the United States Secret Service. Mr. LaPorte received his Bachelor of Science and Bachelor of Commerce in business administration from the University of Windsor in Canada and his Master of Science in forensic science from the University of Alabama at Birmingham. He is a member of the American Academy of Forensic Sciences, Mid-Atlantic Association of Forensic Scientists, American Society of Questioned Document Examiners, and the American Bar Association – Criminal Justice Section. Mr. LaPorte has conducted over 100 lectures, seminars, and training events in 13 different countries for law enforcement agencies, professional organizations, and technical experts. He has more than 20 publications, including chapters in three textbooks, and his lectures and workshops have related to the analysis of questioned documents and forensic science policy. He is a member of various organizations and served as the co-chair for the Standards Practices and Protocols Interagency Working Group under the Executive Office of the President of the United States and on the National Commission on Forensic Science until its close in 2017.

NIJ Program Managers

Gregory Dutton

Gregory Dutton, PhD, is a Program Manager at the National Institute of Justice (NIJ). His portfolio includes the broad umbrella of trace evidence—microscopic materials, chemicals, or nonhuman biological traces recovered from crime scenes as well as impression and pattern evidence (e.g., latent fingerprints, firearms, and shoeprints). His programs at NIJ seek to bring advances from across the physical sciences into the forensic sciences. Prior to joining NIJ, Dr. Dutton was a Research Fellow at the National Institute of Standards and Technology. Dr. Dutton earned his doctorate in chemistry from the University of Minnesota.

Danielle McLeod-Henning

Danielle McLeod-Henning is a program manager/physical scientist in the Office of Investigative and Forensic Sciences at the National Institute of Justice, US Department of Justice. She is responsible for managing projects in Forensic Science Research and Development, specifically in forensic anthropology, forensic pathology, crime scene examination, and related medicolegal death investigation fields. Ms. McLeod-Henning holds a master's degree in forensic sciences from the George Washington University and a bachelor's degree in anthropology from the Pennsylvania State University.

Frances Scott

Frances Scott, PhD, is a Physical Scientist at the National Institute of Justice, where she manages the Controlled Substances and Forensic Toxicology research and development portfolios under the General Forensics portfolio and comanages the Paul Coverdell Forensic Science Improvement Grants program and the Research for Publicly Funded Labs program. Dr. Scott received a bachelor's degree in chemistry from the University of California at Davis and a PhD in physical chemistry from the George Washington University.

NATIONAL INSTITUTE OF JUSTICE
GRADUATE FELLOWSHIP
SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

Apply for NIJ's Graduate Research Fellowship in Science, Technology, Engineering, and Mathematics (GRF-STEM). By supporting outstanding graduate research, NIJ is expanding the future pool of young investigators pursuing research with the potential to provide STEM-based solutions to issues that affect crime and the fair and impartial administration of criminal justice in the United States.

To learn more about the GRF-STEM program and see specific examples of research conducted by past and present fellows, visit **www.nij.gov/GRF-STEM**.

Benefits

- $35,000 annually to cover salary and related costs.
- $15,000 annually to cover tuition, fees, and research expenses.
- Up to three years of funding, usable over a five-year period.

Deadline: April 17, 2019

Applications must be submitted via Grants.gov by the academic institution, which must be a fully accredited, doctoral degree-granting institution in the United States or its territories.

Eligibility

Eligible students must be (1) enrolled full time in a STEM discipline doctoral program and (2) propose dissertation research that is relevant to improving criminal justice practice and policy in the United States.

Qualifying disciplines include, among others:

- Anthropology (Physical)
- Biology
- Chemistry
- Cognitive Science
- Computer Science
- Geoscience
- GIS
- Information Sciences
- Materials Science
- Mathematics
- Pathology
- Physics
- Engineering

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January 2019

NATIONAL INSTITUTE OF JUSTICE
PUBLIC LABS RESEARCH SOLICITATION

The Research and Evaluation for the Testing and Interpretation of Physical Evidence in Publicly Funded Forensic Laboratories (Public Labs) program's intent is to fund projects that direct the findings of research and evaluation toward the identification of the most efficient, accurate, reliable, and cost-effective methods for the identification, analysis, and interpretation of physical evidence for criminal justice purposes.

With this solicitation, the National Institute of Justice (NIJ) seeks applications for research and evaluation projects that will:

- Identify and inform the forensic community of best practices through the evaluation of existing laboratory protocols.
- Have a direct and immediate impact on laboratory efficiency and assist in making laboratory policy decisions.

Program Overview

The Public Labs program is specifically targeted toward applicants from or partnered with publicly funded laboratories and has the following objectives:

- Assessing existing laboratory protocols.

  Improve understanding of the rationales underpinning existing laboratory processes.
- Evaluating emerging methods.

  Assess the value of emerging laboratory processes.

Eligibility

NIJ welcomes public-private partnerships through this program. Applicants must be, or be partnered with, publicly-funded forensic science laboratories that are currently accredited by an independent accrediting or certifying forensic science organization. Publicly-funded forensic science laboratories include State, regional, county, municipal, and tribal agencies. For detailed eligibility information, please refer to the solicitation document.

Applying

In advance of NIJ releasing the FY19 solicitation, we are calling on public laboratories, universities and other research organizations to submit contact information to foster collaboration and/or partnerships to assist in preparing an application for the forthcoming solicitation.

Are you a postgraduate researcher with an interest in forensics? If so, the NIJ has a program that can help you gain experience in working forensic labs with real-world applications. Postgraduate researchers are encouraged to access the contact information posted on the web page to link with potential research opportunities.

As part of our "Research and Evaluation for the Testing and Interpretation of Physical Evidence in Publicly Funded Forensic Laboratories" program, we encourage applicant laboratories to consider partnering with another research organization and funding a postgraduate (master's or doctorate) fellowship as part of their proposal.

Learn more at https://www.nij.gov/topics/forensics/lab-operations/Pages/public-labs-research-fellowships.aspx

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NATIONAL INSTITUTE OF JUSTICE
FORENSIC SCIENCE R&D GRANTS

The National Institute of Justice (NIJ) invites proposals to its **Research and Development in Forensic Science for Criminal Justice Purposes** program. NIJ funded projects are expected to:

- Increase the body of knowledge to guide and inform forensic science policy and practice; or
- Result in the production of useful materials, devices, systems, or methods that have the potential for forensic application.

Goals

Proposals should address at least one of the following goals:

- **Fundamental/Basic Research Goal:** Improve the understanding of the accuracy, reliability, and measurement validity of forensic science disciplines.
- **Applied Research Goal:** Increase knowledge or understanding necessary to guide criminal justice police and practice related to the forensic sciences.
- **Development Goal:** Produce new materials, devices, systems, or methods that have the potential for forensic application for criminal justice purposes.

Photo Source: ShutterStock ©Toth Tamas

NIJ is interested in funding innovative research that aligns with administration priorities and attempts to address the needs of the forensic science community.

Priority Areas of Research

Proposals that advance the following national priorities may be given special consideration in award decisions:

- Supporting Innovative Early-Stage Research
- Maximizing Interagency Cooperation
- Developing a Future-Focused Forensic Science Workforce
- Modernizing and Managing Research Infrastructure

Needs of the Community

For more information on what research and technology forensic practitioners would benefit from, see NIJ's Forensic Science Technology Working Group operational requirements at go.usa.gov/xnvJ3.

Deadline: April 11, 2019

Begin the application process early by registering with Grants.gov. All applications are due before midnight on April 11, 2019. Read the solicitation at http://nij.gov/funding/Documents/solicitations/NIJ-2019-15387.pdf.

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AGENDA

Short Agenda

Tuesday, February 19

8:30–8:40	Welcome
8:40–9:55	Morning Session I—Impression and Pattern Evidence/Trace Evidence
10:35–12:15	Morning Session II—Forensic Biology/DNA
1:35–3:15	Afternoon Session I—Controlled Substances and Toxicology
3:30–5:10	Afternoon Session II—Forensic Anthropology and Forensic Pathology
5:10	Adjourn

Full Agenda

Tuesday, February 19: 8:30 a.m.–5:10 p.m.	
8:30–8:40	**Welcome** Gerald LaPorte, Director, Office of Investigative and Forensic Sciences
	Morning Session I: Impression and Pattern Evidence/Trace Evidence Moderated by NIJ Program Manager Gregory Dutton
8:40–9:05	**Quantitative Assessment of Shoeprint Accidental Patterns with Implications Regarding Similarity, Frequency, and Chance Association of Features**—Empirical Chance Association of Randomly Acquired Characteristics Jacqueline Speir, West Virginia University—2013-DN-BX-K043
9:05–9:30	**Finding the Region of Origin of Bloodspatters in Complex Situations: Physical Description, New Data, Tools, and Reconstruction Method** Daniel Attinger, Iowa State University—2014-DN-BX-K036
9:30–9:55	**Raman Microspectroscopy and Advanced Statistics for Detection and Characterization of Gunshot Residue** Igor K. Lednev, University at Albany, SUNY—2016-DN-BX-0166
9:55–10:20	**Consistent Single Shot Detection of Organic and Inorganic Residues from One Sample using LC/MS and Host-Guest Complexes** Suzanne Bell, West Virginia University—2015-DN-BX-K048
10:20–10:35 — BREAK	
	Morning Session II: Forensic Biology/DNA Moderated by NIJ Program Manager Gregory Dutton
10:35–11:00	**A Method to Estimate the Age of Bloodstains using Quantitative PCR** Robert W. Allen, Oklahoma State University—2014-DN-BX-K025
11:00–11:25	**Proteomic Analysis of a Single Human Hair for Ancestral Classification—Use of Genetically Variant Peptides to Statistically Estimate the Genetic Background of Hair Shafts** Zachary Goecker, University of California, Davis—2015-DN-BX-K065

Tuesday, February 19: 8:30 a.m.–5:10 p.m.	
11:25–11:50	**Cellular Autofluorescence Signatures for Determination of Tissue Type, Age of Evidence, and Separating Contributors from Biological Mixtures** Christopher Ehrhardt, Virginia Commonwealth University—2015-DN-BX-K024
11:50–12:15	**Ultrahigh Speed Direct PCR. A Method for Obtaining STR Based Genotypes in Under 6 Minutes** Bruce McCord, Florida International University—2015-R2-CX-K038
12:15–1:35 — LUNCH BREAK (on your own)	
	Afternoon Session I: Controlled Substances and Toxicology Moderated by NIJ Program Manager Frances Scott
1:35–2:00	**Chemical Analysis of Controlled Substances Using Automated Headspace Solid Phase Microextraction—Gas Chromatography/Mass Spectrometry** Jorn Yu, Sam Houston State University—2014-R2-CX-K005
2:00–2:25	**Δ9-THC Infused Foods** Clark Smith, Denver Police Department Crime Laboratory—2015-DN-BX-K028
2:25–2:50	**Detection and Quantification of Synthetic Opioids in Oral Fluid** Michael Truver and Kaitlyn Palmquist, Sam Houston State University—2017-R2-CX-0019
2:50–3:15	**Comparison of Two Validated LCMSMS Methods for the Quantitative Analysis of Opioids, Cocaine, and Cocaine Metabolites in Biological Matrices** Rebecca Wagner, Virginia Department of Forensic Science—2015-DN-BX-K008
3:15–3:30 — BREAK	
	Afternoon Session II: Forensic Anthropology and Forensic Pathology Moderated by NIJ Program Manager Danielle McLeod-Henning
3:30–3:55	**Detection of Insect Stains from Four Species of Necrophagous Flies on Household Materials using Immunoassays—Development of a Quantifiable Confirmatory Test to Detect Fly Artifacts Contaminating Bloodstain Evidence** David B. Rivers, Loyola University Maryland—2016-DN-BX-0181
3:55–4:20	**ICPUTRD: Image Cloud Platform for Use in Tagging and Research on Decomposition** Audris Mockus, University of Tennessee—2016-DN-BX-0179
4:20–4:45	**Analysis of Alternative Light in the Detection of Cutaneous Bruises: A Multisite Randomized Controlled Trial** Katherine Scafide, George Mason University, and Daniel Sheridan, Texas A&M University —2016-DN-BX-0147
4:45–5:10	**Using Fundamental Mechanics to Predict Infant Skull Fracture Patterns** Brittany Coats, University of Utah—2016-DN-BX-0160
5:10 — Adjourn	

SESSION ABSTRACTS

Morning Session I: Impression and Pattern Evidence/Trace Evidence

8:40 A.M.–9:05 A.M.

Quantitative Assessment of Shoeprint Accidental Patterns with Implications Regarding Similarity, Frequency, and Chance Association of Features—Empirical Chance Association of Randomly Acquired Characteristics
NIJ Award #: 2013-DN-BX-K043

Presenting author: Jacqueline Speir, West Virginia University

Abstract: The power associated with demonstrating a linkage between footwear and an impression left at the scene of a crime is directly related to the perceived rarity of the shoeprint itself, which is a function of observed class, subclass and randomly acquired characteristics (RACs). When individualizing characteristics are present, their relative position, orientation, size, and shape are examined and compared with known exemplars in an effort to establish the strength of the suspected linkage. However, the degree to which a feature might repeat by chance alone is less well understood in many pattern science fields, including forensic footwear analysis.

To inform this question, a handful of theoretical models and empirical analyses describing chance association for randomly acquired characteristics have been proposed and investigated by the forensic footwear community. Each theoretical model, although useful, is bounded by model assumptions, including independence, which have never been fully tested. Similarly, each empirical investigation has been limited by sample size, and essentially no chance associations are reported when RAC geometry is included in the comparison. However, inference suggests that with a large enough sample size, chance association must be greater than zero. In other words, RACs can and do co-occur in position, and if the geometry of the feature is simple (such as a small, isotropic, circularly shaped pinprick) then with a large enough database, an observer will find two "nondescript RACs" that coincide by chance alone. The question then becomes "*What is the magnitude of X before a chance association of 1 in X is detected?*"

To empirically answer this question, the mathematical similarity of more than 3.2 million pairwise RAC comparisons was performed, as a function of more than 72,000 RACs, collected from 1,300 unrelated outsoles. The resulting similarity scores were sorted, and more than 91,000 of the mathematically most similar known nonmatch RACs with positional co-occurrence were visually assessed to determine their degree of observable similarity. Using these empirical assessments, more than 900 spatially specific chance associations are reported and available to the community via an online, open-access, and interactive heatmap at https://www.4n6chemometrics.com/database/.

9:05 A.M.–9:30 A.M.

Finding the Region of Origin of Bloodspatters in Complex Situations: Physical Description, New Data, Tools, and Reconstruction Method

NIJ Award #: 2014-DN-BX-K036

Presenting author: Daniel Attinger, Iowa State University

Abstract: Gunshot spatters can produce more than 40,000 stains. Here we describe the first physical models of the blood atomization related to gunshot spatters. For a backward spatter, the atomization occurs according to the Rayleigh-Taylor instability,[1] a phenomenon that also dynamically shapes volcanic eruption and supernovae. Atomization of a forward spatter is better described using percolation theory,[2] a phenomenon that abruptly fractures a dense medium like in e.g, espresso coffee making. Two open-source databases of more than 100 beating[3] and gunshot spatters are described. Impact speed, bullet shape, and distance between blood source and target wall are the main variables that are investigated. Those data sets provide the forensic community with a rich set of data for testing crime scene reconstruction models. Those data sets also illustrate the predictive capabilities of the physical models described previously. Finally, a model is described that determines the region of origin of spatters based on stain inspection, accounting for drag and gravity. The model relies on a physical description of impact dynamics and drop-flight ballistics. Implications for crime laboratories and forensic investigators are discussed.

References:

1. Comiskey P, Yarin A, Kim S, Attinger D. Blood back spatter caused by a blunt bullet gunshot: theory and experiments. Bull Am Phys Soc. 2017;62. Retrieved from https://meetings.aps.org/Meeting/MAR17/Session/R12.4
2. Comiskey PM, Yarin AL, Attinger D. Theoretical and experimental investigation of forward spatter of blood from a gunshot. Phys Rev Fluids. 2018 Jun;3(6):063901. https://doi.org/10.1103/PhysRevFluids.3.063901
3. Attinger D, Liu Y, Bybee T, De Brabanter K. A data set of bloodstain patterns for teaching and research in bloodstain pattern analysis: Impact beating spatters. Data Brief. 2018 Mar 3;18:648-654. https://doi.org/10.1016/j.dib.2018.02.070

9:30 A.M.–9:55 A.M.

Raman Microspectroscopy and Advanced Statistics for Detection and Characterization of Gunshot Residue

NIJ Award #: 2016-DN-BX-0166

Presenting author: Igor K. Lednev, University at Albany, SUNY

Abstract: Raman spectroscopy is a technique that can provide confirmatory class identification of analytes through low-intensity laser light scattering. The technique is nondestructive, rapid, sensitive, and requires little or no sample preparation. Furthermore, portable Raman spectrometers are readily available, allowing for crime scene accessibility. Raman spectroscopy offers several advantages over the current methodology for gunshot residue (GSR) analysis. The technique has been shown to detect components from both the organic and inorganic constituents of GSR on adhesive tape. This is contrary to current GSR elemental analysis methods, which rely solely on the detection of the heavy metals (lead, barium and antimony). This is problematic because environmental concerns have led to the increased popularity in heavy-metal–free or "green" ammunition. Until recently, the application of Raman spectroscopy for GSR analysis was largely unexplored, although this

approach is not dependent upon detecting metals and is more capable of differentiating environmental contaminants and GSR. Therefore, a Raman spectroscopic method displays numerous advantages in specificity when compared to current techniques.

The firearm discharge process is analogous to a complex combustion reaction. Therefore, the chemical composition of the products (GSR) is directly related to the chemical nature of the reagents (ammunition) and the reaction conditions (firearm). Our preliminary results show that Raman data collected from GSR particles originating from different firearm-ammunition discharges were successfully classified. Discharge samples from 0.38 inch and 9 mm caliber firearms were probed using a 785-nm Raman excitation. Resulting data was treated with statistical methods such as Principle Component Analysis (PCA) and Support Vector Machines (SVM). Our results show a high probability that this method correctly identifies GSR from the two examined calibers. Since GSR is often collected from a suspect, the application of this method to forensic investigations would provide a link between GSR collected from the shooter and the crime scene. We have also developed a new two-fold spectroscopic mapping method for the detection and identification of GSR particles on a substrate of adhesive tape. The advantages of this novel approach relative to the current technique will be discussed.

This emerging technique illustrates the possibility for an on-scene, nondestructive, identification and chemical characterization method for GSR. This method has the potential to greatly impact the forensic science community by increasing the accuracy (and discriminatory power) of GSR detection. The most direct application for this research is a method to exclude a specific firearm-ammunition combination as producing an evidentiary GSR sample. The comparison of a laboratory-generated GSR sample discharge and an evidentiary GSR sample can be made without extensive preliminary studies.

This project was supported by Award No. 2016-DN-BX-0166 awarded by the National Institute of Justice, Office of Justice Programs, US Department of Justice. The opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect those of the Department of Justice.

9:55 A.M.–10:20 A.M.

Consistent Single Shot Detection of Organic and Inorganic Residues from One Sample using LC/MS and Host-Guest Complexes

NIJ Award #: 2015-DN-BX-K048

Presenting author: Suzanne Bell, West Virginia University

Abstract: Significant progress has been made in the past few years in developing methods for detection of organic residues (OGSR) using advanced mass spectrometry. Such instruments are increasingly affordable and available in forensic laboratories and are widely used in forensic toxicology. This presentation will describe a method that utilizes electrospray ionization/liquid chromatography/mass spectrometry to detect the elements found in gunshot residue (GSR) and OGSR from a single sample and small-volume sequential extraction. Elemental constituents were detected in the form of host-guest complexes and identified by selected ion transitions and isotopic abundances. GSR elements were consistently detected from single shots from both 0.38 revolvers and 9mm semiautomatic pistol discharges. Background and blank studies confirmed that residues were not associated with background contamination or carryover. Samples were collected using scanning electron microscopy stubs topped with a soft commercial polymer that were dabbed against the skin analogous to the collection method for scanning electron

microscopy/energy dispersive X-ray spectroscopy. The polymer was sequentially extracted in a centrifuge tube first with dilute aqueous acid and then methanol. Initial studies utilized crown ethers (15-5 and 18-6) to complex cations of barium, antimony, and lead. Sample was introduced via flow injection through a C18 guard column and characterization via triple quadrupole mass spectrometry. Barium, lead, and iron were recovered from every hand swab from 1-3 shots while antimony was not recovered. Inductively coupled plasma mass spectrometry analysis confirmed that the initial digestion process was insufficiently aggressive to solubilize this element from GSR. For OGSR, the methanolic fraction was injected through a C18 column and in all cases, ethyl centralite, methylcentralite, and n-nitrosodiphenylamine was recovered. Interestingly, diphenylamine detected in only one sample, 3 shots discharged from the revolver.

Subsequent studies were undertaken to improve digestion of the antimony, explore other complexing agents, and develop a single injection mode for simultaneous detection of GSR and inorganic GSR. Current results on these studies will be presented.

Morning Session II: Forensic Biology/DNA

10:35 A.M.–11:00 A.M.

A Method to Estimate the Age of Bloodstains using Quantitative PCR

NIJ Award #: 2014-DN-BX-K025

Presenting author: Robert W. Allen, Oklahoma State University

Abstract: The value of RNA analysis in the forensic laboratory as one means of identifying the nature of biological evidence of forensic relevance has been well established. The degradation of RNA in dried body fluid stains has also been an area of forensic interest because of the potential to estimate the age of a stain recovered from a crime scene. Here we describe a somewhat novel quantitative polymerase chain reaction (qPCR) assay that demonstrates it is possible to estimate the age of bloodstains with reasonable accuracy. The 5'–3' qPCR assay exploits the observation the 5' end of an mRNA transcript degrades in dried stains faster than the 3' end. This differential degradation pattern can be followed with a qPCR assay that quantifies ~90 bp amplicons produced from the 5' and 3' ends of a panel of four transcripts chosen from the transcriptome of blood because of the degradation kinetics determined initially using RNA sequencing. Statistical analysis of degradation curves suggests, depending upon the age of the sample, the window of accuracy in age estimates is about 2–4 weeks for stains less than 6 months of age and 4–6 weeks for stains 6 months to 1 year old.

11:00 A.M.–11:25 A.M.

Proteomic Analysis of a Single Human Hair for Ancestral Classification—Use of Genetically Variant Peptides to Statistically Estimate the Genetic Background of Hair Shafts

NIJ Award #: 2015-DN-BX-K065

Presenting author: Zachary Goecker, University of California, Davis

Abstract: Recent developments in proteomic analysis offer the prospect of considerable improvement for use of hair evidence for individual identification. Individual variation in the form of genetically-variant peptides (GVPs) are a consequence of nonsynonymous single nucleotide polymorphisms that are translated as single amino acid polymorphisms. Known and well-characterized nonsynonymous mutations permit detection of GVPs in digests of hair proteins. Proteomic methods provide quantitative values with experimentally

determined error rates. Currently, random match probabilities derived from protein reach into the millions for a single hair. To further maximize the usefulness of proteomic technology, two factors were explored. The first was optimization of hair processing so that a single hair fragment would suffice for a rapid analysis. We can now process less than one inch of hair in under 24 hours. The second was that processing different ancestral groups assumes that the method used is consistent across different biogeographic backgrounds.

Results testing 2 cm of hair indicate that protein digestion is improved at room temperature, reducing using 100 mM DTT, and agitating by stirring. Trypsinization for 6 hours solubilizes most of the hair by mass and results in detection of more unique peptides than with longer digestion times (>24 hr). An optimized hair-processing procedure, with shorter times for both reduction and digestion, has yielded improvements in detection of GVPs, and results in a similar number of GVPs compared to other approaches. For 2 cm of hair, powers of discrimination have reached up to 1 in 106 million, and for 4 mg of hair, 1 in 231 billion. Current work addresses proteomic equivalence between European and African protein expression levels and GVP occurrences. Because GVPs from less abundant proteins are more likely to be observed consistently with increased efficiency of hair digestion, protocol optimization is envisioned to increase the number of GVP identifications and increase resulting discrimination. Further work is also underway to automate creation of GVP profiles, and to characterize GVPs through the use of internal standards to aid in meeting the Daubert standard of evidence admissibility. This research may advance both ancestral classification and individual identification. Proteomics may bolster hair evidence as an objective identification method alongside mitochondrial haplotyping.

11:25 A.M.–11:50 A.M.

Cellular Autofluorescence Signatures for Determination of Tissue Type, Age of Evidence, and Separating Contributors from Biological Mixtures

NIJ Award #: 2015-DN-BX-K024

Presenting author: Christopher Ehrhardt, Virginia Commonwealth University

Abstract: Analysis of biological mixtures is a significant problem for forensic laboratories. The presence of cells from multiple individuals in a biologic stain complicates DNA profile interpretation and often leads to loss of evidence. One promising strategy is to utilize morphological and/or intrinsic fluorescence profiles (i.e., "autofluorescence") to discriminate, and ultimately separate, contributor cell populations in a mixture. Although autofluorescence signatures have demonstrated applications for clinical diagnostics, they have yet to be investigated as a tool for processing cell mixtures for DNA casework. Therefore, the goal of this study was to survey cellular autofluorescence signatures across a range of forensically relevant cell types (saliva, buccal, epidermal, blood) and deposition conditions (dried and aged between 24 hours and 2 months) and then develop a workflow for using these signatures to separate contributor cell populations from biological mixture samples. Results showed that cell populations from each of the four tissue types could be resolved with a high degree of accuracy regardless of sample age. Specifically, epidermal cells were distinguished from vaginal and buccal cells with a classification accuracy of ~94%, whereas blood cells could be differentiated from the three epithelial cell types with an accuracy over 97%.

Analysis of variable weights indicated that measurements capturing the circularity, aspect ratio, and autofluorescence between 450 and 680 nm of cells were the largest drivers of multivariate differences between tissue types. In order to demonstrate applications for

DNA case working units, autofluorescence signatures were used to physically isolate contributor cell populations from both mixed tissue and single cell type mixtures prior to DNA profiling. Results from two-person mixtures consisting of buccal cells and blood cells showed near single source profiles from mixtures that had been aged for up to 72 hours and various contributor ratios (3:1, 1:1, 1:3). Similar results were obtained for single cell type mixtures of whole blood, with single source profiles obtained in mixtures with varying contributor ratios, age (up to ~96 hours), and with as many as five contributors. Another important outcome for this work is that cellular autofluorescence profiles were observed to change systematically as the sample aged and could be used to determine the time since deposition for an unknown biological sample. Specifically, the median intensity of autofluorescence detected between 350 and 680 nm increased incrementally at 24-hour time points between 0 and 7 days. Nonlinear differences were also observed between 1 week and 2 months. Autofluorescence signatures were then used to construct a multivariate framework to predict the time since deposition in an unknown biological sample. Results showed that cell populations were correctly associated with eight different time points between 24 hours and 2 months with an accuracy of ~85%.

Overall, results from this project suggest that cellular autofluorescence measurements such as these, which can be obtained in a high throughput and nondestructive fashion, can be used to separate contributor cell populations in many types of biological mixtures and simultaneously provide probative information regarding the age of an evidence sample.

11:50 A.M.–12:15 P.M.

Ultrahigh Speed Direct PCR. A Method for Obtaining STR Based Genotypes in Under 6 Minutes

NIJ Award #: 2015-R2-CX-K038

Presenting author: Bruce McCord, Florida International University

Abstract: Recent advances in DNA polymerases, thermal cyclers and microfluidic systems have the potential to provide the forensic DNA community with methods for rapid analysis of samples. We have been exploring the potential to increase the speed of multiplex polymerase chain reaction (PCR) through careful optimization of experimental parameters including polymerase, PCR cocktails, and amplification ramp rates. In our research experimental design methods and PCR enhancement techniques have been utilized to produce seven locus multiplex amplifications as fast as 6 minutes using extracted DNA and direct PCR amplifications (no extraction at all) in 12 minutes. The results can be visualized in under 80 seconds using a microfluidic electrophoresis system containing a heated plate with a denaturing polymer buffer. In this paper we discuss the aspects of our experimental design and the optimization of polymerase and buffer conditions. We believe that this high-speed genotyping in combination with microfluidic detection has great potential in suspect screening and other projects where rapid identification of individual suspects is necessary.

Afternoon Session I: Controlled Substances and Toxicology

1:35 P.M.–2:00 P.M.

Chemical Analysis of Controlled Substances Using Automated Headspace Solid Phase Microextraction—Gas Chromatography/Mass Spectrometry

NIJ Award #: 2014-R2-CX-K005

Presenting author: Jorn Yu, Sam Houston State University

Abstract: Forensic applications of automated heated headspace-solid phase microextraction coupled to a gas chromatography/mass spectrometry (HHS-SPME-GC/MS) in controlled substance analysis will be discussed in this talk. This analytical platform offers a good potential to be used as a rapid and sensitive process to capture chemical features for evidence. A variety of controlled substances in a variety of forms can be extracted with HHS-SPME. Nonvolatile analytes could be extracted well at 150° C. Incubation times ranging from 5 to 10 minutes proved sufficient for extraction and derivatization. The presence of other impurities from the headspace of evidence potentially could serve as unique identifiers for revealing formulation trends, synthesis methods, growing regions, and other information that could be of interest to forensic tasks. The heated process for SPME also demonstrated beneficial to facilitate one step headspace derivatization for less volatile analytes. Examples of using HHS-SPME-GC/MS for cannabinoids, fentanyl, synthetic cathinones, psychedelic mushrooms will be presented. We will demonstrate that the HHS-SPME-GC/MS platform for chemical analysis of controlled substances is rapid, efficient, and cost-effective. Many controlled substances could be readily extracted and detected from the headspace of evidence by HHS-SPME-GC/MS. With almost no sample preparation, the technique enables an automated process that efficiently transforms headspace chemical signature of evidence into digital data. We expect the analytical platform will be a rapid and reliable analytical testing method for the development of artificial intelligence for characterization of controlled substances.

2:00 P.M.–2:25 P.M.

Δ9-THC Infused Foods

NIJ Award #: 2015-DN-BX-K028

Presenting author: Clark Smith, Denver Police Department Crime Laboratory

Abstract: Delta-9 tetrahydrocannabinol (Δ9-THC) is the active chemical in marijuana that causes intoxicating effects. Colorado has an active market in which Δ9-THC is infused into foods. State regulations mandate certain manufacturing processes but clandestinely manufactured food materials remain a constant issue and the amount of Δ9-THC in food can be a criminal matter. Developing and validating a quantitative food analysis method is an important forensic tool.

City of Denver Forensics and Evidence Division has been working to develop a Δ9-THC infused foods method. Quantitation can be difficult due to varying food matrices. Research focus includes analyzing hard candies, infused liquids, and baked goods.

The presentation will focus on several techniques to aid in the analysis of Δ9-THC infused foods. Topics of research include methods and results for:

- dry ice homogenization;
- enzymatic digestion of triglycerides; and
- removing sugars and fats from the matrix, extraction solvent selection, and matrix effects on gas chromatography and liquid chromatography.

2:25 P.M.–2:50 P.M.

Detection and Quantification of Synthetic Opioids in Oral Fluid

NIJ Award #: 2017-R2-CX-0019

Presenting authors: Michael Truver and Kaitlyn Palmquist, Sam Houston State University

Abstract: Synthetic opioids, like U-47700 and furanyl fentanyl, were introduced into the illicit drug market as heroin adulterants. As a result, the number of opioid-related deaths in the United States increased significantly. Oral fluid has been investigated as a toxicological matrix of interest as it may indicate recent drug use and may be useful for determining drug use trends. To address the limitations of routine forensic analyses, two analytical methods were developed and validated for the screening and quantification of fentanyl- and nonfentanyl–related synthetic opioids in oral fluid using liquid chromatography-tandem mass spectrometry (LC-MS/MS) techniques. Pooled oral fluid (containing 1:3 oral fluid:Quantisal buffer) was fortified with deuterated internal standards and extracted with a polymeric solid-phase extraction column. After aqueous and organic washing, analytes were eluted with 5% ammonium hydroxide in ethyl acetate and 5% ammonium hydroxide in 80:20 dichloromethane: isopropyl alcohol for the screening and quantification methods, respectively. Analytes were dried down and reconstituted in mobile phase. Comprehensive screening and quantification methods for fentanyl analogs and other synthetic opioids were developed and validated according to Scientific Working Group for Toxicology Standard Practices for Method Validation in Forensic Toxicology guidelines. The screen was performed using an Agilent Technologies 1290 Infinity liquid chromatograph coupled to an Agilent Technologies 6530 Accurate Mass Time-of-Flight mass spectrometer in two acquisition modes: TOF mode and All Ions Fragmentation mode. Personal Compound and Database Libraries were produced in house containing fentanyl analogs of interest (n = 14), as well as other drugs of abuse and additional synthetic opioids (n = 53). An Agilent 1290 Infinity liquid chromatograph system equipped with an Agilent 6470 Triple Quadrupole Mass Spectrometer was used for quantification of buprenorphine, U-47700, U-49900, U-50488, AH-7921, MT-45, W-18, W-15, and heroin markers (6-acetylmorphine, morphine). For the screening method, the limits of detection (LOD) for all fentanyl analogs in oral fluid were 0.25 ng/mL and 2.5 ng/mL in time-of-flight and all-ion-fragmentation modes, respectively. No carryover or interferences were observed. Matrix effects in oral fluid were considered acceptable for all analytes with ion suppression and enhancement ranging from -11.7-13.3%. Processed sample stability was assessed after 24 hours in the autosampler (at 4°C), and all analytes were determined to be stable, except alfentanil (>25% loss in autosampler). For the quantification method, LOD and limit of quantitation (LOQ) for all analytes were 5 ng/mL and 10 ng/mL, respectively. Linearity was determined between 10 and 500 ng/mL ($R2 > 0.9959$). Bias and precision were $<\pm 11.1\%$. Matrix effects ranged from -21.1% to 13.7%. No carryover or qualitative/quantitative interferences were detected. All analytes were stable under all conditions tested. Authentic oral fluid samples (n = 18) collected via Quantisal devices from arrestees (under a protocol approved by an institutional review board) did not contain any novel synthetic opioids. Morphine or heroin use was indicated in 4 cases. Additional drugs detected included methamphetamine (n = 15), amphetamine (n = 7), cocaine (n = 4), codeine (n = 1), alprazolam (n = 1), and mephedrone (n = 1). Morphine concentrations were <LOQ, 32, 104, and 146 ng/mL and 6-acetylmorphine in those same cases were <LOD, 15, <LOQ, and 110 ng/mL. These methods are currently being used to analyze authentic samples from various populations in order to help assess the prevalence of these synthetic opioids. The comprehensive screening method will also help determine drug use trends of common drugs of abuse.

2:50 P.M.–3:15 P.M.

Comparison of Two Validated LCMSMS Methods for the Quantitative Analysis of Opioids, Cocaine, and Cocaine Metabolites in Biological Matrices

NIJ Award#: 2015-DN-BX-K008

Presenting author: Rebecca Wagner, Virginia Department of Forensic Science

Abstract: The proliferation of misuse of both prescription and non-prescription opioids, in recent years, has caused an opioid epidemic in the United States. Forensic toxicology laboratories often encounter implications of abuse in both driving under the influence of drugs and death investigation cases. The Toxicology Section of the Virginia Department of Forensic Science (VADFS) receives driving under the influence/driving under the influence of drugs, death investigation, and other police cases for analysis. From 2012 to 2017, VADFS had a 191% increase in the number of reported opioid results and a 1439% increase in the number of reported fentanyl results for death investigation cases. The increased prevalence of drug use extends to all case types and is complicated by poly drug use. Traditionally, analyses are completed by individual drug class, which subsequently requires an individual case to be evaluated using multiple analytical techniques for comprehensive analysis.

To ease the impact of ever-increasing case submissions and case complexity, VADFS has validated two liquid chromatography tandem mass spectrometry (LCMSMS) methods for the quantitative analysis of opioids, cocaine, and cocaine metabolites in biological matrices. The methods were validated in accordance with the Scientific Working Group for Forensic Toxicology method-validation guidelines and VADFS validation requirements. The methods were then compared to determine the advantages and disadvantages of each analytical technique. The newly developed methods not only require a decreased sample volume, but they also combine four analytical techniques into one method, which significantly impacts laboratory productivity. Furthermore, since implementation, the qualitative analysis of over 30 fentanyl derivatives has been validated as an addition to the opioid, cocaine, and cocaine metabolite method. Two sample preparation techniques, solid phase extraction and protein precipitation, were employed for the validation of the two quantitative positive ionization mode DynamicMRM LCMSMS methods. Aspects evaluated during the validation were accuracy and precision, sensitivity, calibration model, ionization suppression/enhancement, recovery, carryover, interferences, dilution integrity, and post-extraction stability. All compounds passed the comprehensive validation for antemortem and postmortem blood for both methods whereas urine only passed qualitative acceptance criteria. Overall, the protein precipitation indicated more ionization suppression than the solid phase extraction, but the presence of ionization suppression was determined to have minimal effect on the methods limit of detection or accuracy and precision. A comprehensive comparison of the two methods was completed using the validation data and a cost-benefit analysis. The rapid protein precipitation extraction, in conjunction with an 11-minute analysis time, significantly increased laboratory efficiency upon implementation in the Toxicology Section of VADFS. Given the prevalence of emerging fentanyl derivatives, over 30 fentanyl derivatives have been qualitatively validated using the protein precipitation extraction to further increase laboratory efficiency. Therefore, the use of either fully validated method for the analysis of opioids, cocaine, and cocaine metabolites can aid in streamlining forensic toxicology analysis.

Afternoon Session II: Forensic Anthropology and Forensic Pathology

3:30 P.M.–3:55 P.M.

Detection of Insect Stains from Four Species of Necrophagous Flies on Household Materials using Immunoassays—Development of a Quantifiable Confirmatory Test to Detect Fly Artifacts Contaminating Bloodstain Evidence

NIJ Award #: 2016-DN-BX-0181

Presenting author: David B. Rivers, Loyola University Maryland

Abstract: Despite claims that fly artifacts can be detected based on morphological features, alternate lighting, and presumptive chemical tests, few species have been tested by the reported methods for discernment and none have proven to be consistently reliable in distinguishing insect stains from human body stains. In an effort to overcome deficiencies in current methods used for identification of insect stains, an immunoassay has been developed that utilizes polyclonal antisera (termed anti-md3) based on a unique cathepsin D-like proteinase found in some *cyclorrhaphous Diptera*. The confirmatory immunoassay (dot blot) recognizes insect stains that contain fly digestive enzyme, specifically fly regurgitate and defecatory or fecal stains. In this study, artifacts produced by four species of necrophagous flies (*Protophormia terraenovae, Calliphora vicina, Cynomya cadaverina, and Sarcophaga bullata*) were examined using the confirmatory immunoassay to determine if insect stains could be distinguished from a range of human body fluids (e.g., blood, semen, urine, saliva, feces). Adult flies were fed ad libitum human blood, semen, urine, feces, or saliva for 24 hours at 25°C and permitted to deposit artifacts on a range of household materials: ceramic tile, carpet (plush), t-shirt (cotton), wood block, and unfinished drywall. A lift technique was developed that permitted transfer of fly artifacts from the test materials to filter paper (Whatman #4 110 mm Æ) for dot blot analyses. Artifact transfers were confirmed visually and with ALS using a 450 nm emission filter and an orange contrast filter. All species readily deposited artifacts on all test household materials regardless of diet consumed. Despite differences in texture and porosity of the household materials, artifacts of all species transferred to saturated filter paper (Dulbecco's PBS) with apparent equal efficiency based on visual inspection. With all fly species, anti-md3 sera bound to artifacts produced after feeding on semen, blood, feces, urine, and saliva. Binding appeared proportional to the size of the artifact transferred during the lifts. By contrast, none of the human fluids tested positive in the immunoassays, nor did lifts from household materials not exposed to flies. There was no evidence of false positives with any of the fly species tested, regardless of diet consumed. Similarly, there was also no indication of false negatives with any of the dot blot assays. However, flies did deposit artifacts not derived from the digestive tract on the test materials that, as expected, did not yield positive reactions with the immunoassay. Such artifacts generally cannot be visually distinguished from regurgitate and defecatory stains and thus can yield results perceived as false negatives. These observations suggest that immunoassays using anti-md3 sera coupled with a simple lift technique can be used effectively as a confirmatory assay to distinguish fly regurgitate and fecal stains from human body fluids. The new method overcomes the limitations of current techniques and can be performed reliably by anyone properly trained without the need of a forensic expert for consultation.

3:55 P.M.–4:20 P.M.

ICPUTRD: Image Cloud Platform for Use in Tagging and Research on Decomposition

NIJ Award #: 2016-DN-BX-0179

Presenting author: Audris Mockus, University of Tennessee

Abstract: Daily documentation of longitudinal decomposition across hundreds of human donors throughout the seasons is key to understanding the myriad of factors that can affect decomposition and hence explains the appearance of a body when it is found at a crime scene. Since 2011, the Forensic Anthropology Center has taken daily photos of all donors during decomposition at the Anthropology Research Facility, creating a database that demonstrates the effects of scavenging, insect activity, weather events and other factors that affect the pattern and rate of decomposition. The photo database now includes over 1 million images and occupies over 4 TB of disk space. Despite the promise of digitally preserving fleeting instances of decomposition, the collection is too large for manual inspection and the relevant forensic information is hidden within images, making it impossible to use for meaningful forensic and statistical analysis. An extensible online platform, called Image Cloud Platform for Use in Tagging and Research on Decomposition (ICPUTRD), has been developed to support forensic work on this digital collection. More specifically, the platform supports four of the most basic tasks a research study might undertake: explore the collection, find artifacts based on metadata, find artifacts based of forensic relevance, and curate the database to facilitate a variety of research studies. Meanwhile, the platform has to be able to handle the size of the data, be easily accessible, simple to use, and easily extensible. To satisfy these requirements, this project utilizes common web and cloud technologies such as MEAN stack (MongoDB, Express, Angular JavaScript, and Node JavaScript) and Docker containers to build ICPUTRD. After importing images and populating the database of metadata (weight, age, height, date), the next daunting task was a three-step process to extract forensically relevant information from the images themselves. By creating a nomenclature of standard terminology commonly used in the medico-legal community and applying it to tag specific parts of each photo (e.g., "eggs" or "adipocere"), the database currently contains over 1,000 images that were tagged with 5,000 terms. Furthermore, Conventional Neural Network (CNN) techniques were being implemented to train CNN over the tagged images and predict tags on the remaining images. Human decomposition experts can easily add and share standard nomenclature or study-specific tags, thus enriching the database. To determine whether the platform is achieving its goals and to find areas in which it needs to be extended, an evaluation study is underway in which 20 forensic researchers are performing searches of previously tagged images and tagging new images themselves. The preliminary results of the study are highly encouraging, with users being able to quickly find relevant forensic features. It is anticipated that ICPUTRD will become a standard tool for forensic researchers of human decomposition and will answer questions relevant to law enforcement investigations. We hope that curation capabilities that allow experts to tag additional images (and share the tags) would result in an extremely rich resource for studies of human decomposition.

4:20 P.M.–4:45 P.M.

Analysis of Alternative Light in the Detection of Cutaneous Bruises: A Multisite Randomized Controlled Trial

NIJ Award #: 2016-DN-BX-0147

Presenting authors: Katherine Scafide, George Mason University, and Daniel Sheridan, Texas A&M University

Problem Statement: Victims of violence often have cutaneous bruises latent or barely visible to the naked eye due to skin color, injury age, or depth. Unidentified injuries can cause a disparity in forensic investigations, leading to unsuccessful or lack of criminal prosecutions. An alternate light source (ALS) with short narrowband visible (NBV) or long ultraviolet (UV) spectrums may improve detection and visibility of cutaneous bruises. However, the limited research available is not definitive about whether light absorption within these wavelengths results from bruising or artifact. Little is known how skin color affects bruise visibility using an ALS.

Purpose: The purpose of this study was to analyze the effectiveness of ALS in improving bruise detection and visibility over white light. We also explored the effects of skin color, gender, localized fat/muscle and bruise size, mechanism, and color on specific wavelength performance over time.

Partnership: This multisite study is a partnership between two US universities.

Subjects: Participants include 156 healthy adults, ages 18–65, with equal sampling of six skin color categories.

Methods: Using a crossover randomized controlled trial design, the order of ALS and white light application was randomized for each bruise. Bruises were created under controlled application of a paintball pellet and dropped weight to randomly selected upper and lower arm, respectively. Both bruised areas were assessed for bruise detection and visibility under white and alternate light at 21 time points over a 4-week period. A smaller subset (n = 30) of subjects continue to have their bruises assessed for up to 8 weeks. Bruise visibility using wavelength peaks within UV (365 nm) and NBV (415 nm, 450 nm, 475 nm, 495 nm, 515 nm, 535 nm) spectrums and filters (yellow, orange, red) are examined. Spectrophotometric measures of skin and bruise color are obtained along with digital photographs under each light source.

Results: Descriptive summaries of findings will be presented on this recently completed study. In addition, ALS photographic techniques developed for the study will be discussed as they will advance current practice standards.

Conclusion: ALS has the potential to improve bruise detection on diverse victims of violence and extend the timeframe for when bruises may be visible. Image analysis of bruise photographs may hold the key towards objective assessment of bruise visibility and detection under ALS.

4:45 P.M.–5:10 P.M.

Using Fundamental Mechanics to Predict Infant Skull Fracture Patterns
NIJ Award #: 2016-DN-BX-0160

Presenting author: Brittany Coats, University of Utah

Background: Approximately 686,000 children are victims of abuse and neglect every year. The highest percentage of these children are between birth and 3 years of age and are more likely to experience a recurrence of maltreatment if the abuse is not identified. Accidental falls are the leading cause of nonfatal injury in infants and the most common explanation given by caretakers suspected of abuse. Thus, distinguishing a truthful history of a fall from a false one proves to be a difficult but important task for a clinician and for the legal system. Skull fracture is a common finding for both accidental falls and abusive injuries, but it is unknown how to distinguish fracture from accidental or abusive scenarios. There is an urgent need for careful biomechanical investigations to determine characteristics of trauma that lead to specific skull fracture patterns in infants. The purpose of our research is to develop and validate a computational toolset for predicting skull fracture patterns in infants. We then plan to use the toolset to identify skull fracture patterns from common low height accidental falls in infants, and to evaluate the effect of head impact direction, impact energy, and skull thickness on skull fracture patterns.

Methods: Human infant parietal and occipital bone specimens (n = 17) were obtained from autopsy and tested in a custom three-point bending high-rate (1.66 ± 0.09 m/s) impact system to identify rate-, region-, and direction-dependent material properties. Using the resulting properties, we developed a high-fidelity computational framework to predict crack propagation following a head impact. The framework integrates three-dimensional crack growth software based on fundamental fracture mechanics to identify patterns of crack growth with finite element software for complex dynamic simulations. The framework was validated against a reported parietal skull fracture in a 5-month old infant cadaver dropped from 15 cm onto concrete.

Results: Occipital and parietal infant cranial bones were 10 times stiffer when tested parallel trabecular fibers compared to perpendicular to the fibers. Regardless of fiber orientation, parietal bone was consistently stiffer than occipital bone. Interestingly, cranial bone was only rate dependent when tested parallel to the fibers rather than perpendicular. This is similar to some fiber dominant tissues, such as tendon. The computational framework and associated workflow was successfully created, and accurately predicted the skull fracture pattern of a 5-month-old cadaver head impact to concrete.

Conclusions: Infant cranial bone is unique compared to adult cranial bone in that it has noticeable trabecular fibers that significantly influence the mechanical response of the bone. The mechanical effect of these structures is 7 times greater than originally believed. These data led to the development of a successful computational framework for predicting infant skull fracture patterns. Future studies with the framework will parametrically evaluate the effect of impact energy and impact direction on skull fracture patterns in children and provide the medical and legal communities with empirical data to improve medical and judicial accuracy in child abuse cases.

PRESENTER BIOS

Robert W. Allen

Dr. Robert W. Allen is the chair and program director as well as a professor of forensic sciences at the School of Forensic Sciences, Center for Health Sciences, Oklahoma State University, Tulsa, Oklahoma. His PhD in molecular biology and genetics was awarded in 1977 from Purdue University, West Lafayette, Indiana, after which he had a postdoctoral fellowship at the Scripps Clinic and Research Foundation in La Jolla, California. He has published 82 publications, with 2 more in press and 2 in preparation. He is the Editor in Chief of the *Journal of Forensic Investigation*.

Daniel Attinger

Dr. Daniel Attinger is an adjunct lecturer of forensic science at the University of the West Indies and an associate professor of mechanical engineering at Iowa State University. His scholarship is in multiphase fluid dynamics, with applications to energy technologies and bloodstain pattern analysis. He has produced 4 patents and 100 peer-reviewed scientific publications and has given dozens of invited lectures at international conferences. He has led multiple interdisciplinary research projects funded by US Federal Research Agencies. He is the recipient of a National Science Foundation CAREER award and the Silver Medal of ETH. Dr. Attinger is a Fellow of the American Society of Mechanical Engineers and a full member of the International Association of Bloodstain Pattern Analysts. Educated in Switzerland, Dr. Attinger appreciates quality work, shared governance, and mountaineering. He respects the First Amendment and enjoys the American drive for transformative innovations.

Suzanne Bell

Dr. Suzanne Bell is a professor and chair of the Department of Forensic and Investigative Sciences at West Virginia University. She served on the National Commission on Forensic Science (NCFS) from 2014 to 2017. In addition, she has served on the Scientific Working Groups for Seized Drug Analysis and Gunshot Residue, the Forensic Science Education Program Accreditation Commission, and the Organization of Scientific Area Committees subcommittee on GSR. She teaches forensic chemistry and toxicology courses and mentors students at the bachelor, master's, and doctoral level. She has published numerous papers in internationally recognized peer-reviewed journals and is the associate editor for chemistry for the *Journal of Forensic Sciences*. She collaborates with forensic scientists and practitioners in the United States, Europe, and Brazil and did a sabbatical at the National Institutes of Standards and

Technology in 2015. She is the author of two editions of the textbook *Forensic Chemistry* (Pearson/Prentice Hall), *Introduction to Microscopy* (CRC Press), and the 4th and 5th editions of the comprehensive introductory text *Forensic Science: An Introduction to Scientific and Investigative Techniques* (CRC Press). She gives invited lectures and teaches workshops on estimation of uncertainty in forensic science at conferences and for state and local forensic science laboratories. Her current research projects relate to the toxicity of synthetic cannabinoids and new approaches to firearms discharge residue.

Brittany Coats

Dr. Brittany Coats is an associate professor and associate chair of mechanical engineering at the University of Utah. She holds affiliated positions in ophthalmology and visual sciences, pediatrics, and bioengineering. Her research focuses on injury mechanics of the brain and eye, with specific interest in understanding microstructural features and properties that lead to better prevention, detection, and treatment strategies for injury in children and adults. She received her PhD in bioengineering at University of Pennsylvania. Her postdoctoral research forged collaborations with neurosurgeons and ophthalmologists at the University of Pennsylvania to investigate the effect of repetitive head trauma on brain and ocular injury. Her current research efforts are supported by grants from the Department of Defense, National Institutes of Health, National Science Foundation, and National Institute for Justice.

Christopher Ehrhardt

Dr. Christopher Ehrhardt is currently an associate professor in the Forensic Science Department at Virginia Commonwealth University in Richmond, Virginia. He received his PhD from University of California–Santa Barbara in earth and environmental sciences and completed postdoctoral appointments at the Federal Bureau of Investigation's Laboratory Research Unit (Quantico, Virginia) and the National Security Directorate at Pacific Northwest National Laboratory (Richland, Washington). At Virginia Commonwealth, his research group studies the biochemistry, optical properties, and genetics of trace biological samples as well as front end methods for resolving cell mixtures for DNA casework.

Zachary Goecker

Mr. Zachary Goecker is a PhD candidate in the pharmacology and toxicology program at the University of California, Davis, where he is researching the role of genetic variation in human hair shaft protein as a forensic tool. Mr. Goecker now studies under Drs. Robert Rice and Glendon Parker at UC Davis. He has participated in research involving natural products, touch DNA, nanotechnology, and proteomics.

Igor K. Lednev

Dr. Igor K. Lednev is a professor in chemistry at the University at Albany. His expertise is in the development and application of novel laser spectroscopy for biomedical research and forensic purposes. Dr. Lednev served as an advisory member for the White House Subcommittee on Forensic Science and on editorial boards of four scientific journals including the Journal of Raman Spectroscopy and Forensic Chemistry. Dr. Lednev is a fellow of the Society for Applied Spectroscopy and the Royal Society of Chemistry and is a recipient of the Society for Applied Spectroscopy Gold Medal Award. Lednev has coauthored over 210 peer-reviewed publications.

Bruce R. McCord

Dr. Bruce R. McCord is a professor of analytical and forensic chemistry at Florida International University. Dr. McCord received a PhD in analytical chemistry from the University of Wisconsin-Madison in 1986. Prior to working at Florida International, he was an assistant professor at the Ohio University (1998–2004) and a research chemist at the Federal Bureau of Investigation Laboratory (1989–1998). His current research interests involve forensic genetics, toxicology, and explosives residue detection. Dr. McCord has published over 100 peer-reviewed papers and 12 book chapters, and his research has been supported by the National Institute of Justice, the National Science Foundation, Technical Support Working Group, the Department of Homeland Security, and various industrial concerns. He serves as deputy editor for the journal *Electrophoresis* and is a member of the editorial board the *Journal of Forensic Chemistry*. He also is a member of the scientific advisory board of the Green Mountain DNA Conference, The Latin American Capillary Electrophoresis Conference, and the Biological Methods subcommittee of the National Institute of Standards and Technology's Organization of Scientific Area Committees. In 2008, he received the Paul Kirk Award of the Criminalistics Section of the American Academy of Forensic Science for his contributions to the field.

Audris Mockus

Dr. Audris Mockus is the Ericsson-Harlan D. Mills Chair Professor in the Department of Electrical Engineering and Computer Science of the University of Tennessee. His latest interests concern models of the entire open-source software ecosystem based on version-control data and anthropological phenomena hidden in large image collections. He is interested in recovering information and creating models of reality from big operational data. Previously, he worked at Avaya Research, AT&T, and Lucent Bell Labs. He received a PhD in statistics from Carnegie Mellon University in 1994.

Kaitlyn Palmquist

Ms. Kaitlyn Palmquist is a doctoral student in the Department of Forensic Science at Sam Houston State University. She received the Lucas Grant Award from the Forensic Science Foundation for her project investigating the screening of fentanyl analogs in whole blood using liquid chromatography–hybrid quadrupole time-of-flight mass spectrometry. Her dissertation research focuses on developing analytical methods for the detection of fentalogs in various biological matrices and the application of those analytical methods to produce pharmacokinetic/pharmacodynamic models. Previously, Ms. Palmquist interned with the Johnson County Sheriff's Office Criminalistics Laboratory in Olathe, Kansas (2017), and the Office of the Chief Medical Examiner's Toxicology Lab in Baltimore, Maryland (2015).

David Rivers

Dr. David Rivers is professor of biology and director of forensic studies at Loyola University Maryland. He received a PhD in entomology with a concentration in insect physiology from the Ohio State University and was a National Institutes of Health postdoctoral fellow in cellular and molecular parasitology at the University of Wisconsin. He is a member of the North American Forensic Entomology Association, Entomological Society of America, and American Academy of Forensic Sciences. He also is co-author of the critically acclaimed textbook *The Science of Forensic Entomology* and conducts research in several areas involving necrophagous flies and parasitic wasps as they relate to legal investigations.

Katherine Scafide

Dr. Katherine Scafide is an assistant professor at the George Mason University's College of Health and Human Services, where she conducts research and mentors doctoral studies. As a forensic nurse, she worked as a pediatric and adult sexual assault nurse examiner for 8 years and was a death investigator for the State of Maryland's medical examiner's office (2005–2010). Dr. Scafide's prior research explored the use of colorimetry in examining the impact of skin color, fat, and sex on changes in bruise color over time. The results were published in leading forensic and medical journals. She is still known as the "paintball lady" for her unique method of creating bruises. Dr. Scafide has also developed and tested a metric for quantifying bruise visibility (Bruise Visibility Scale). Through existing engineering partnerships, she hopes to expand this work using machine learning of digital images. Dr. Scafide's current research interests involve addressing the disparity in the identification and documentation of injuries among victims of violence, particular those of color, using innovative technologies.

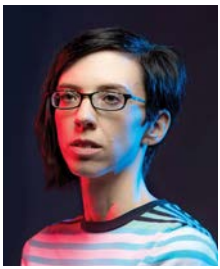
Daniel Sheridan

Dr. Daniel Sheridan is a professor at the Texas A&M University College of Nursing, where in 2015, he created its Forensic Nursing Education, Research and Intervention Program. Dr. Sheridan has been a forensic nurse since 1986 and is a former president of the International Association of Forensic Nurses. Dr. Sheridan has created two hospital emergency department–based family violence intervention programs: the first at Chicago's Rush Medical Center; the second at the Oregon Health Sciences University Hospital in Portland, Oregon. He has extensive clinical experience with patients experiencing intimate partner violence, adult sexual assault, strangulation, and the abuse/neglect of older and vulnerable persons. Dr. Sheridan has performed over 500 forensic sexual assault/intimate partner evidentiary exams, most at Baltimore's Mercy Medical Center Forensic Nurse Examiner Program. He used alternate light in his forensic clinical practice for many years. He created and coordinated for 12 years a forensic nursing graduate academic program at the Johns Hopkins School of Nursing and has chaired and co-chaired numerous violence/injury-related dissertations and thesis capstone projects. His research interests include use of alternate light to improve bruise assessments; identification of topical products that could give false positive results mimicking bruises; identification of women at risk of intimate partner homicide; primary prevention of violence with school-aged children; and increased identification of abuse/neglect of older and vulnerable persons.

Clark Smith

Mr. Clark Smith is currently a forensic scientist at the Denver Crime Laboratory. Previously, he was employed as an environment analytical chemist from 1990 to 2000. Areas of expertise include controlled substances identification, GSR, paint, tape, glass and explosives analysis.

Jacqueline Speir



Dr. Jacqueline Speir is an assistant professor at West Virginia University, currently conducting research in the areas of forensic pattern recognition. Jacqueline has an MS in forensic science from John Jay College of Criminal Justice and a PhD in imaging science from the Rochester Institute of Technology. She is a diplomate of the American Board of Criminalistics, an associate member of the criminalistics division of the American Academy of Forensic Sciences (AAFS), a member of the National Institute of Standards and Technology Organization of Scientific Area Committees Subcommittee on Footwear and Tire Tread, and secretary of the Footwear and Tire Tread Consensus Body of the AAFS Standards Board. Previous to her appointment at West Virginia University, she was involved with extensive microscopy-related teaching and course development for practitioners while at the McCrone Research Institute in Chicago, Illinois, including the education of many Weapons of Mass Destruction Civil Support Teams.

Michael Truver

Mr. Michael Truver is a doctoral student in the Department of Forensic Science at Sam Houston State University. His current research involves method development and validation on liquid chromatography/tandem mass spectrometry with a novel synthetic opioid in various biological matrices. He was previously employed by Harris County Institute of Forensic Sciences, where he was responsible for assisting in method development of their analytical methods.

Rebecca Wagner

Dr. Rebecca Wagner is employed by the Virginia Department of Forensic Science (VDFS) as a Research Analyst. Her duties include method development and validation, monitoring quality assurance/quality control, and technical training in the Toxicology, Controlled Substances, and Trace Evidence Section's. She has played a pivotal role in the approach Virginia has taken in the estimation of uncertainty for measurements in toxicology and controlled substances. She is an affiliate member of the Organization of Scientific Area Committees and has co-chaired several workshops on uncertainty of measurement and method development for both regional and national forums. She is a member of the Society of Forensic Toxicology and routinely presents her research at the annual meeting. She received her PhD in analytical chemistry from Duquesne University in Pittsburgh, Pennsylvania. She has been with VDFS since February of 2012.

Jorn Yu

Dr. Jorn Yu is a forensic scientist with 8 years of practical experience in crime scene investigation. He is currently a professor with the Department of Forensic Science at Sam Houston State University. Dr. Yu earned his PhD in chemistry from Carleton University in Ottawa, Canada. Dr. Yu is certified in comprehensive criminalistics (Diplomat-ABC) with the American Board of Criminalistics. He is a fellow with the American Academy of Forensic Sciences. Dr. Yu's research interest is in the areas of chemical analysis of trace evidence and the development of chemical intelligence for crime scene investigation. The ultimate goal in his research laboratory is to develop artificial intelligence for forensics from chemical analysis of physical evidence.

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