

Journal of Bloodstain Pattern Analysis



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jscozz@hotmail.com

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cgonzalez61.cg@gmail.com

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Historian

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jamesforen@aol.com

President's Message

On behalf of the IABPA officers, I'm happy to write a welcome message for this December 2016 issue of our Journal of Bloodstain Pattern Analysis.

I am pleased to report that 2016 was a busy and productive year. The annual training conference was unique and well attended. During the business meeting our committee chairs and officers provided updates on their assignments. The 2016 officers completed the revision of our bylaws and after voting by full members during the business meeting, the bylaws were adopted and subsequently posted to our website. One of the bylaw revisions changed the process for election of officers. Voting now takes place through our website, www.iabpa.org. Our webmaster, Joe Slemko, reminds us that while the majority of members have created an account to access the members only section, we are not yet 100%. If you haven't created an account, follow the link below to apply. While you're there, please have a look at your bylaws, also linked below.

<http://www.iabpa.org/website-registration-form>
<http://www.iabpa.org/uploads/files/Bylaws/IABPA%202016%20Bylaws.pdf>

Vice President Rich Tewes (Mountain Region), former IABPA President Tom "Grif" Griffin and newly nominated Vice President Brittany Nelson hosted the annual training conference this year in Salt Lake City, Utah. We commend them for their work in organizing perhaps the most "hands on" conference in memory. We didn't see them often during general session as they were quite busy behind the scenes; managing the workshop areas, building and tweaking the "blood room" and handling the logistics and administrative issues that go with conference hosting.

2017 will bring two opportunities for members and colleagues to meet and train at conferences. The 6th European conference will be held June 21-23 in Jachranka, Poland and the annual training conference will be held this fall in Redondo Beach, California. Limited information is available now on our website and more information will be added soon.

Lastly, I call on any members with skill and interest in publication editing. Stuart James, will be looking to pass the baton after many years as Editor our Journal of Bloodstain Pattern Analysis. A challenge indeed! If you have interest, please contact Mr. James or your region's Vice President.

I am grateful to the IABPA officers, committee members, conference speakers and attendees for making 2016 very successful for the association. Happy holidays and best wishes for 2017!

Regards,

Jeff Scozzafava
President



The 2014/15 Daniel Rahn Memorial Research Grant Project

The Effects of Dyes on the Near-Infrared Detection of Bloodstains on Dyed Apparel Fabrics

Tess Mercer¹, S. Mac A. Fergusson², Rajiv Padhye² and Edmund ‘Ted’ Silenieks³

Introduction

Forensic science encompasses an ever-expanding, powerful group of disciplines many of which can aid crime scene reconstruction and are constantly refining their methodologies. Bloodstain Pattern Analysis (BPA) in particular, provides a wealth of information that can deliver diverse insights into the events of a crime. BPA relies on known, reproducible characteristics of bloodstains to interpret and define mechanisms that created bloodstains left at a crime scene or found on the clothing worn by people involved in a bloodletting event [1].

Locating and interpreting bloodstain evidence on dyed apparel fabrics can be deceptive and laborious, with dark and/or patterned apparel fabrics being particularly unaccommodating when trying to visualise blood [2, 3]. Restricting the examination of clothing to the visual spectral region seen by the human eye will not always reveal the existing bloodstain evidence. Where bloodstain evidence is suspected but cannot be seen with the naked eye, the use of near-infrared (NIR) cameras has gained popularity as a screening tool as they are easy to use and non-destructive [4, 2].

NIR cameras rely on the different NIR absorption properties of haemoglobin in blood and the substrate the bloodstain is deposited on. The different absorption properties can increase the contrast between the bloodstain and a dark substrate, allowing for stain visualisation and analysis [5, 6]. Bloodstains absorb near infrared and appear dark coloured and substrates commonly reflect near infrared and appear pale coloured [5]. However, these cameras sometimes do not visualise the bloodstain evidence on certain dyed apparel fabrics [5]. The reason for the lack of visibility of a bloodstain on some dyed apparel fabrics is not known and is, so far, unexplained.

The reliability of NIR as a blood-screening tool for textiles, in particular apparel fabrics, lies in the molecular interaction of the NIR electromagnetic waves and the fabric substrate being screened [7]. The visual contrast created between fabrics viewed in the NIR region relies on the chemistry of a substrate and the differing vibrations of the electrons associated with the atoms within that substrate [8]. If the frequency generated by electrons of the atoms does not match the frequency of the irradiating light, the light waves will not be absorbed, but instead are reflected [7]. Fabrics that absorb NIR radiation do so with unique vibrations of NIR frequency and the NIR spectrum generated by each chemical element is unique. The NIR spectral graphs generated by different substrates will vary depending on the quantity and type of different elements present.

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1. 2014/15 Recipient of the IABPA Daniel Rahn Memorial Research Grant, and PhD candidate, Royal Melbourne Institute of Technology, Melbourne, Victoria, Australia.
 2. Royal Melbourne Institute of Technology, Melbourne, Victoria, Australia.
 3. Forensic Science SA, Adelaide, South Australia, Australia.

Fourier transform near infrared spectroscopy (FT-NIR) is a technique that can be used to generate a spectrum of the infrared absorption of a substrate; either a solid, liquid or gas. When an FT-NIR analysis is performed on the different forms of haemoglobin, the absorption of deoxyhaemoglobin is found to peak at 750nm to 760nm, oxyhaemoglobin peaks at around 800nm to 880nm and the methaemoglobin moves even further into the near-infrared region peaking at around 925nm (see Figure 1) [9].

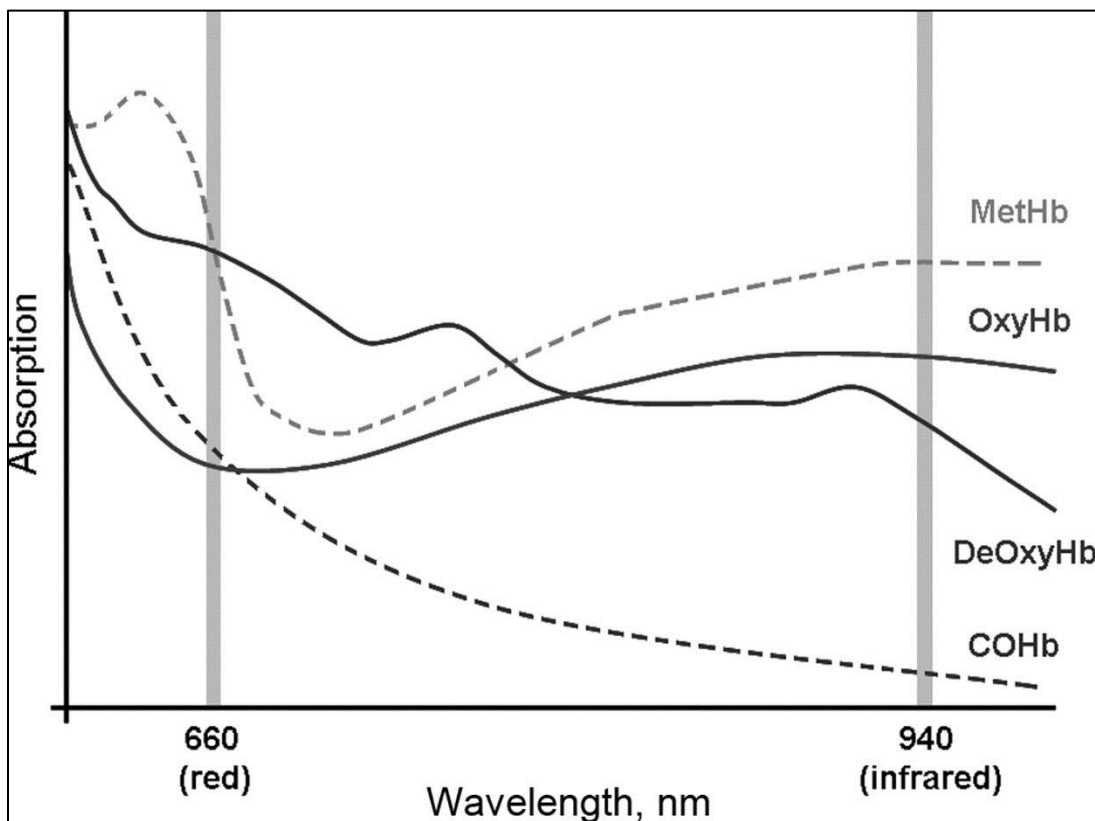


Figure 1. The FT-NIR spectrum for the common forms of haemoglobin [9]

If an object is irradiated with a halogen lamp, which emits light rich in NIR, the NIR energy will be transmitted within the atoms of that object, which have the same natural frequency as the NIR energy emitted from the halogen globe, and they will be sent into a vibrational motion. The near-infrared region experiences its most prominent vibrational motions from hydrogen – the lightest atom [7]. The quantity of hydrogen present in a chemical ultimately establishes the degree of NIR absorption, for example the haemoglobin in a bloodstain or the dyes used on apparel fabrics.

The NIR absorption of the different forms of haemoglobin is well documented [9, 10, 11, 12, 13, 14], but the factors that can inhibit the visualisation of a bloodstain on dark or patterned apparel fabrics in the near-infrared region are yet to be fully understood. There are many different dark coloured dyes used by the textile industry and it is the dyes that are the most widely suspected inhibitor for the visualisation of bloodstains on dark or patterned apparel fabrics.

Materials and Methods

Dyes tested

- Solophenyl Turquoise Blue (Copper Phthalocyanine, Direct dye)
- Diresul Bordeaux RDT-6R (Solulisable Sulphur dye)
- Diresul Green RDT-N (Solulisable Sulphur dye)
- Diresul Blue RDT-G (Solulisable Sulphur dye)
- Diresul Black RDT-LS (Solulisable Sulphur dye)
- Alizarine Blue OCR (Chrome dye)
- Neolan Black P (1:2 Metal Complex dye) – referred to as Neolan Black P throughout the text
- Acidol Brown M-BL (1:2 Metal Complex dye)
- Acidol Black MSRL (1:2 Metal Complex dye)

Textiles

Woven cotton, knitted Nylon 6,6 and woven wool raw fabrics were selected as suitable substrates as they are all compatible with the respective textile dyes (listed above) and are common in apparel fabric production.

Blood

Fresh, mechanically defibrinated porcine blood obtained from Australian Ethical Biologicals was utilised in the experiments. Human blood was ethically inaccessible for this work and porcine blood was verified by veterinary and medical scientists to be most similar to human blood. EDTA was not used as an anticoagulant in the blood as it chelates the metal ions in the haemoglobin, affecting the oxidation rate and therefore the results. It sequesters the metals, which may affect the appearance of the bloodstain in the near-infrared region.

A synthetic blood substitute was not opted for (as recommended in the American Society for Testing Material Test Method F1819-07) due to it being too dissimilar to human blood which is a complex non-Newtonian fluid. The synthetic blood substitute has a lower viscosity and surface tension than real blood [15] and will not accurately represent the near-infrared absorption spectra of haemoglobin.

Near-infrared light source

Two Osram Classic ECO 240V 46W halogen globes were used as the near-infrared radiation source.

Near-infrared camera

The DSLR Nikon D5200 camera was converted to allow NIR visualisation. To visualise bloodstains, the camera was used in the monochromatic mode in conjunction with a R72 near-infrared lens filter attachment.

Fabric Sample Preparation

The raw fabrics were cut to a minimum of 210mm x 300mm (approximately A4 size).

Dyeing

Each fabric sample was dyed in-house with a dye compatible to the fibre type in accordance with each dye manufacturer's pattern card instructions. Dyeing was carried out using an Ahiba Turbomat 1000 glycol laboratory dye machine.

Testing Methodology

Blood application

The porcine blood was warmed to between 37°C and 38°C to replicate human blood expulsion temperature. Bloodstains were created on each fabric sample using the following two mechanisms:

1. Drip stains were created by dropping single drops of blood from a height of 300mm using a pipette.
2. Transfer stains were created using a blood-soaked cotton swab in two consecutive swiping motions across the surface of each dyed fabric.

NIR Irradiation of bloodstains

Two halogen globed lamps were used at opposite oblique angles to eliminate shadowing on the fabric surface and to optimise near infrared radiation of the bloodstained fabrics.

Near-infrared photography at specific time intervals

A converted DSLR Nikon D5200 camera was used in conjunction with a R72 Infrared lens filter, which blocked light below 720nm, to photograph the bloodstained fabrics.

The camera was positioned perpendicular to the fabric surface and photographs were taken immediately after blood application, then after 15, 30, 45, 60, 90 minutes, and after 24 hours). This was to determine the effect of time and drying on the near-infrared detectability of bloodstain evidence.

Visibility Rating

A subjective scale (seen in Table 1) was developed to rate the visualisation of bloodstains on the differently dyed fabrics using the NIR camera as shown in Table 2.

Table 1. Visibility Rating

Rating	Description
0	Essentially no visible stain
1	Slight visible stain
2	Partially visible stain
3	Visible stain but with no intricate detail
4	Visible stain with some detail
5	Fully visible stain with complete detail

Results

Table 2. Visibility rating of drip and transfer bloodstains on the differently dyed tested fabrics

Dye	Fabric structure	Fibre content	Drip Stains		Transfer Stains	
			Immediately after deposition	24 hours after deposition	Immediately after deposition	24 hours after deposition
Solophenyl Turquoise Blue	Woven	Cotton	4	4	3	3
Diresul Bordeaux RDT-6R	Woven	Cotton	5	4	4	3
Diresul Green RDT-N	Woven	Cotton	5	3	4	1
Diresul Blue RDT-G	Woven	Cotton	3	1	2	1
Diresul Black RDT-LS	Woven	Cotton	4	1	3	0
Alizarene Blue OCR	Woven	Wool	1	0	0	0
Neolan Black P	Woven	Wool	5	5	1	1
	Knitted	Nylon 6,6	5	3	4	1
Acidol Brown M-BL	Knitted	Nylon 6,6	5	4	1	0
Acidol Black MSRL	Knitted	Nylon 6,6	4	2	1	0

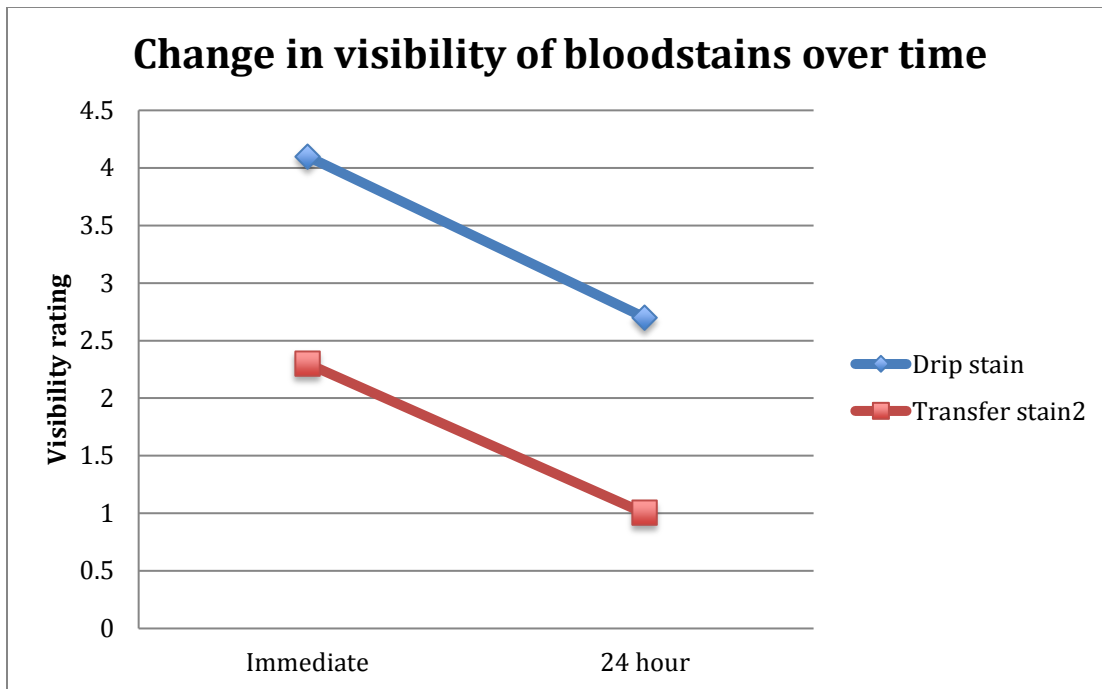


Figure 2. The graph demonstrates the reduction of NIR detectability of drip and transfer bloodstains over a 24-hour period

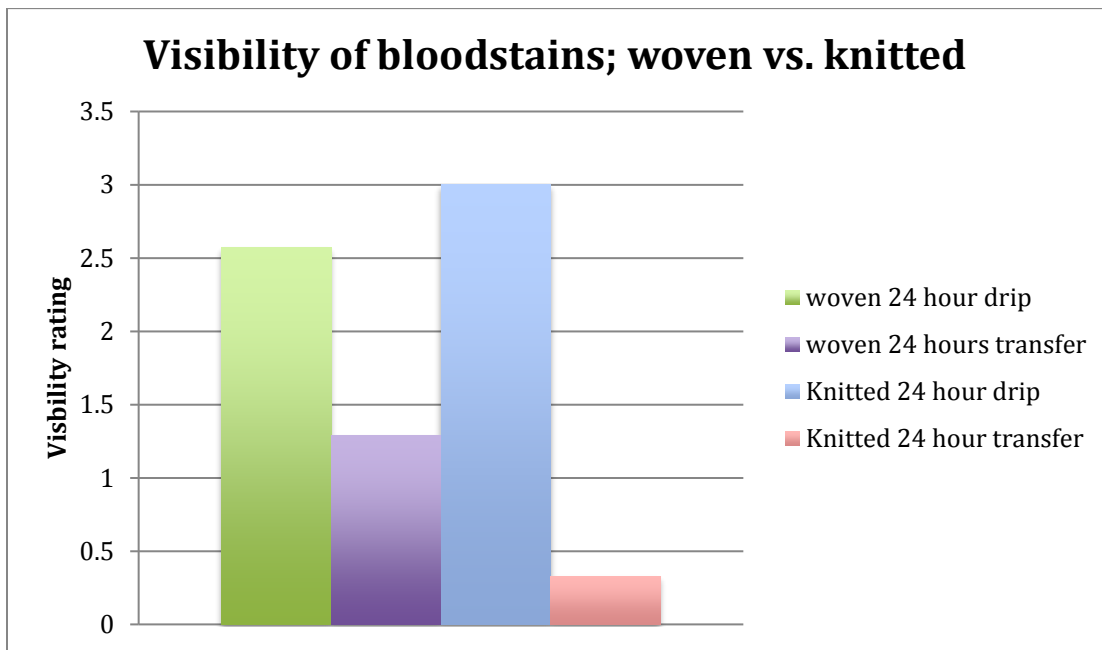


Figure 3. The graph demonstrates the difference in the NIR detectability of drip and transfer bloodstains on knitted and woven fabrics

Discussion

The reliability of interpreting bloodstain patterns is critical to bloodstain pattern analysis, particularly on apparel fabrics [16]. The bloodstain deposition mechanism is an important diagnostic feature and the results indicated a significant difference in the ability to visualise complete bloodstains deposited by different mechanisms when using NIR (Figure 3). Overall, the passive drip stains had a much higher degree of visibility using NIR compared with the transfer bloodstains. On average, drip stains were 48.5% more visible than the transfer bloodstains. This is likely due to the drip stain mechanism causing the blood to penetrate and completely cover the fabric yarns [17] resulting in lower surface interference and a larger ratio of stained fabric to unstained fabric, compared with the transfer bloodstains. The swipe transfer mechanism used did not fully cover and penetrate all fabric yarns with blood, which resulted in a lower ratio of stained fabric to unstained fabric (see Figures 4 and 5). The unstained, exposed yarns were able to reflect NIR and the NIR absorbance of the bloodstained yarns was partially hidden or quenched by adjacent exposed, reflecting fabric yarns and fibres.

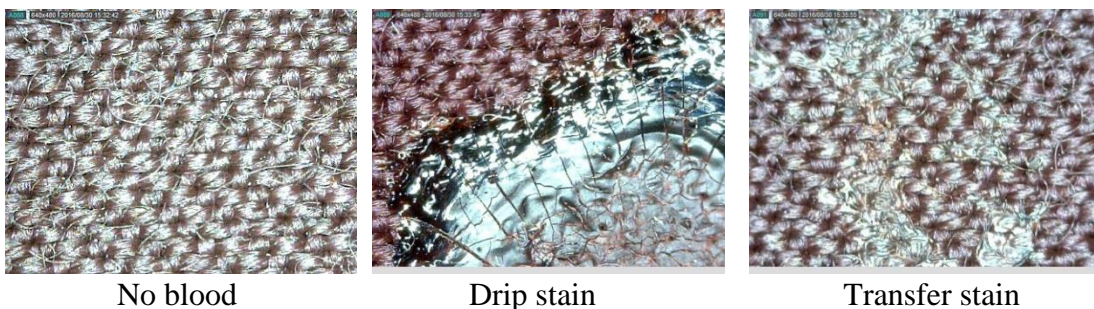


Figure 4. Woven wool fabric dyed with Neolan Black P

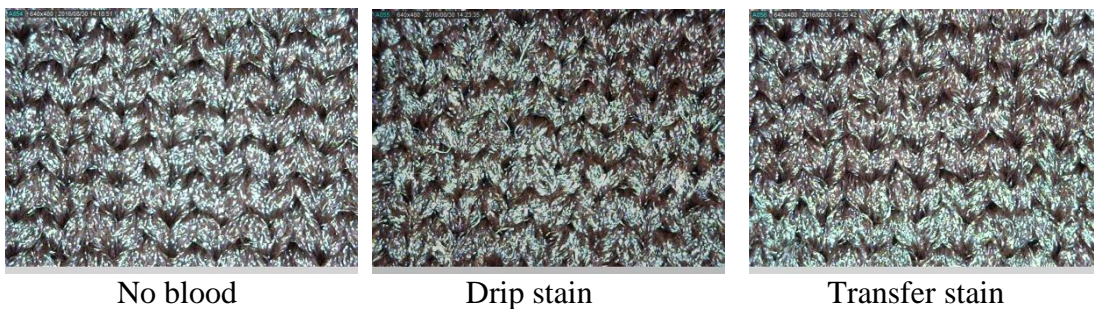


Figure 5. Knitted Nylon 6,6 fabric dyed with Neolan Black P

As all bloodstains dried over the 24-hour period, generally they became less visible under NIR (Figure 2). For the drip stains, the average decrease in visibility after 24 hours was 34.2%, and for the transfer bloodstains the average decrease in bloodstain visibility was 56.5%. 15% of all bloodstains deposited were rated as 5, being fully visible with complete detail. 15% of all bloodstains were rated at 0, considered to be essentially not visible. 55% had a rating of 3 or 4, being visible with intricate or at least some detail and 45% were rated 1 or 2, indicating they were only partially visible or less.

In the case of the Neolan Black P dye on Nylon 6,6 fabric, bloodstains became significantly harder to visualise as time passed. When the chemical structure of the heme molecule within haemoglobin and the structure of this dye are compared, we can draw some similarities (see Figure 6) [18]. It can be seen that the Neolan Black P dye molecule is comprised of functional groups containing hydrogen, double bonds and oxygen atoms, all of which strongly absorb NIR radiation.

From this information, we can hypothesise that the dye should absorb strongly in NIR region and therefore a fabric dyed with Neolan Black P should appear dark when visualising it using the NIR camera, offering potentially little contrast between that fabric and any blood deposited on it. This similarity between the heme and dye structure indicates they should both absorb similar amounts of NIR radiation.

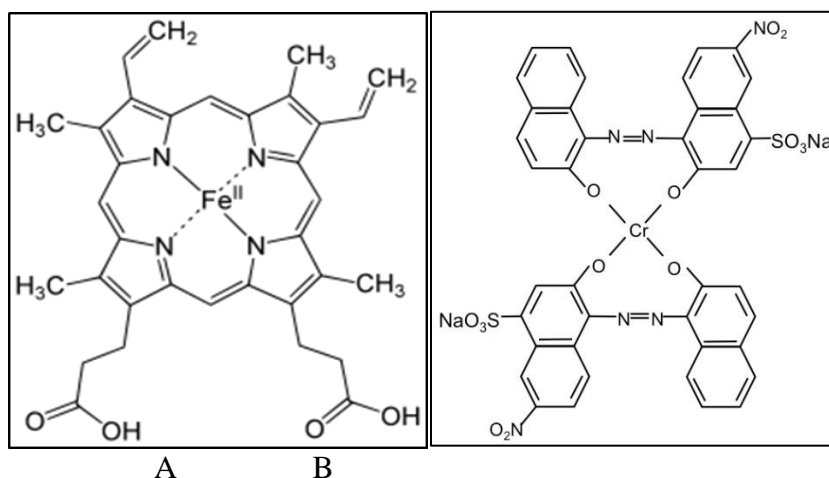


Figure 6. The chemical structures of the Heme group (seen in A) and of Neolan Black P (seen in B)

Figures 7 to 9 demonstrate how the bloodstains deposited on the Neolan Black P dyed Nylon 6,6 fabric became significantly less visible under near-infrared as the blood oxidised, producing results that supported the hypothesis that the dyestuff causes interruption to blood visibility in the NIR region. However, when the Neolan Black P was used to dye woven wool fabric, opposing results were produced. The drip stains on the wool remained consistently dark after the 24-hour oxidation period and the transfer stains became only marginally lighter. This contradicted the hypothesis that it is the dyestuff causing the interruption in BPA on dyed apparel fabrics.



Figure 7. Sample under white light

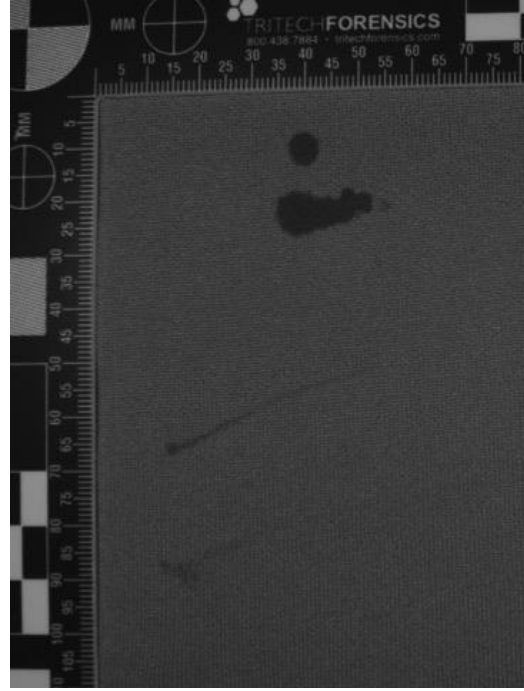


Figure 8. Sample under NIR immediately after blood deposition

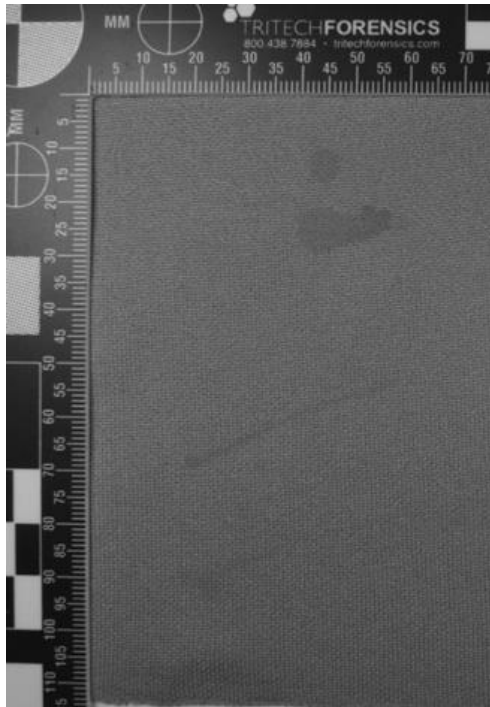


Figure 9. Sample under NIR 24 hours after blood deposition

When the FT-NIR spectra of the Neolan Black P dye on wool and on Nylon 6,6 are compared, similarities over the 750-1000nm wavelength range are observed (see Figures 10 and 11). Nylon 6,6 has slightly greater absorption of near-infrared radiation, but they are almost identical over the two most important points for visualising blood in the near-infrared region (750nm for fresh blood and around 850-900nm for oxidised, or dried, blood). This indicates that it is not purely the dyestuff

absorption causing the difference or similarities in near-infrared absorbance of blood for these two fabrics. When the microscopic features of these two fabrics are examined an indication into why they appear to contradict one another in the way they absorb NIR is observed.

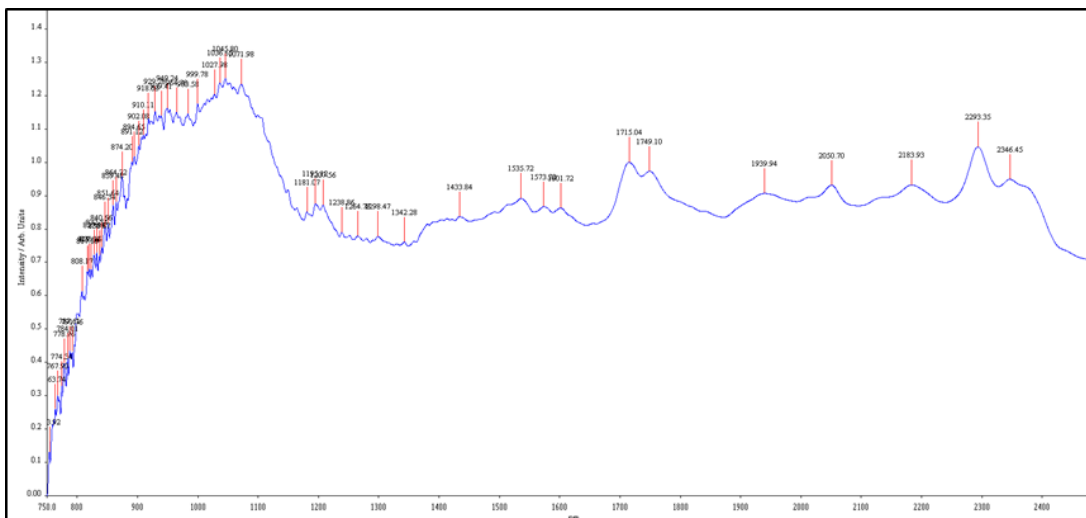


Figure 10. The FT-NIR graph of Nylon 6,6 fabric dyed with Neolan Black P

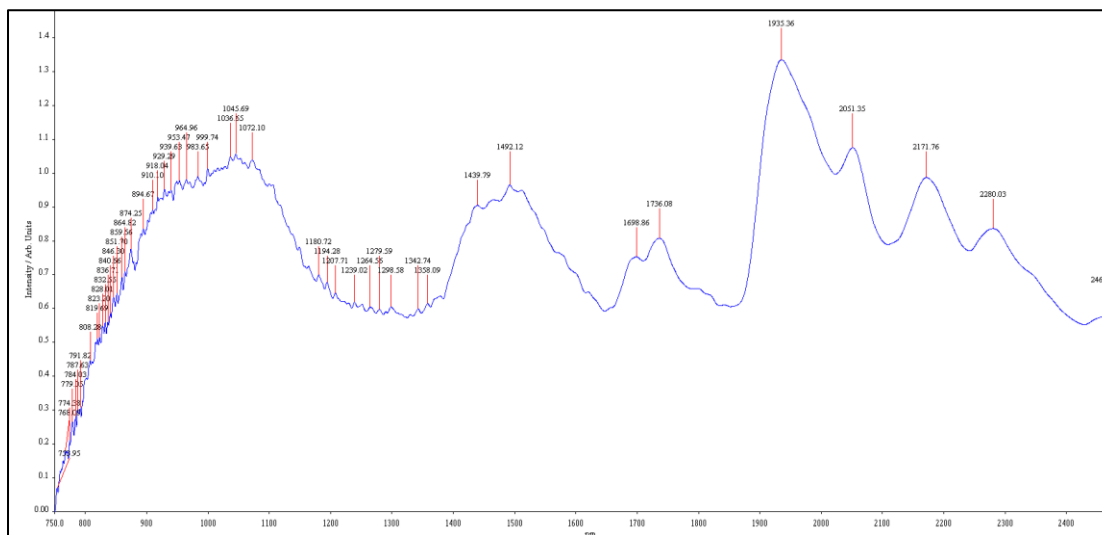


Figure 11. FT-NIR graph of wool fabric dyed with Neolan Black P

Nylon 6,6 yarns are composed of long, synthetic filament fibres and the fibres are contained within the yarn structure, resulting in a relatively smooth fabric surface. These smooth, non-absorbent filament fibres offer little resistance to blood and promote it to spread or wick through the fabric, resulting in light coating of blood over the yarns rather than the blood pooling on the surface of the fabric. Wool yarns are made of short, staple fibres, with fibre ends protruding from the yarns, resulting in a rough or coarse fabric surface. The staple fibres and resultant rough fabric surface of the wool fabric samples offer some resistance to the spread of blood. Wool also has a hydrophobic exterior which prevents liquid absorption into the fibres, so the comparatively high friction of the fabric surface, the hydrophobicity of both wool and the drying blood appear to have significantly limited the spread of the liquid blood, resulting in a concentrated bloodstain which strongly absorbed NIR. The difference in fibre structure and properties explains the disparity between the two different fabrics dyed with the same dye.

Conclusion

This research has thus far revealed that there are several factors that influence the visibility of a bloodstain on a fabric when using NIR cameras. Firstly, there is a clear correlation between the NIR absorption of blood and that of the substrate it has been deposited on. There is also evidence to support a link between the fibre type, fibre properties, the fabric construction and the amount of dried blood on the surface of fabrics available to absorb NIR and hence to be visualised using the NIR camera. Different fibre types and fabric structure leads to variation in the surface characteristics of fabrics resulting in different pore sizes (air pockets), contact points (protruding fibres), and wicking properties of the fabric [6]. This ultimately affects the ability of liquid blood to spread and form a bloodstain, the drying time and the oxidation rate of blood on different fabrics.

The degree of fuzziness, roughness, smoothness and wickability, etc. of a fabric will all influence how blood behaves, spreads and dries either on, in, or through a fabric [19]. This results in an inconstant ability to visualise bloodstains on certain fabrics in both the visible and near-infrared regions. Generally, the more “hairy” a yarn is (i.e. comprised of staple fibres) and the looser a fabric is woven or knitted, the harder it is for blood to wick along a yarn. The blood becomes entrapped in the fibre matrix comprising the fabric and appears to be more quickly oxidised due to the larger air spaces between the yarns of the constructed fabric.

The true underlying issues that inhibit the visualisation of a bloodstain using specialised NIR cameras is hard to define as the substratum found at crime scenes can vary immensely. Each item encountered will potentially have a chemical composition that could interfere with the optical and differential capabilities of a NIR camera. Even limiting this to apparel textiles, the potential variability is still vast.

In order to aid the current knowledge and improve the NIR blood-screening methodology on fabrics, further studies are warranted. These should specifically target the broad range of factors that affect the NIR detection of bloodstains on dyed apparel fabrics.

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Considerations for the Assessment of Bloodstains on Fabrics

Dr. Mark Reynolds¹ and Edmund Sileniaks²

When blood is shed during a violent crime against a person, the clothing of the victim(s), the perpetrator(s) and any nearby witnesses may become bloodstained. Whilst DNA profiling (source level evidence) of any bloodstains located on the clothing is now a routine and scientifically reliable procedure, determination(s) regarding the behaviour of those involved in the bloodshed event (activity level evidence) often relies, wholly or in part, on the correct evaluation and interpretation of the bloodstains and bloodstain patterns on the clothing item(s) examined. Often those bloodstains likely to give good source level evidence (saturation bloodstains etc.) are not the same as those capable of providing more probative activity level evidence (transfer, spatter etc.). Without an understanding of the mechanism(s) responsible for the deposition, thus an ability to correctly classify the bloodstains observed on the clothing, the activity evidence bloodstains can easily be overlooked, or not considered, during the analytical sampling process.

Whilst bloodstains and bloodstain patterns can potentially provide a retrospective window to the physical events that have occurred during a bloodshed event, the theoretical concepts that govern the evaluation and interpretation of bloodstains and bloodstain patterns on smooth, static non-porous surfaces found at crime scenes often cannot be used to underpin the assessment and interpretation of bloodstains deposited on fabrics. Currently little scientific research exists regarding some of the challenges encountered in this area of Bloodstain Pattern Analysis. Variables such as fabric construction, composition, history, treatment(s), moisture content, resultant vector influences and fabric surface curvature or folding can add additional levels of complexity to the reliable determination of the mechanism(s) responsible for the deposition of the bloodstains and bloodstain patterns observed. Obviously these variables and their effect permutations are many and all cannot be described here.

Holbrook (2010) observed spatter and transfer bloodstains on selected fabrics and found that certain fabric characteristics, such as composition and absorbency, appeared to influence the resultant shape of the bloodstains seen. de Castro *et al* (2013, 2016) found that factors such as pre-laundering, fibre content and fabric structure of apparel fabrics could influence the resultant shape of drip stains. In some circumstances, the influence of fabric variables can be dramatic. Figures 1 and 2 show drip stains on 100% synthetic polyester filament fibre (Figure 1) and 100% (treated) natural cotton staple fibre (Figure 2). Droplet volume and dropping height were the same in both instances. In Figure 1, the blood has preferentially diffused along the non-absorbent (i.e. **ad**sorbent) synthetic filament fibres, giving a stain appearance more akin to that of a transfer.

Of note for Figure 1, is that whilst initially having a typical "drip stain" appearance the adsorbent traits exhibited by the synthetic polyester fibres promoted preferential diffusion to occur very soon after deposition such that any stain shape alterations would be completed, long before any practical exhibit examination and bloodstain documentation could occur. Figure 2 however shows how the natural staple cotton fibres have **ab**sorbed the blood and inhibited the wicking of blood through the fabric, resulting in the bloodstain exhibiting a shape which more closely correlates to what might be expected given the deposition (drip) mechanism. In a general sense, research and training observations demonstrate that fabrics composed of natural staple fibres will more closely reflect the original size and shape of the bloodstains than fabrics composed of synthetic filament fibres.

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1. Forensic Science Consultant and Manager, Quality Assurance, Perth, West Australian Police
 2. Coordinator – Evidence Recovery, Forensic Science SA, Adelaide, South Australia

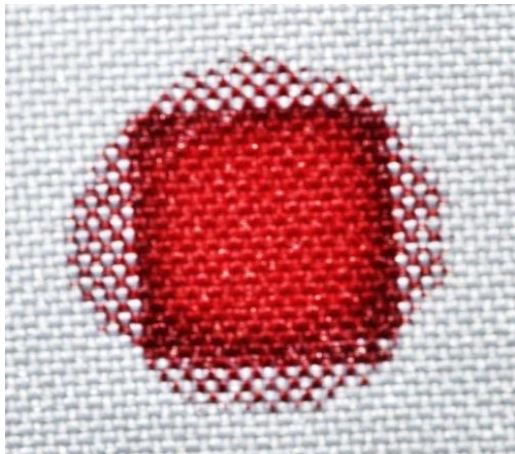


Figure 1. Drip stain on 100% woven polyester filament fibres



Figure 2. Drip stain on 100% knitted cotton fibres

Figures 3 and 4 show drip stains created side by side on a curved surface, mimicking for example a trouser leg. These figures demonstrate how two bloodstains deposited by the same mechanism and from the same height can exhibit vastly different shape even when they have been deposited side by side by similar sized droplets produced from the same height and angle. The shape difference is due to the degree of curvature of the receiving surface. It is the author's belief that in instances where clothing items are examined in two dimensions (i.e. laid flat on a laboratory examination bench, recording bloodstains on only a front and a back) it would be possible for erroneous interpretations regarding deposition mechanism and / or number of deposition events to occur.



Figures 3 and 4. Two drip stains, both deposited on a curved surface from 90°. Directionality features are vastly different, demonstrating the unreliability of assessing directionality on worn clothing.

In order to fully comprehend the phenomenon of preferential diffusion it is important to understand that whilst in simplistic terms it can be said that all fabrics will absorb blood, in a more technical sense the same cannot be said about all fibre types. Whilst natural fibres generally absorb blood, with a cross sectional view of the fibre showing blood has penetrated and been drawn in towards the fibre core (Figure 5), synthetic fibres do not. The interaction of blood with synthetic fibres involves a phenomenon known as adsorption. In a fibre context, adsorption is surface coating by a fluid, whereby the non-permeating nature of the synthetic fibre means that the blood will only coat the surface of the

fibre. A cross sectional view of the fibre would show the unstained, non-penetrated core surrounded by a ring-like coating of blood (Figure 6). It is this adsorption that allows the blood to preferentially diffuse via capillary action between the filament fibres and wick through and along the synthetic yarns resulting in an atypical stain shape when correlated to deposition mechanism.

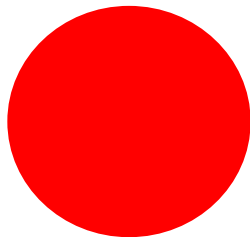


Figure 5. Absorption penetrates fibres.

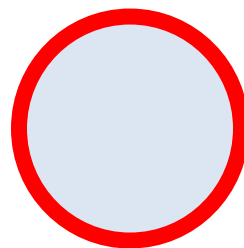


Figure 6. Adsorption coats fibres.

Subsequently the wicking rate and direction of blood flow through fabrics composed of synthetic fibres can be vastly different to that of fabrics composed of natural fibres. The wicking rate and direction of blood flow may differ yet again for composite fabrics composed of different fibres blended together (that is varying percentages of natural and synthetic fibres).

The changes to the geometric display of the bloodstains and bloodstain patterns due to the aforementioned variables can have significant practical consequences. As previously mentioned these bloodstain shape changes often begin immediately after blood deposition with major changes to stain shape occurring within minutes of blood deposition. Obviously, the assessment of bloodstains and bloodstain patterns rarely, if ever, occurs within the time frames just mentioned, thus the clothing examiner or bloodstain analyst is presented with a historic view of the bloodstain which can often bear little shape resemblance to that of the bloodstain immediately following deposition. Some examples of these changes include, but are not limited to, multiple pattern transfers blending into one unremarkable bloodstain (see Figures 7 and 8). Thus, the features of the pattern transfer source or pattern evidence can change shape and configuration to such an extent as to possibly render an exclusion of the contacting surface (Figures 9 and 10).



Figures 7 and 8. Demonstrates how a pattern transfer dramatically changes as the blood wicks through the fabric, from the initial deposition (Figure 7) to five minutes after deposition (Figure 8).



Figures 9 and 10. The transfer pattern (Figure 9) produced by the outsole (Figure 10) shows the shape of the stains is changing. The stains created by the raised round elements of the outsole are diffusing to form square shapes.

It is also important for the bloodstain pattern analyst assessing bloodstains and bloodstain patterns on fabrics to have some understanding of fabric construction as factors as simple as whether a garment is a weave or a knit can have bloodstain shape implications (Taupin and Cwiklik 2011). The basal unit for any fabric is the fibre which composes the yarn. Yarns are comprised of single or multiple fibre types and most commonly are either natural or synthetic in composition. To form the broad layer of a fabric the yarns are then either woven with a minimum of at least two yarns interlaced perpendicular relative to each other, or knitted with a minimum of at least a single yarn forming interlocking loops (see Figure 11). In a general sense, any garment that can stretch is a knit with weaves typically more robust than knits and exhibiting greater mechanical strength, thus less stretch.

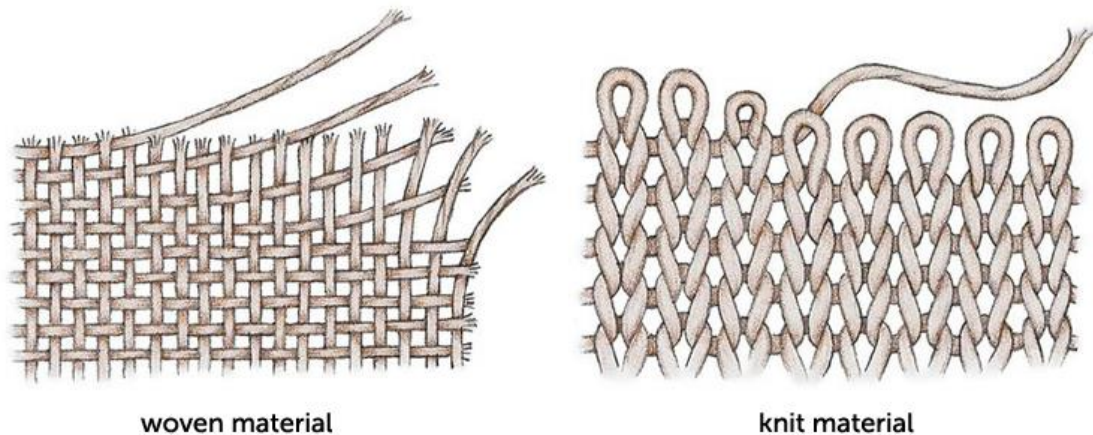


Figure 11. Woven and knitted fabric structures.
(Available at <http://www.onelittleminuteblog.com/knitsvs.wovens>. Accessed 16th November, 2016)

The footprint of synthetic fibre use in the clothing industry is increasing dramatically (The Fiber Year 2016). Unfortunately for the clothing examiner or bloodstain analyst, clothing manufactured from synthetic fibres, or high synthetic fibre blends, represent the most challenging clothing category with regards to bloodstain evaluation and interpretation. What is also becoming clearer is that whether knitted or woven, bloodstains deposited on clothing items manufactured from synthetic fibres, or high synthetic fibre blends, will almost certainly undergo some form of the aforementioned bloodstain shape change(s) following deposition.

Of additional concern regarding the assessment of bloodstains and their deposition mechanism(s) is the fact that under certain circumstances transferred bloodstains on fabrics can mimic impact spatter especially when the bloodstains are only viewed at the macroscopic level (see Figures 12 and 13). Figure 12 shows an impact spattered bloodstain (approximately 3.0mm in diameter) deposited on a 50% cotton / 50% polyester blend fabric. Figure 13 shows a transferred bloodstain (approximately 2.0mm in diameter) deposited on 100% polyester fabric. Note in Figure 12 that apparent air bubbles are present in the bloodstain. The presence of air bubbles within bloodstains can be misused as a key to diagnose an expired deposition mechanism. In this instance, however, the likely cause was air entrapment at the time of bloodstain formation due to the irregular receiving surface.



Figure 12. Impact spatter bloodstain deposited on 50%/cotton/polyester blend

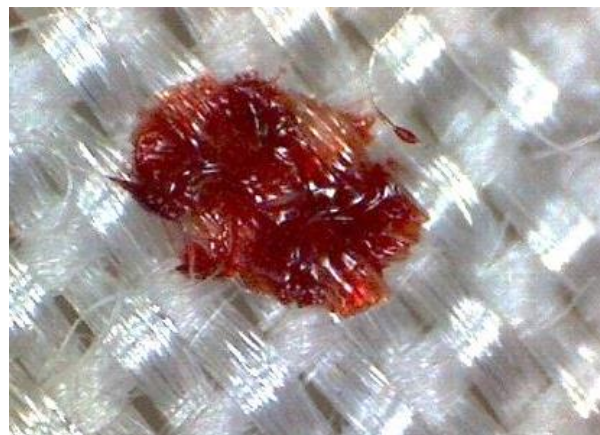


Figure 13. Transferred bloodstain deposited on 100% polyester blend looking like an impact spatter bloodstain

While Karger et al (1998) has initially described macroscopic differences between bloodstains caused by contact (transfer) and droplets (spatter) it is the authors experience that these described differences can be equivocal. Recent research (Yuen et al 2015) and training observations indicate however that apparent discernible differences may indicate separation criteria exist between small transfer and spatter bloodstains at the microscopic level (i.e. surface coating features of fibres and the presence of micro-satellite spatter adjacent to the parent stain). Further dedicated research is required to confirm if microscopic differences exist in all instances and what diagnostic value they have. It is the experience of the authors however that in some instances these potential microscopic separation criteria is not always seen.

Intuitively, when large numbers of spattered bloodstains are present on clothing the correct categorisation of deposition mechanism (spatter versus transfer) can often be made. However, when only small numbers of small bloodstains are present the appropriate classification of deposition mechanism becomes more problematic with a misidentification likely to have considerable implications within the judicial environment.

Subsequently, when assessing small numbers of small bloodstains on fabric, caution must be exercised in the use of macro features such as defined stain shape, penetration of blood into the fabric and / or a raised peripheral stain edge as diagnostic clues for the accurate determination of deposition mechanism.

It appears that in many laboratories little bloodstain pattern analysis training is provided to clothing examiners or bloodstain analysts, especially those responsible for activity level evidence sampling, with regards to the complexities and challenges involved in assessing bloodstains and bloodstain patterns on fabrics. In instances where no training is provided or where the training has a concentration on principles associated with smooth, static non-porous surfaces there is a very real potential for inappropriate sampling and / or interpretations to occur. In cases that result in multiple items of bloodstained clothing being examined or that involve more than one bloodstain contributor the results of inappropriate sampling or interpretations are likely compounded.

In a recent study by Taylor *et al* (2016), high error rates were observed when bloodstain analysts were asked to interpret bloodstains and bloodstain patterns on fabrics. As research and training in the area of assessing bloodstains and bloodstain patterns on fabrics progresses it is becoming evident that that increased recognition and consideration of the potential influence of the variables mentioned earlier on the size, shape and distribution of the bloodstains and bloodstain patterns observed must occur. Failure to understand and recognise the potential influence of these factors may lead to erroneous stain sampling, or worse, scientifically unsupportable or misleading interpretative conclusions.

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3D Bloodstain Pattern Analysis on Complex Surfaces using the FARO Focus Laser Scanner

Nathan Kwan^{a*}, Eugene Liscio^a and Tracy Rogers^b

ABSTRACT: The purpose of this research was to determine the accuracy of the FARO Focus3D laser scanner paired with the FARO Scene software in estimating the area of origin of bloodstain patterns on a complex surface. Ten bloodstain patterns were created using a custom-built bloodstain rig to estimate the area of origin (x= origin to surface, y=origin to right side of rig and z= origin to floor). The pattern was scanned using the FARO Focus3D laser scanner, photographs were taken using a Nikon D7000 camera and overlaid onto the 3D model to provide higher resolution. The scene was rendered and the area of origin calculated using the FARO Scene program. The mean difference between the calculated and true area of origin is 8.3cm in the x, 1.0cm for the y and 4.7cm for the z-direction. The SD for the x, y and z direction was $\pm 3.6\text{cm}$, $\pm 0.8\text{cm}$ and $\pm 3.0\text{cm}$ respectively. This technique greatly improved the accuracy of area of origin estimation from 22cm to less than 10 cm in all dimensions. A new acceptable accuracy range should be established for bloodstain pattern analysis because this method has proven to be much more accurate than traditional methods with an acceptable area of origin within 22cm.

KEY WORDS: forensic science, bloodstain pattern analysis, FARO Focus3D, FARO Scene, complex surfaces, area of origin, laser scanner

Introduction

Bloodstain pattern analysis (BPA) uses physical characteristics of bloodstains, such as the shape, size, angle of impact, and location in order to establish a conclusion about the bloodstain pattern's area of origin, i.e. where the injured person was sitting, standing, or laying on the scene when the injury occurred. This location is commonly known as the area of origin (1). The angle of impact can be calculated from a blood droplet using the Balthazard equation, which relates the angle to the arc sin of the width and length of the blood droplet (preferably an elliptical shaped blood droplet) (3).

$$\theta = \sin^{-1}\left(\frac{W}{L}\right)$$

The angle of impact is used to estimate the approximate path of the blood droplets and when several pathways are plotted, the point at which the majority of these trajectories converge is the estimated area of origin. Traditionally, strings are used to mark the pathway of the droplets to find the point of convergence. There are many disadvantages to this approach. Stringing is time consuming and tedious because it requires strings to be physically placed at the crime scene; a process that risks contaminating the crime scene (4). Virtual stringing methods are now being used to reduce the time needed to determine the area of origin, while maintaining the integrity of the scene. The virtual stringing method uses computer programs such as BackTrackTM and Hemospat to calculate the angle of impact and area of origin. Both programs along with FARO do not take into account gravity that is the main source of error in determining the area of origin. FARO scene program compounds the individual error of measuring individual droplets and estimates the path and area of convergence. Even though this does not eliminate the error due to gravity, accurate calculations of ellipse size and angle, direction and convergence could significantly increase the potential accuracy of estimating the area of origin. A study done by de Bruin and colleagues examined the accuracy of BackTrackTM and Hemospat by having bloodstain pattern analysts examine seven different bloodstain patterns. They concluded that the droplets selected for examination should be closer to the suspected area of origin in order to increase the accuracy of area of origin estimate. The droplets chosen should also be large and have a distinct elliptical shape (7).

^{a*} University of Toronto Mississauga, 3359 Mississauga Road, Mississauga, ON, L5L 1C6, Canada. Current Address: 144 Ferncliff Cres. SE, Calgary, AB, T2H 0V4, Canada, ^aAI2-3D, 352 Via Carmine Ave., Woodbridge, ON, L4H 2N8, Canada.
^b University of Toronto Mississauga, 3359 Mississauga Road, Mississauga, ON, L5L 1C6, Canada
Corresponding Author. Email: kwannathan@yahoo.ca

Both programs suffer from the fact that they require manual documentation of the blood droplets in order to determine the area of origin. The position of each individual blood droplet must be documented and photographed, which causes documentation time to increase. The FARO laser scanner has the advantage over these methods because it can analyze a cluster of blood droplets rather than individual droplets.

Both the stringing method and the virtual stringing method calculate the area of origin by approximating the blood droplet's flight path as a straight-line trajectory. In reality, the flight path of a blood droplet is parabolic due to the force of gravity and air resistance. This assumption causes an overestimation of the area of origin's height by 50% (6). It is recommended by the BPA community to present the maximum height for the calculated area of origin (6).

Only one BPA study has been completed on a complex surface. A complex surface is defined as one that is curved or irregular, is reflective, or offers some other complication for either manual stringing or laser imaging. The New South Wales Police Force determined that most of the trajectories tracked back and were above the original area of origin (8). One limitation with the study is that the laser scanner they used is not a portable piece of equipment and is more suitable for lab situations. The FARO Focus laser scanner however, is a portable and efficient device that can scan the entire crime scene, including the blood droplets needed for BPA. The purpose of this research was to determine the accuracy of the FARO Focus laser scanner paired with the FARO Scene software in determining the area of origin of bloodstain patterns on a complex surface. The method will be considered successful if the average estimated area of origin of the 10 trials are within the current acceptable range of 22cm. The FARO Focus laser scanner and the Faro Scene program have already been proven to be an accurate and reliable device in determining the area of origin on flat and angled surfaces (5,9), but have yet to be validated in determining the area of origin on complex surfaces. If the FARO Focus3D laser scanner and FARO Scene software are as effective in estimating the area of origin on curved surfaces as they are on flat and angled surfaces, the possible scenarios in which blood stain pattern analysis can be used will increase significantly, e.g. car interiors and exteriors, windows, etc. The time saved, the permanent record of the scene in three dimensions, maintaining scene integrity and reducing the potential for contamination, and the increased functionality of BPA analysis will make a significant contribution to crime scene investigation.

Materials and Methods

A similar method to that of Hakim and Liscio (5) and Lee and Liscio (9) was used in this research. A car door with its windows intact was tied to a metal frame, keeping the bottom of the door parallel to the floor. A car door was selected as the test complex surface because it provides a curved surface, which alters the ellipse of the bloodstain, and a glass surface, which is challenging to a laser scanner due to its reflective qualities. A custom-built bloodstain rig was placed on top of a coffee table 50cm away from the car door (Figure 1).



Figure 1. Car door with scanner and at the bottom of the picture is the bloodstain rig

Sheep's blood that contained 1% sodium fluoride as a preservative and potassium oxalate as an anti-coagulant was ordered from the Canadian Food Inspection Agency (CFIA) and stored in a refrigerator at 4°C until needed. The blood was taken out of the refrigerator and allowed to warm to room



Figure 2. Bloodstain rig in an open position ready to create a bloodstain pattern

temperature before use, because the colder the blood is, the more viscous it becomes (10). Viscosity affects how the blood travels in the air and how it spatters onto a surface. Allowing the blood to return to room temperature makes it closer to body temperature, without the additional problems of heating and maintaining the blood at exactly at 37°C. 2mL of blood was placed onto the checkered target of the bloodstain rig (Figure 2) using a syringe. The rig arm was pulled back so that the arm was roughly 12cm above the area of origin using a cable attached to the rig arm. When released, the arm dropped and the pin hit the blood on the target creating the blood spatter. A total of eleven impact patterns were created; 10 trials and one backup, in case there was a problem with one of the original 10., e.g. if some of the photographs were not clear enough, the backup trial could be used as a replacement.

Once the bloodstain pattern was created, it was examined for suitable bloodstain clusters. A minimum of three clusters was identified, usually one from the right, left and centre of the surface, in order to obtain a more accurate estimate of the area of origin. 6-8 target markers were placed among each of the clusters identified as a visual reference during the analysis. The bloodstain rig was left open and the entire scene was scanned using the FARO Focus laser scanner with ¼ resolution and 3x quality as its settings. Using ¼ resolution will allow it to be clear enough for analysis and using 3x quality will allow the scan to be completed quicker. The rig was left open because it would be easier to determine the difference between the calculated and true area of origin. When the scan was completed, photographs were taken on a Nikon D7000 DSLR camera.

The scans and photographs were uploaded onto a laptop and analyzed using the Faro Scene program. The photographs were aligned to the scan by overlaying the photographic image onto the point cloud. FARO scene assists with this process, providing assessments of the degree of agreement between the original photo and the 3D scan. The program restricts the potential placement of the photograph within a 1mm placement error. Once the photograph was aligned within the acceptable error range, a minimum of 8 bloodstains were selected from each cluster to create the trajectories. The user must define the ellipse of the bloodstain, but the software then calculates the angle, pathway, and trajectory

of each blood drop. It also combines the information from all stains to calculate the area of origin, as illustrated by the red spike in Figure 3. The distance for each of the three axes was determined using a measuring tool in the program.

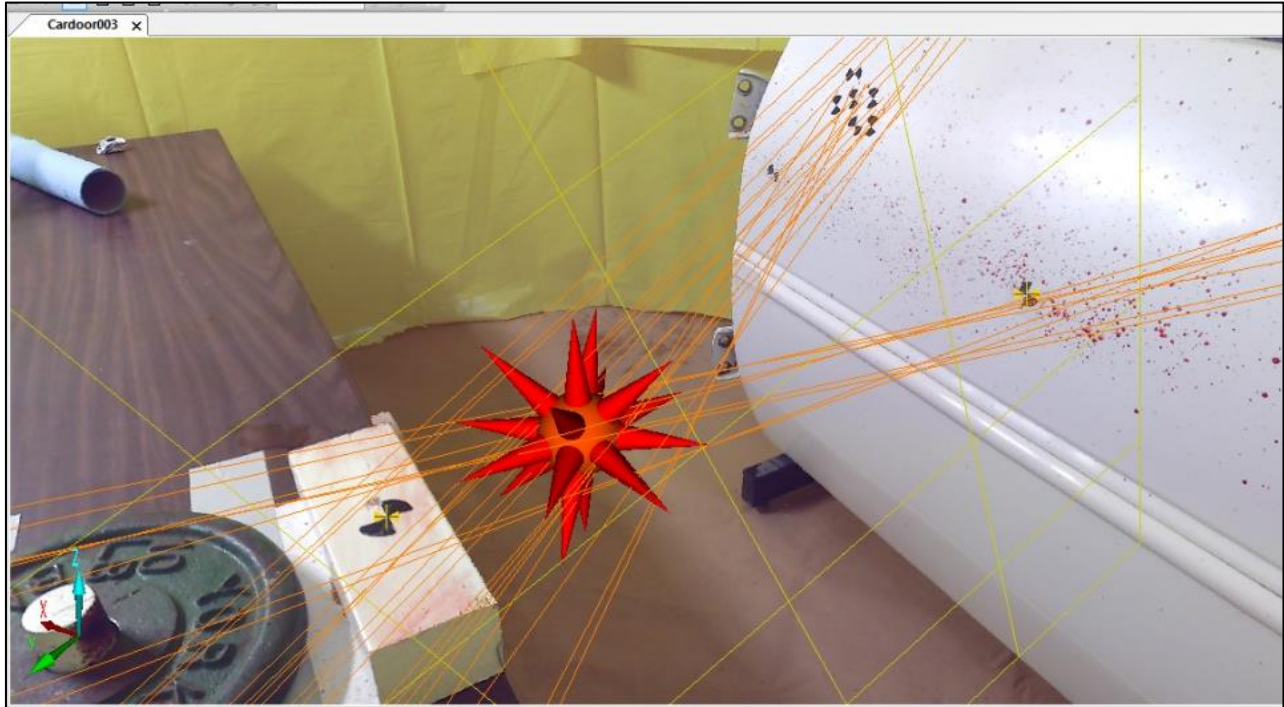


Figure 3. Calculated origin in the Faro Scene Program

Results

The difference between the true and calculated distances for the x, y and z direction for all ten trials are depicted in Table 1.

Table 1. Difference between the calculated and true area of origin

Trial	Axis	Difference (cm)
1	x	6.9
	y	0.1
	z	1.9
2	x	12.0
	y	0.7
	z	0.8
3	x	9.4
	y	0.3
	z	1.5
4	x	5.3
	y	1.2
	z	6.0
5	x	5.4
	y	2.0
	z	8.1
6	x	3.3
	y	1.3
	z	5.0
7	x	9.8
	y	0.4
	z	5.6
8	x	15.4
	y	0.3
	z	4.0
9	x	8.6
	y	2.3
	z	10.4
10	x	6.9
	y	1.3
	z	3.4

Table 2 shows the mean values of the x, y and z axis for all ten trials along with the standard deviation (SD).

Table 2. Summary of all the data collected

	Axis		Mean Difference (cm)	SD (cm)
n=10	x		8.3	±1.8
	y		1.0	±0.4
	z		4.7	±1.5

Discussion and Conclusions

The accuracy of the FARO Focus laser scanner paired with the FARO Scene software in estimating the area of origin of a bloodstain on a complex surface was determined. The acceptable level of accuracy for BPA varies in the literature, anywhere from the size of a tennis ball (6.54-6.86cm) up to 30.5cm given by Bevel (12). Hakim and Liscio (5) found the further the origin is away from the surface, the greater the error and therefore the larger the acceptable range of accuracy. A new range of acceptable accuracy should be implemented in all future BPA because the laser scanning method has proven to be much more accurate than the traditional methods.

The results of this research have shown the average difference between the calculated and true area of origin is 8.3cm in the x-direction, 1.0cm in the y-direction and 4.7cm in the z-direction. This is an unexpected result because the largest difference is the x-direction. Generally, the z-direction exhibits the largest difference because the estimated straight line trajectory does not take the effects of gravity into consideration. In this study, the rig was situated close to the car door (50cm) which means the true area of origin might not have been far enough away from the surface to allow for the gravitational force to have any significant effect on the blood droplets. Since gravitational force did not have major effects on the blood droplets, the flight path of the droplets would still be relatively linear, hence the z-direction is more accurate than the x-direction. Another possibility is that during the alignment of the photographs to the scan, the photographs were rotated slightly downward causing the trajectories of the x-dimension to move further away from the original x-dimension, thereby increasing the error. This rotation would also have been in a downward direction, causing the estimate to more accurately represent the true declining trajectory of the blood droplet due to gravity.

This is the first study in which the FARO Focus laser scanner has been used to determine area of origin on a complex surface. Previous research done by Hakim and Liscio (2015) and Lee and Liscio have used the FARO Focus laser scanner and the FARO Scene software to analyze bloodstain patterns on flat and angled surfaces (5,9). Comparing this study to the New South Wales Police Force results (8), all the trajectories were tracked back to and were above the true area of origin in both cases.

One limitation of this study is the degree of surface curvature. The greater the curvature, the more the bloodstain shape can become distorted, making it difficult to accurately document the bloodstain and calculate the area of origin. Rather than specifically addressing the degree of curvature at which the estimated area of origin can no longer be effectively estimated, this study opted to use a curved surface commonly associated with crime scenes, a car door. Having demonstrated that, in principle, it is possible to accurately estimate the area of origin of a bloodstain, the next step will be to determine the functional degree of curvature; the point after which is no longer possible to accurately estimate the area of origin. One limitation of both this test and BPA in general, is the size of the stains. The size of the droplets and resultant stains are extremely small with impact spatter events such as gunshot, making it difficult to initially document the stains and, in turn, to estimate the area of origin.

Future work could apply this technique to other complex surfaces that could be found in real cases, for example, a set of stairs, pillars, or arches. The functional point of curvature should also be determined, so that analysts could know at the outset whether or not BPA is worth pursuing on a given complex surface.

Acknowledgements

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Abstracts of Presentations Given at the 2016 IABPA Training Conference

Physical Evidence and Bloodstain Pattern Analysis in a Serial Killer Investigation

Stuart H. James

James and Associates Forensic Consultants, Inc.

Fort Lauderdale, Florida

During the span of the years 2001-2003 in Southern Louisiana, the bodies of six women were discovered in Baton Rouge and to the west towards Lafayette close to Interstate 10. A seventh victim survived an attack. Most of the victims were attacked in their homes with no sign of forced entry. This presentation will review the evidence that led to the arrest and conviction of the suspect, Derrick Todd Lee dubbed the I-10 Serial Killer. The important physical evidence included physical comparison of footwear impressions, cut telephone wire and DNA analysis. Bloodstain pattern analysis provided reconstruction at the multiple scenes.

Identification of Bloodstains Deposited on Military Garments Used in the German Air Force

Michael J. Schwerer^{1/2}, Oliver Peschel², Matthias Graw², Martin M. Schulz²

¹ *Air Force Centre of Aerospace Medicine, Fuerstenfeldbruck, Germany*

² *Institute of Forensic Medicine, Ludwig-Maximilians-University, Munich, Germany*

Background

The detection of small bloodstains deposited on dyed fabric surfaces is one of the most challenging tasks in the field of bloodstain pattern analysis. Especially blood depositions on military garments are often difficult to assess because of the cloth's surface colouration, which is applied for the purpose of reducing contrast.

Methods

Bloodstain deposition was precipitated in the laboratory using 0.1 mL of undiluted human blood from a volunteer. Drip patterns with differences in size and shape of the depositions, as well as small sized spatter patterns were created. The study material involved battle dress with camouflage print, as well as different kinds of flight suits and dress uniforms. The investigation was carried out both under daylight conditions and by employing forensic light sources in the near-infrared (NIR, ~ 800-1200 nm) and near-ultraviolet (NUV, ~ 415 nm) spectra.

Results

The camouflage print on battle dress obscured blood depositions under daylight conditions, especially in portions with dark colours. Investigation of these areas with NIR and NUV light photography successfully highlighted the blood depositions. Accordingly, blood stains on the dark blue coloured dress uniforms were often visible only when using the forensic light sources. In contrast, a decrease in visibility was noticed when using NIR and NUV light on flight suits, especially with small sized spatter patterns. In general, an increased recognisability of blood stains was observed in garments made of cotton compared to uniform parts consisting of synthetic material.

Conclusions

Reliable bloodstain pattern analysis on military garments requires the application of forensic light sources/equipment covering the NIR and NUV spectra of light. Further studies employing a larger sample of military garments are required to present validated guidelines on how to handle the challenge of bloodstain pattern analysis on these samples.

How to Tackle Contextual Bias? A Laboratory Based Project on Contextual Information Management

Gerco Kramer
The Netherlands forensic Institute (NFI)
The Hague, the Netherlands

In recent years, the importance of redesigning the work flow within the NFI around contextual information becomes bigger. In 2015 the lab based BPA team (Biological Trace Department) started a pilot to canalize the given information by the police. Investigators performing BPA on the lab were told to analyse the items without any knowledge of the case. In this presentation, we will discuss the pilot and the outcomes so far.

Between the Words - Understanding Beginnings of BPA in Poland

Kacper Choromanski
Forensic Scientist
Warsaw, Poland

What you see here on the wall? How can you name it? Why do you name this stain in this way? Are we talking about the same thing? These questions can be often heard in the court room, forensic class or conversation at the crime scene. Our main tool to work as a BPA expert is having clear and precise communication with other people. We need to have a common language. How does it look in Poland and why it so complicated? How you become an expert witness in Poland? What lessons can be learned about this situation by other countries? This presentation will give you necessary information to understand the long and hard process of developing BPA in Poland.

Can the Balthazard Equation Be Used for Single Bullet Impacts?

Eugene Liscio
Professional Engineer
Ontario, Canada

When dealing with single bullet impacts, especially in metal panels, calculating the angle of impact can be a difficult task depending the characteristics of the hole or defect. Recent research has shown that the Balthazard formula has some interesting effects when applied to impacts on metal panels. Errors appear to be accumulated at specific impact angles and with an understanding of the type of ammunition and surface being impacted, it may be possible to improve the angle of impact estimate.

Documenting Bloodstain Patterns Under Paint Using Forensic Photography Multi-Spectrum Techniques

Natasha Dilkie

The objectives of this study were to compare and analyze reflective ultraviolet photography, reflective infrared photography and fluorescent photography techniques in their potential ability to document bloodstain patterns which have been concealed underneath layers of house paint. The research provided an alternative method to enhance the photographs by use of High Dynamic Range (HDR) photography and HDR post-processing analysis through Photoshop CC. Four paint types were tested against three types of bloodstain patterns and a control of no blood for a total of 16 experimental samples. White acrylic paint and white latex paint displayed the most bloodstain information of the four paint types used in the experiment. Infrared photography did not yield positive results for any paint type while reflective ultraviolet and fluorescent photography depicted bloodstain patterns under the white acrylic and white latex paints, and minimal information from the black latex and maroon latex paints. Chemiluminescence testing with Luminol was performed on all 16 samples following the completion of all other photography documentation and yielded positive results. Additionally, the control samples containing no blood for both white acrylic and white latex also exhibited luminescence while black latex and maroon latex no blood controls did not. HDR processing resulted in similar photographs, compared to the originals, for infrared and reflective ultraviolet. HDR processing for fluorescence yielded positive results for all filters and bandwidths used.

In conjunction to the photography results, all of the paint types were tested using non-invasive chemical analysis. Raman testing and Attenuated Total Internal Reflectance- Fourier Transform Infrared Spectroscopy (ATR-FTIR) testing were used to analyze the chemical components of the paint and assist in characterizing the absorption profiles of the different paint types. Analysis suggests that optical brighteners present in both white acrylic and white latex are responsible for the false positive reaction to the Luminol testing. UV-VIS-NIR Spectroscopy was performed to determine the absorption and reflectance profiles of the paints. The results of this testing are consistent with the infrared photography evidence suggesting that both white acrylic and white latex have high reflectance while black latex and maroon latex contained high absorption properties. These chemical analysis results support the visual evidence present from photography analysis.

Blood Pools

*Nick Laan**, *Fiona Smith[‡]*, *Céline Nicloux**, *David Brutin[‡]*

**Institut de Recherche Criminelle de la Gendarmerie Nationale, Pontoise, France*

[‡]Aix-Marseille Université, Marseille, France

Often blood pools are found on crime scenes providing information concerning the events and sequence of events that took place on the scene. However, there is a lack of knowledge concerning the drying dynamics of blood pools. In our collaborative study, called D-Blood, we focus on the drying process of blood pools to determine what relevant information can be obtained for the forensic application. Foremost, we are investigating if it is possible to determine when the blood pool was created by means of the drying progression. This information can be very important to determine at what point in time the crime was committed. We recorded the drying process of blood pools with a camera and measured the weight. We found that the drying process can be separated into five different stages: coagulation, gelation, rim desiccation, centre desiccation, and final desiccation. Moreover, we show that the mass of the blood pools diminishes similarly and in a reproducible way for blood pools created under various conditions. In addition, we verify that the size of the blood pools is directly related to its volume and the wettability of the surface. Our study clearly shows that blood pools dry in a reproducible fashion. This preliminary work highlights the difficult task that represents blood

pool analysis in forensic investigations, and how internal and external parameters influence its dynamics. We conclude that understanding the drying process dynamics would be advancement in timeline reconstitution of events.

This study is part of a collaborative research, called D-Blood, between the IRCGN (Institute de Recherche de Criminelle de la Gendarmerie Nationale) and IUSTI (Institute Universitaire des Systèmes Thermiques Industriels) which is governed and funded by the ANR (Agence Nationale Recherche).

Blood Pools

Fiona Smith[‡], Nick Laan, Céline Nicloux*, David Brutin[‡]*

**Institut de Recherche Criminelle de la Gendarmerie Nationale, Pontoise, France*

‡Aix-Marseille Université, Marseille, France

Tracking down the origin of a blood pool, a blood droplet or a bloodstain present on a crime scene has become of major importance in bloodstain pattern analysis. The physics behind the drying dynamics of blood and the pattern formation are not yet well understood. In the frame of a collaboration, the D-BLOOD ANR project, work on this topic was realised in order to provide new evidence to investigators in crime solving. The aim of this work is to understand the dynamics of the complex fluid that is blood and the pattern of formation that it exhibits. We studied in parallel the drying dynamics of blood pools in order to then determine the time at which the pool started forming, and the pattern that drops of blood form after an impact initiated from a droplet dripping naturally. Indeed, the purpose of this second research topic is to be able to determine from where do drops, found on crime scene, originated from. Thus, finding this information about drops of blood dripping naturally from the wound would help knowing for example the position of the victim (e.g. standing or kneeling). To realise our experiments, we varied parameters such as substrate, external parameters, etc. Post drying analyses were then realized. By linking the results obtained in the post drying analysis with the different experimental parameters, we were able to highlight some interesting features that the blood exhibits. This study aims to then provide new investigation tools to forensic teams that are encountering such traces present on crime scenes.

This study is part of a collaborative research, called D-Blood, between the IRCGN (Institute de Recherche de Criminelle de la Gendarmerie Nationale) and IUSTI (Institute Universitaire des Systèmes Thermiques Industriels) which is governed and funded by the ANR (Agence Nationale Recherche).

Do Target Properties and Hematocrit Matter for Trajectory Reconstruction in Bloodstain Pattern Analysis?

Sungu Kim, Y. Ma, P. Agrawal

Department of Mechanical Engineering, Iowa State University, Ames, Iowa

Trajectory reconstruction from inspection of bloodstain patterns is relevant to crime scene investigation. While the influence of target properties on trajectory reconstruction has been often qualitatively discussed, it has rarely been quantified. Similarly, few impact studies measure the viscosity of the blood used in impact experiments. In this work, the impact of blood drops is characterized on targets of practical relevance, with a range of surface roughness and surface material. Uncertainties in the backward reconstruction of trajectories associated with using an impact correlation unspecific to the target of interest, are estimated analytically and numerically on the basis of experimental data. A similar analysis is done when the hematocrit of the blood is assumed rather than measured [1].

[1] S. Kim, Y. Ma, P. Agrawal, and D. Attinger, "How important is it to consider target properties and hematocrit in bloodstain pattern analysis?" *Forensic Science International*, vol. 266, pp. 178-184, 2016.

Bloodstain Pattern Education and Training: Remote Learning and Mentorship

Barr J¹, Taylor Dr. M.C.²

¹ *Institute of Environmental Science and Research Ltd (ESR), Auckland, NZ*

² *Institute of Environmental Science and Research Ltd (ESR), Christchurch, NZ*

The education and training of bloodstain pattern analysts to an advanced level is an ever-changing landscape, growing with the learnings of practicing analysts. Training is undertaken to different degrees and over varying time periods internationally, with consideration given to pre-training knowledge, casework experience, research, accreditation requirements and organisational procedures.

It is generally accepted that a mentorship program of an advanced level analyst will include the demonstration of fundamental BPA concepts as they pertain to crime scene reconstruction and item examination. For the majority of agencies undertaking BPA analysis, part of this mentorship program will involve trainees completing a practical course of 40 hours or more. The sporadic necessity for training and resourcing issues make in-house courses difficult, therefore a trainee may attend a reputable IABPA approved training course, if and when available.

The desire for education and training to be delivered from reliable sources, combined with an ambition of experts to share knowledge in an electronic world, has seen to the advancement of E-learning applications in various forms. This presentation will explore the pros and cons of completing an advanced level BPA course in an E-learning based environment, inviting discussion on the practical aspects of delivering education to those unable to attend in-person courses. The course was completed out of the BPA Resource and Learning Centre at the Institute of Environmental and Scientific Research, Christchurch, New Zealand.

UV/IR Digital Imaging

Julio Sosa

The results of bloodstain pattern analysis utilizing the new Fujifilm X-T1IR camera will be demonstrated. This camera has an unprecedented range of capture that extends at least up to 1180 nm in the IR range and down to 320 nm in the UV range utilizing a quartz lens.

Abstracts of Workshops Given at the 2016 IABPA Training Conference

Sequencing – Can it Be Done?

Holly Latham

Kansas Bureau of Investigation

Forensic Laboratory

Topeka, Kansas

Workshop attendees will be presented with targets of varying surfaces and given the opportunity to anonymously determine whether they can be sequenced with confidence. Following that a lecture will be presented discussing physical characteristics that may allow an analyst to sequence and the variables that have to be taken into consideration when contemplating sequencing. After being presented with and discussing the pertinent variables and characteristics involved with sequencing analysts will be provided the opportunity to revisit the targets.

3D Technologies for Bloodstain and Crime Scene Documentation

*Eugene Liscio
Professional Engineer
Ontario, Canada*

3D Technologies have proven their worth in documentation get and reconstructing crime and accident scenes. Bloodstains, bullet trajectories and even suspect height analysis photographs can be accomplished by incorporating crime scene photographs with laser scan data.

This workshop will allow participants to get some hands-on exposure analyzing a bloodstain pattern using FARO Scene's Forensic Extension as well as some first-hand experience with a laser scanner and hand scanner.

Properties of Blood for the Bloodstain Pattern Analyst

*T. Paulette Sutton
Forensic Consultant
Memphis, Tennessee*

*Stuart H. James
James and Associates Forensic Consultants, Inc.
Fort Lauderdale, Florida*

Bloodstain pattern analysts often talk about patterns only in terms of the physical stain characteristics at a crime scene without taking into account how the inherent properties of blood affect the residual pattern. This workshop is designed as a basic primer on the biological, chemical and physical properties of blood. It is specifically directed at the participant lacking formal training in the science of blood or the analyst new to the field of BPA but would be a good refresher course for all.

The second portion of this workshop examines the role of bloodstain patterns in death investigations. We will examine common injuries and discuss when external blood is produced or not produced. When external blood is produced, what will be the physical appearance of the blood and why in light of the biological, chemical and physical properties previously discussed?

Evidence Photography; Infrared and Ultraviolet

*Detective Jeff Scozzafava
Somerset County Prosecutor's Office
Somerville, New Jersey*

Commonly encountered evidence such as bloodstains, gunshot residue, latent prints and footwear impressions can be difficult to document with conventional photography when the evidence is obscured by colors or textures. By utilizing a conventional DSLR with ultraviolet lighting or a modified for infrared DSLR, evidence can often be documented with good contrast and at examination quality.

This workshop is designed for forensic photographers who have previous training and experience with a DSLR camera and understand basic aperture and exposure adjustments. Participants will receive a presentation regarding infrared and ultraviolet photography, then use DSLR cameras to photograph evidence items under infrared and ultraviolet lighting. Participants are welcome to bring cameras to document activities and a USB flash drive to archive their work.

Chemical Reagents for the Detection, Enhancement and Verification of Blood

*Richard Tewes
Forensic Scientist
Pioneer Forensics, LLC
Loveland, Colorado*

Chemical applications can visualize latent evidence, tell you what the evidence is, fix evidence that is fragile, bring clarity to evidence that needs to be examined or find evidence that otherwise would go unnoticed. Using one or more application in sequence can enhance the desired effect and minimize risk. Too often investigators are afraid of introducing chemicals into their crime scene when the proper usage will improve their results and minimize the time spent.

This workshop will focus on blood reagents; How to use, when to use, where and why are all topics covered. Students will use multiple reagents on commonly encounter bloodstained items in the course of the workshop.

Limitations Associated with Bloodstain Pattern Examinations on Fabrics

*Tom “Grif” Griffin and Ross M. Gardner
Bevel, Gardner, and Associates
Norman, Oklahoma*

Purpose: To illustrate some of the limitations imposed by fabric substrates when examining typical bloodstain pattern issues. The workshop will consist of three parts:

Part 1: A lecture outlining issues associated with examination of bloodstains on fabrics.

Part 2: Participants will then rotate through five stations in small groups designed to illustrate the issues involved in BPA fabric considerations presented in the lecture:

- Determining directional angles.
- Determining impact angles.
- Classifying bloodstains based on standard taxonomy
- Differentiating contact stains from small spatter.
- Using alternate light sources to enhance contrast of bloodstains on fabrics.

Part 3: In small groups participants, will examine a set of bloodstained clothing and determine if sufficient information exists to support or refute a specific hypothesis associated to the clothing. *Then, each group will do a short presentation on their findings.*

INTERNATIONAL ASSOCIATION OF BLOODSTAIN PATTERN ANALYSTS

2016 Business Meeting Minutes

October 7, 2016

Salt Lake City, Utah

OFFICERS IN ATTENDANCE:

Jeffrey Scozzafava, President

Richard Tewes, Vice President of Region II

Gord Lefebvre, Vice President of Region IV

Martin Eversdijk, Vice President of Region V

Janette Psaroudis, Vice President of Region VI

Celestina Rossi, Sergeant at Arms

- 11:13 AM President Scozzafava called the meeting to order.
- President Scozzafava requested the organization extend a Thank You to Dan Christman in acknowledgment of his efforts in putting together a presentation for hosting the conference next year.
- He then addressed whether we had a Quorum, and a discussion followed.
- President Scozzafava requested a motion to approve the 2015 meeting minutes which had been published in the Journal and were also available at the 2016 meeting. Sue Ann Derkach moved that the minutes be approved and Lisa Perry seconded the motion. The motion was approved.
- A motion for advancement from applicant to provisional members, as well as for provisional to full members, was made by Gillian Leak and seconded by Tom Griffin. The motion was approved.
- President Scozzafava requested a motion to accept the Treasurer's report. The motion was made by Colin Hoare, and seconded by Phillipe Esperanca.
- Officer Reports:
- President Scozzafava led discussions involving the Editor's Position, Journal Issues, and the Travel Award.
 - Stuart James is considering retiring from the Editor position
 - During the discussion of the Journal, Sue Ann Derkach made a motion for purchasing an ISBN number to attempt to increase submittals, while Gord Lefebvre requested we defer the motion until we had a new editor.

Executive Board Reports

- Vice President Christina Gonzalez's report was delivered by Celestina Rossi, indicating that she had processed 13 applications for Provisional to Full Membership. Her region, with multiple Southern California agencies, would be hosting the 2017 conference.
- Vice President Richard Tewes, Region II, received 9 new applications, and 5 for promotion. This is his third and therefore last year of service.
- Vice President DeWayne Morris' report was delivered by Jeffrey Scozzafava, indicating he received 22 applications, and 2 for promotion. He continues to spread the word about the IABPA and recruiting new members. This is his last year as Central Vice President.
- Vice President Gord Lefebvre, Region IV, has received 33 new applications for Provisional Membership, 4 applications for promotion, and 8 for associate membership. He reiterated that Ottawa is interested in hosting the 2018 conference.

- Vice President Martin Eversdijk, Region V, has received 24 applications. He expressed that trainings are spreading throughout the region, partially in thanks to Gillian Leak. They are expecting 200 attendees at the upcoming 2017 European conference. This will be his last year of service.
- Vice President Janette Psaroudis, Region 6, has received 6 new member applications, and the region currently has 46 members. There has been an abundance of training across their region in the scope of fluid dynamics and BPA on clothing, etc. Their region had a 3-day workshop creating their own group to address the PCAST report. The ANZFSS conference was a huge success with more than 850 delegates in attendance. There were two days of BPA topics, with unique research presented. Much research and development continues to come from Dr. Michael Taylor and Mark Reynolds.
- Sergeant at Arms Celestina Rossi reported that the attendees were well behaved and she had no incidents in maintaining order.
- Secretary/Treasurer Norman Reeves missed only his second conference in 33 years, and his report was delivered by President Scozzafava. The organization has 800 members and is solid financially. The website has resulted in decreased spending, as postage was very expensive for mailing the journal, etc. The Dallas/Fort Worth conference was a booming success both financially and content-wise.
- Historian Stuart James had no report

By-Laws Committee

Mark Reynolds stepped down from his position. Continuing from the discussions referenced at the 2015 business meeting, the “immediate past president” position was eliminated, and the by-laws were revised to state that if the President of the organization steps down, the Vice Presidents will elect a new President. The other noteworthy change in the by-laws was to address the addition on-line voting and processing of memberships. The term “executive” was also removed from references to the Board. The by-laws had been posted, and were available at the back of the meeting room.

A motion to accept the changes to the by-laws was made by Joe Slemko and seconded by Colin Hoare. The motion was approved.

Education Committee

Erin Simms has been leading the evaluation of all Basic Bloodstain Pattern Analysis courses. Her committee is assessing all instructor’s agendas to ensure they fit the established criteria. 73 instructors state that they offer approved classes, however only 48 have gone through the verification process, and 31 were approved. It was stated that this “approval” indicates that the classes/instructors met the guidelines, versus being IABPA approved. The organization does not endorse any training.

Ethics Committee

Rich Tewes reported that there is one current complaint under investigation. He noted that there may be a need to add a new member to the committee.

Dan Rahn Grant

Lynne Herold’s report stated that there were no applicants during the year, however there is anticipation of one from Tess Mercer in 2017.

Translation Committee

Phillipe Esperanca stated that the translation process is going well overall. However, there are currently issues with the Italian translations. Phillipe is not receiving responses to his e-mails regarding their translations.

Webmaster Report

Joe Slemko stated he has nothing to report regarding the site. He commented that he feels the Journal is intimidating, being “peer reviewed” and that is perhaps why we are not receiving submissions. He discussed establishing a cut-off time zone for on-line voting. Additionally, he stated that during the previous election, it was found that some members were voting more than once and therefore “spoiled” their votes. All ballots are archived and available for 2 years if evaluation is ever requested.

Nominations:

President Scozzafava put forth the Executive Board’s nomination recommendations forth, while encouraging other members to put forth their names as well.

- Jeffrey Scozzafava – President
- Christina Gonzalez – Vice President Region 1
- Brittany Nelson – Vice President Region 2
- Christine Ramirez – Vice President Region 3
- Gord Lefebvre – Vice President Region 4
- Phillippe Esperanca – Vice President Region 5
- Janette Psaroudis – Vice President Region 6
- Norman Reeves – Secretary
- Norman Reeves – Treasurer
- Celestina Rossi – Sergeant at Arms
- Stuart James – Historian

President Scozzafava called for additional nominations to these positions. No additional nominations were made from the floor. A motion to close the nominations was made by Tom “Grif” Griffin, which was seconded by Sue Ann Derkach. The motion was approved.

New Business:

On the topic of the Travel Award, LeeAnn Singley suggested using it to send the President and/or a Vice President to the ANZFSS conference every 2 years, as the conference has dedicated BPA sessions. VP Janette Psaroudis was interested in this idea, as she would like to raise membership levels in Region 6. She felt having Executive Board members attend the ANZFSS conference would bring attention to the region, and thus would help to raise membership and awareness of our organization. (This comment was tabled from President Scozzafava’s officer report regarding the Travel Award)

Brian Yamashita inquired as to whether journal submittals should still be sent to Stuart James. The board stated that until a replacement has been found, all submittals should still be sent to Stuart.

Gillian Leak suggested that for future conferences, there be a way to connect all spouses traveling with attendees.

Sue Ann Derkach made a motion to close the business meeting, which was seconded by Gillian Leak. The motion was approved, and the meeting was adjourned at 12:34 p.m.

Recent BPA Articles Published in the Scientific Literature

Stotesbury, T., Illes, M., and Vreugdenhil, A. J. An Impact Velocity Device Design for Blood Spatter Pattern Generation with Considerations for High-Speed Video Analysis, J. Forensic Sci. March 2016, Vol. 61., No 2

Taylor, M.C., Laber, T.L., Kish, P.E., Owens, G. and Osborne, N.K., The Reliability of Pattern Classification in Bloodstain Pattern Analysis – PART 2: Bloodstain Patterns on Fabric Surfaces, J. Forensic Sci. November 2016, Vol. 61., No 6

Kowalske, Z., Casting bloodstain Patterns: AccuTrans versus Mikrosil, Journal of Forensic Identification, Vol. 66, Issue 5, 2016

Dubyk, M. and Liscio, E., Using a 3D Laser Scanner to Determine the Area of Origin of an Impact Pattern, Journal of Forensic Identification, Vol. 66, Issue 3, 2016

Organizational Notices Moving Soon?

All changes of mailing address need to be supplied to our Secretary Norman Reeves and webmaster Joe Slemko. E-mail your new address to Secretary Norman Reeves at: norman@bloody1.com and to webmaster Joe Slemko at jslemko@alberta.com.

Membership Applications / Request for Promotion

Applications for membership as well as for promotion are available on the IABPA website:
IABPA Website: <http://www.iabpa.org>

The fees for application of membership and yearly dues are \$40.00 US each. If you have not received a dues invoice for 2017 please contact Norman Reeves at norman@bloody1.com. Also, apparently, non US credit cards are charging a fee above and beyond the \$ 40.00 membership/application fee. Your credit card is charged only \$40.00 US by the IABPA. Any additional fees are imposed by the credit card companies.

IABPA now accepts the following credit cards:

**Discover MasterCard
American Express Visa**



Training Opportunities

February 13-17, 2017
Bloodstain Pattern Analysis I
Salt Lake City Police Department
Salt Lake City, Utah

Presented by Bevel, Gardner & Associates
Instructors: Ross M Gardner and Tom "Grif" Griffin
Contact: Craig Gravel, Training Coordinator
Tel: 405-706-8489
E-mail: rcgravel@aol.com

February 20-24, 2017

Math & Physics for Bloodstain Pattern Analysts
San Diego County Sheriff's Office
San Diego, California

Presented in partnership with the International Association of Identification and Trittech Forensics
Instructor: Brian Yamashita
Contact: Phil Sanfilippo:
Tel: 800-438-7884 x 7800
E-mail: phil@tritechusa.com

March 6-10, 2017

Basic Bloodstain Pattern Analysis Course
Johnson County Sheriff's Office
11890 S. Sunset Drive
Olathe, Kansas

For more information contact:
Paul Erwin Kish
Forensic Consultants and Associates
Tel: 607-962-8092
E-mail: paul@paulkish.com

Jeremiah Morris
Johnson County Sheriff's Office
Criminalistics Laboratory
Tel: 913-826-3230
E-mail: Jeremiah.Morris@jocogov.org

March 20-24, 2017

**BPA – Documenting, Reporting and Presenting
Douglas County Sheriff's Office
Omaha, Nebraska**

Instructor: Craig Moore
For more information contact:
Jodi Adams
Acting CSI Field Supervisor
Douglas County Sheriff's Office
Tel: 402-444-7524
E-mail: Jodi.adams@douglascounty-ne.gov

**April 3-7, 2017
Bloodstain Pattern Analysis I
Midwest City Police Department
Midwest City, Oklahoma**

Presented by Bevel, Gardner & Associates
Instructors: Tom "Grif" Griffin
Contact: Craig Gravel, Training Coordinator
Tel: 405-706-8489
E-mail: rcgravel@aol.com

**April 24-28, 2017
Bloodstain Pattern Analysis I
NESPIN
Franklin, Massachusetts**

Presented by Bevel, Gardner & Associates
Instructor: Kenneth Martin
Contact: Craig Gravel, Training Coordinator
Tel: 405-706-8489
E-mail: rcgravel@aol.com

October 23-27, 2017

**Basic Bloodstain Analysis Course
(40 hours – 5 days)
Roma, Italy**

Instructor: Martin Eversdijk
Loci Forensics B.V.
Products – Training – Consulting
Flierveld 59
2151 LE Nieuw-Vennep
The Netherlands
E-mail: Info@lociforensics.nl
Website: <http://www.lociforensics.nl/>
Fax: +31(0)20-8907749

Articles and training announcements for the March 2017 issue of the Journal of Bloodstain Pattern Analysis must be received before February 15th, 2017

Editor's Corner

This December 2017 issue of the Journal of Bloodstain Pattern Analysis is just the second of the year. Articles submitted by Tess Mercer, the 2014/15 Daniel Rahn Memorial Research Grant Project, Dr. Mark Reynolds and Edmund Sileniaks and Nathan Kwan have made this possible.

This has been the second consecutive year (2016-2017) that only two issues of our Journal instead of the normal four have been published for the membership. The lack of submitted articles for peer review and publication has been a systemic problem for longer than two years. I have found to be discouraging to say the least. I have informed our President Jeff Scozzafava that after twelve years as the Editor of our Journal, I am ready to turn over this responsibility to another interested member. I have enjoyed my tenure as Editor for the most part and have told Jeff that I will stay on until my successor has been found. If anyone is interested in the position of Journal Editor, contact either President Jeff Scozzafava or myself.

Stuart H. James
Editor
jamesforen@aol.com



**Publication Committee
Associate Editors**

**Barton P. Epstein
Paul E. Kish
Daniel Mabel
Jeremy Morris
Jon J. Nordby
Joe Slemko
Celestina Rossi
Jeffrey Scozzafava
T. Paulette Sutton**

Past Editors of the IABPA News/Journal of Bloodstain Pattern Analysis

Anita Y. Wonder	1984-1985
Norman Reeves	1984-1989
David Rimer	1990-1996
Toby L. Wolson	1997-2000
Paul E. Kish	2001-2003
Stuart H. James	2004-present

Past Presidents of the IABPA

V. Thomas Bevel	1983-1984
Charles Edel	1985-1987
Warren R. Darby	1988
Rod D. Englert	1989-1990
Edward Podworny	1991-1992
Tom J. Griffin	1993-1994
Toby L. Wolson, M.S.	1995-1996
Daniel V. Christman	1997-1998
Phyllis T. Rollan	1999-2000
Daniel Rahn	2001-2002
Bill Basso	2002-2006
LeeAnn Singley	2007-2008
Iris Dalley	2009-2010
Todd A. Thorne	2011-2012
Pat Laturus	2013-2015

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