Forensic Technology
CENTER OF EXCELLENCE
A program of the National Institute of Justice

IN- BRIEF

Bloodstain Pattern Analysis on Textiles: A Technology Transition Workshop

"This was an absolutely excellent workshop. It provided training that has long been neglected or ignored, making one even more aware of the potential for drawing incorrect conclusions."

–Workshop Attendee

Overview

The Forensic Technology Center of Excellence (FTCoE) hosted a Bloodstain Pattern Analysis (BPA) on Textiles Technology Transition Workshop on October 11–13, 2017. This workshop was hosted in conjunction with North Carolina State University (NCSU) and instructed by Dr. Stephen Michielsen, an expert in the field of textiles. Dr. Michielsen's current research involves BPA on textiles and the surface modification of fibers for a wide range of applications, including medical textiles, antimicrobial textiles, and enzyme-immobilized textiles.

The three-day workshop provided 28 attendees with hands-on laboratory experiments involving sheep's blood on various textiles. The purpose of these laboratory experiments was to demonstrate how the principles of traditional BPA differ from BPA on textiles. For example, attendees learned that substrate differences can produce variable results and ultimately influence the conclusions drawn about a bloodshed event.

Over the course of the workshop, attendees were exposed to a combination of lecture and laboratory components because BPA is a skill learned best through hands-on experience.

Objectives

- Educate forensic science practitioners on bloodstain pattern analysis on textiles.
- Demonstrate how fabric manufacturing and structure affect bloodstains and bloodstain patterns.
- Provide attendees with an understanding of the textile manufacturing process.
- Simulate a bloodshed experience to better understand blood-textile interactions.
- Demonstrate the transfer of blood between textile substrates and other surfaces.
- Communicate how blood-textile interactions can affect interpretation and conclusions.

Background

Forensic Technology Center of Excellence

The FTCoE, led by RTI International, is supported through a cooperative agreement with the National Institute of Justice (NIJ), award number 2016-MU-BX-K110. The FTCoE supports the implementation of new forensic technology and best practices by end users, bridging the gap between the scientific and criminal justice communities. One way the FTCoE moves knowledge from research to impact is through hosting technology transition workshops that provide forensic practitioners with access to recent academic findings and appropriate methodologies to use in both the laboratory and the field. In previous years, the NIJ awarded two grants to Dr. Michielsen to explore the fundamentals of bloodstain patterns on textiles (awards 2012-DN-BX-K052 and 2014-IJ-CX-K002). This workshop transitioned the lessons learned through Dr. Michielsen's research into practice.[1,2] The workshops hosted by the FTCoE also provide agencies with limited training budgets the opportunity to expand their knowledge and positively impact the community.

Dr. Michielsen explaining a topic in the laboratory. Photo credit: RTI staff.

Addressing a Need

Bloodstain pattern evidence is common at many crime scenes, warranting the need for guidance in the field. Many traditional BPA courses cover impact angles, interpretation, and reconstruction on flat surfaces, such as walls and tile floors. Often, however, traditional BPA courses do not adequately address the interpretation of bloodstains on complex surfaces, such as textiles.

Without understanding the complexities of interpreting bloodstains on textiles, an analyst could reach improper conclusions. It is important to note that all textiles do not interact with blood in the same way; in fact, blood-textile interactions differ based on the fiber type, manufacturing and finishing processes, and surfactants added post-production. Therefore, it is crucial that analysts be aware of the differences in textile types when examining bloodstain patterns to ensure that conclusions are not overstated.

This workshop aimed to transition knowledge from NIJ funded research in this area of BPA and provide agencies with resources to consult when certain types of bloodstain patterns are encountered in the field.

Workshop Overview

There were three major components to this workshop: lectures, laboratory exercises, and tours of textile production facilities. The lecture portion of this workshop was kept short to maximize the amount of time spent in the laboratory recreating bloodshed events. Hands-on experiments are one of the most effective ways to learn how to interpret bloodstain patterns, as examiners can see how blood interacts with a substrate in real time. Ultimately, this experience allows an examiner to associate a pattern with a specific type of bloodshed event. Facility tours allowed attendees to better understand the textile manufacturing process. Learning about the manufacturing process facilitates better understanding of the factors that could influence blood-textile interactions encountered at a crime scene.

Laboratory Experiments

Laboratory topics included drip patterns, swipes, wipes, and interpretation considerations. Laboratory experiments demonstrated the material discussed in the lecture portion of the workshop. Attendees had the opportunity to learn about fabric structure and how to use microscopy to distinguish different characteristics, such as the warp and weft, which refer to the construction of the textile.

Day 1 | Drip Stains and Impact Spatter on Textiles

When found at a crime scene, drip stains and impact spatter patterns can provide an analyst with substantial information. Drip stains on a tile floor, for example, may indicate where a bloodied person or object has traveled, the direction that the person was traveling, and the approximate pace of the individual.[3] These patterns can prove useful during scene reconstruction, but it is important to keep in mind that the substrate on which the blood is found can impact

Assessing drip stains from a 90° angle onto different textile substrates. Photo credit: RTI staff.

interpretation. This experiment was designed to explore the effect of different textile substrates on the appearance of drip patterns.

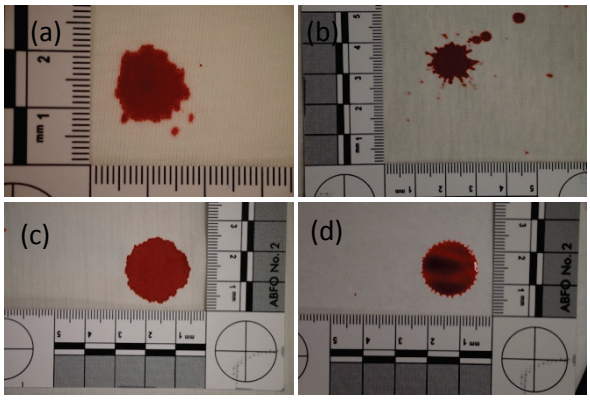


Fig. 1. Sheep's blood was dropped from a 90° angle onto different surfaces: (a) a knit textile on a pad to simulate a pillow; (b) a knit textile on tile; (c) a woven textile; and (d) paper on tile. Photo credit: Stacey Sneider.

Figure 1(d), for example, is an image of blood that was dropped at a 90° angle onto a hard, flat surface (paper on top of a tile floor). A stain that is almost perfectly round is the expected outcome when dropping blood from a 90° angle. However, when blood was dropped from the same height and angle onto different textiles and underlying surfaces, as pictured in Figures 1(a)-(c), the same result was not replicated because of the differing blood-textile interactions. Both the type of textile and the surface underneath the textile are very important factors affecting the shape of the resulting bloodstain.

On the first day of the workshop, attendees also explored impact spatter on textiles. Impact spatter is a pattern "resulting from some application of force to a blood source."[3] Ultimately, impact spatter patterns can indicate the type of force that was applied and the locations of the suspect and the victim at the time of the incident.

Attendees preparing to simulate an impact spatter event. Photo credit: RTI staff.

During the controlled impact spatter experiments, several factors were held constant, such as impact force, direction, and distance, in order to simulate impact spatter events. Different textile types were mounted into an embroidery hoop, pulled taught, and hung inside of a laboratory glove-box chamber. Lasers were used to indicate the target area where blood would impact the substrate. This experiment demonstrated that spatter may be more difficult to locate on certain types of textiles than on other surfaces, such as smooth walls and floors. Additionally, textiles may cause interpretation challenges depending on the wicking nature of the textiles; that is, it may be more challenging to determine the directionality of small impact spatter stains. Figure 2 depicts an example of the resulting impact spatter.

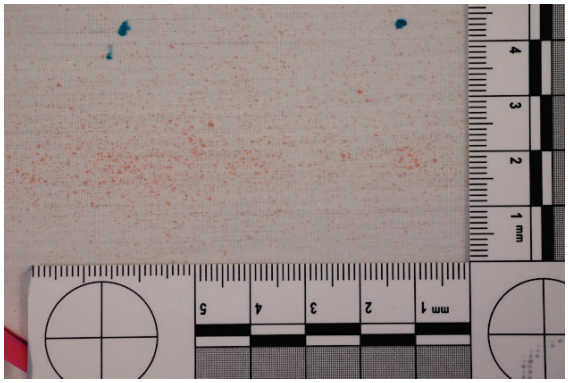
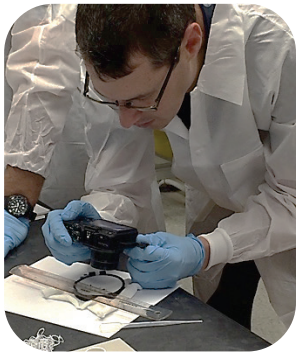


Fig. 2. Example of a controlled impact spatter event on a woven textile. Photo credit: Stacey Sneider.

Day 2 | Yarn Laboratory Experiments, Transfers, Wipes, and Swipes

On the second day, attendees explored blood interactions with yarn. The wetting and wicking properties of a single strand of yarn were explored using blood, water, and oil. Oil was used to simulate body oils, which could potentially impact how blood interacts with the clothing of a victim or suspect. An analyst should take the wetting and wicking properties of a yarn or textile into account before reconstructing an event because these properties can differ among yarn types. For example, attendees noticed that blood was dispersed faster and more evenly on certain yarn types than others (Figure 3(a)).



Attendee photographs a textile after an experiment. Photo credit: RTI staff.

Transfers, wipes, and swipes were also explored on the second day of the workshop. The transfer experiments demonstrated how textile composition can influence how much blood is transferable to or from a textile after a certain period of time. This concept is especially important when evaluating witness stories about the presence or absence of blood on their clothing.

The swipe transfer exercise demonstrated what is observed after a cloth saturated with blood comes in contact with a non-porous substrate, such as a ceramic tile. Conversely, a wipe transfer was demonstrated by placing a drop of blood on a tile and moving a textile through the blood (Figure 3(b)). These two exercises produced noticeably different patterns on the textile and tile; knowledge about the differences between these types of patterns could prove useful when found at a crime scene.

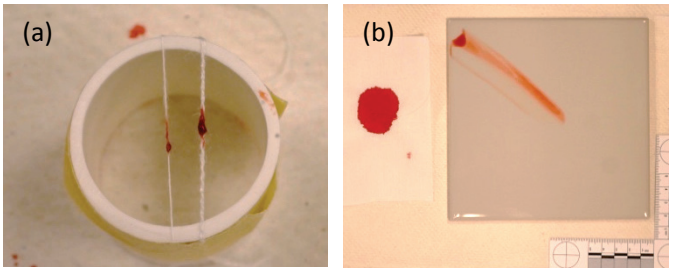


Fig. 3. (a) Wetting and wicking experiment: spun polyester (left) and nylon (right); (b) fabric wiped through blood on tile. Photo credit: Stacey Sneider.

Day 3 | Simple Textile Tests

On the last day of the workshop, attendees explored blood interactions with multiple types of textiles, including denim, lace, and carpet. These experiments demonstrated that the manufacturing process of textiles plays a role in how they interact with blood. The yarn type and the dyeing, finishing, and printing processes can all influence how blood wicks into a fabric. Figure 4 demonstrates different bloodstain patterns observed between various textile types exposed to impact spatter.

It should also be noted that small spatter stains may be very difficult to visualize on certain types of fabric, such as denim. A stereomicroscope or loupe magnifier enables better visualization of spatter stains.

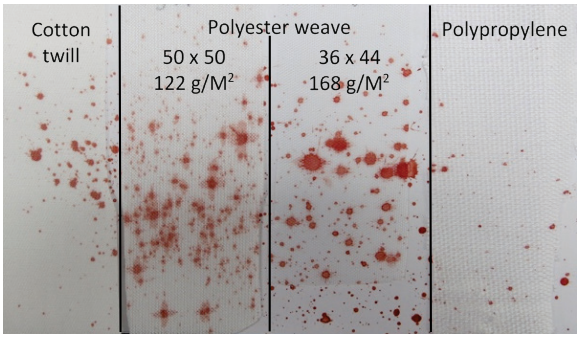


Fig. 4. Impact spatter observed on four different textile types. Note the difference in blood-textile interactions. Photo credit: Workshop attendee.

Facility Tours

The College of Textiles at NCSU houses state-of-the-art textile manufacturing facilities. Attendees toured six laboratories during the course of this workshop: the knitting, weaving, spinning, physical testing, dyeing and finishing, and printing laboratories. These tours provided insight into the complex production process of textiles and how this process could potentially impact a blood-textile interaction at a crime scene.

Fig. 5. (a) Jersey circular knitting machine in the knitting laboratory; (b) raw cotton in the spinning laboratory; and (c) a loom making denim in the weaving laboratory. Photo credit: RTI staff.

Take-Home Message

This course ultimately transitioned knowledge from previously funded NIJ grants (awards 2012-DN-BX-K052 and 2014-IJ-CX-K002) into the field. Attendees learned that the way blood interacts with different textiles varies and that traditional BPA techniques cannot always be applied when interpreting bloodstains on textiles. Additionally, attendees learned that textile manufacturing and finishing processes can impact the patterns observed.

During his lectures, Dr. Michielsen noted the importance of being "liberal on thought but conservative on interpretation." In other words, analysts should always take as many scenarios as possible into account but be careful when making conclusions. Bloodstain patterns found on textiles are not always straightforward to interpret; it is necessary to take a step back and consider the factors that can cause bloodstains to appear the way they do.

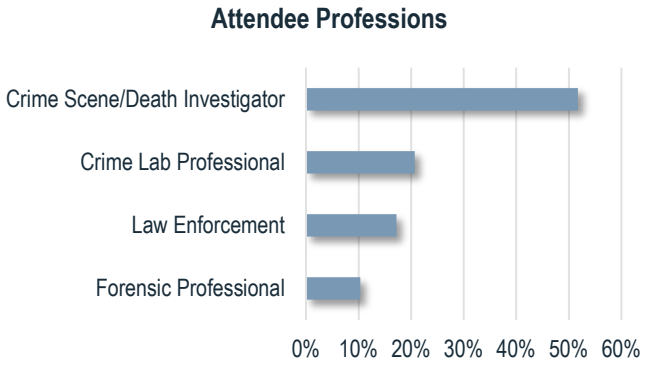
"The workshop allowed me to understand that an identification is not always possible. Sometimes it's ok to say 'I don't know.'"

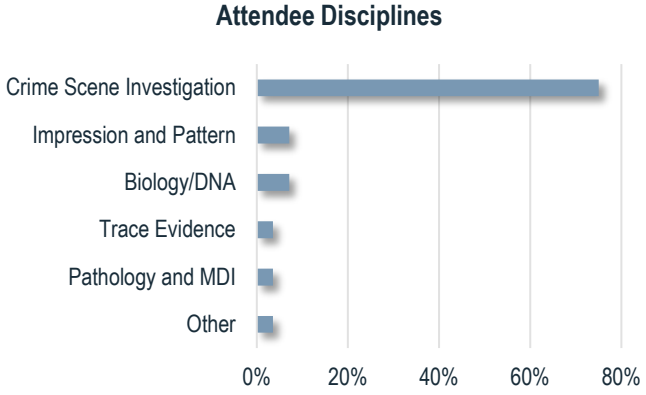
–Workshop Attendee

Attendee Overview

In total, 28 individuals attended this workshop. Of the 28 attendees, 26 are current forensic science practitioners, and 2 are retired police officers who currently teach BPA courses to practitioners. Attendees came from 15 states, and one attendee was international.

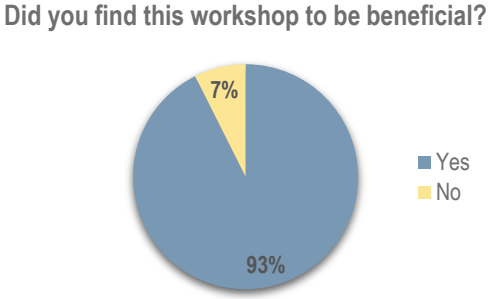
Group photo of workshop attendees. Photo credit: RTI staff.





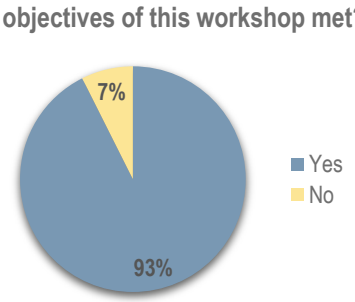
Impact

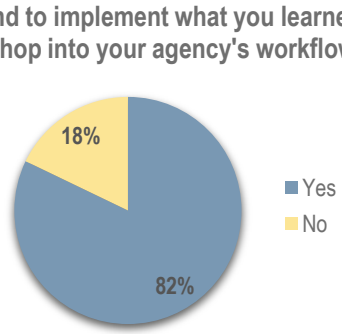
Attendees were asked the following questions after the workshop:



"The opportunity was one that turned out to be valuable. After attending the workshop, the practice was put into place two weeks later on a murder case."

–Workshop Attendee





"I plan on using the information that I learned to hopefully provide guidance for other analysts as they approach BPA on textiles in the lab and in the field."

–Workshop Attendee

Resources

[1] Michielsen, S., Taylor, M., Parekh, N., Ji, F. (2015). *Bloodstain Pattern on Textile Surfaces: A Fundamental Analysis*. National Institute of Justice, Award 2012-DN-BX-K052. https://www.ncjrs.gov/pdffiles1/nij/grants/248671.pdf

[2] Li, X., Li, J., Michielsen, S. (2017). Effect of yarn structure on wicking and its impact on bloodstain pattern analysis (BPA) on woven cotton fabrics. In Forensic Science International, Volume 276, 2017, Pages 41-50. http://www.sciencedirect.com/science/article/pii/S0379073817301482

[3] Bevel, T., & Gardner, R. (2008). *Bloodstain pattern analysis with an introduction to crime scene reconstruction*. CRC Press: Boca Raton, FL.

Image Credits

Page 1 - Image of attendees completing a workshop exercise: RTI staff.

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