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Dr. Alan Wildeman, President, University of Windsor

Dr. Wildeman opened the conference and expressed happiness at the huge turnout for the TIFS-16 conference. He mentioned that it seems to have become “The Forensic Sciences event in Ontario, Canada.” He motivated the Forensics community and wished them all good luck.

Dr. Jeff Berryman, Acting Associate Vice Provost, Academic, University of Windsor

Dr. Jeff Berryman spoke and expressed his enthusiasm to be at such a large Forensic Science event. He also wished the entire Forensic community good luck and congratulated them for organizing this event.
Mr. Al Frederick, Chief, Windsor Police Services

Mr. Al Frederick spoke for the second consecutive year at the conference. This year, he was again accompanied by many Police Officers from the Windsor Police Services. He mentioned the importance of this conference right from choosing the name “Trends” as very appropriate. His presence and speech strengthens the community outreach.

Dr. Peter Frade, Director, Forensic Sciences, Wayne State University, Michigan, USA

It was indeed a pleasure to listen to the encouraging words from Dr. Peter Frade for the second consecutive year. Dr. Peter Frade gave the keynote address for the TIFS-15 conference. He again reinforced his invitation for the collaborative Forensic Sciences programs with the University of Windsor.
The Student Coordinators & Registration Team

Top Row (left to right) Olivia Wuerch, Rebecca Linzner, Peter Truong, Nadia Stephaniuk (Student Coordinator), Meagan Beaton, Jessie Boycott, Ourania Kourelias (Student Coordinator)

Bottom Row (left to right) Georgina Abrego, Nikki McLeod, Theresa Tran, Munira Jamali

Masters of Ceremony

Brooke Frisby (right), President of the Forensic Association, and Martin Yancy (left), Vice-President of the Forensic Association

Brooke Frisby is a fourth year Forensic Science student specializing in Biology. Martin Yancy is also a fourth year student in the B.A. combined with Criminology. They have been active members of the Forensic community for all four years.
Keynote Address

Dr. Jayantha Herath, Medical Director, Ontario Forensic Pathology Services, Canada

MD, MSc, DLM, MD (Forensic), FCAP, FRCPC

The Multidisciplinary Approach to Death Investigation in Ontario

Dr. Herath described that a medicolegal (forensic) autopsy is conducted to answer questions that interest the coroner’s system, judiciary and the public to determine how and why its citizens die. In Ontario this is done by the Office of the Chief Coroner, Ontario Forensic Pathology Service, police, fire marshal, public health, Canadian military and many others. He discussed in depth the categories of a medicolegal autopsy and the objectives of such. As well as the duties of a forensic pathologist and different fields that work together to determine answers to the questions of interest.
Guest Presentations

Camelia Prescott
B.A., CFI, D-ABMDI

Death Investigation 101

Ms. Prescott discussed jurisdiction in relation to specific events, initial notification such as date, time of notification, time of call, time of death, etc. She went into detail about circumstances and the questions that need answers to such as when and where the decedent was last known alive, what were they doing, who found the body, to name a few. Ms. Prescott then spoke about the five different manners of death, what to look for when examining the body, different types of evidence that could be present, as well as preliminary reports.

Lou Mendes-Kramer
M.A., PA (ASCP)

Suicide Analysis: An 11 Year Retrospective Study

Ms. Mendes-Kramer discussed her and her colleagues findings about the recent trends in suicide between 2000-2011 for both Wayne and Monroe counties. They looked at male vs female suicides, the age vs the number of suicides, firearm involvement, and the GSW location. She discussed investigative considerations at the scene that investigators look for, such as presence of weapons or means of death, self-inflicted injuries or wounds, motive and how to protect the evidence at the scene.
**Dr. Bulent Mutus**

*Ph.D.*

**The Central Role of Analytical Chemistry in Forensics**

Dr. Mutus discussed techniques and complicated vs simple instruments for analysis of forensic samples. The Mass Spectrometry imaging could be used as an example of a complicated instrument for analysis in forensic samples by using it to depict drug incorporation into hair. He went into detail about the procedure and recommendations of this procedure. He then discussed a simple instrumental analysis method called microplate-based colorimetric detection of free hydrogen sulfide.

**Gary Scoyne**

**Evidences at the Crime Scene**

Mr. Scoyne is a sessional professor here at the University of Windsor that teaches the Digital Photography course (14-57-313). He took the time to discuss this class and went through two of the student groups final projects to depict certain items an investigator must look for when entering and photographing a crime scene.
Krystal Hans  
*MSc*  

**Forensic Entomology**

Ms. Hans discussed the importance and applications of insect evidence in criminal investigations, whether it be urban, stored products, or medicolegal and gave examples of cases that she had personally worked on relating to these. She also discussed a case study about the Cleveland Strangler.

Marisa Dery  

**Voice Biometrics**

Ms. Dery spoke about her specialization in forensic audio- which includes audio enhancement, authentication and voice identification. She was the 1st Prize Winner in the Non-Group (Single) Category in the Audio Enhancement contest at the AES 33rd International Conference in Denver, USA.
Forensic Student Presentations

Andrew Ethier
Detection of Writing and Fingerprints on Burnt Documents Using the Video Spectral Comparator
Mr. Andrew Ethier discussed the Forensic purpose of this research and what the video spectral comparator is. He went into detail about his methods and what his overall conclusion was.

Azeza Al Masri
The Forensic Biometrics Analysis of Emotions for Facial Expressions, Heart and Skin
Ms. Azeza Al Masra spoke about her Forensic relevance and materials/methods. She went into detail about live analysis of emotions and the results she found.

Danielle Lachance
New Techniques for Visualization of Latent Fingerprints on the Canadian Polymer Banknotes
Ms. Danielle Lachance discussed the Forensic importance of this research, previous research, the goals of this research and methods. She went into great detail about her results and spoke about future research that could be conducted.

Ali Shadzik
Exploring Open-Source Toolkits in Mobile Forensics
Mr. Ali Shadzik discussed volatile data, Forensic data acquisition, different types of physical acquisitions, and what Root access is. He also discussed different devices that could be used for extraction of information.
### Forensic Sciences Research Showcase

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## CSI-Windsor Hands-On Forensic Workshops

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Awards Ceremony

Research Poster Awards:

- First Prize – Kristina Marrella
- Second Prize – Danielle Lachance
- Third Prize – Victoria Panecaldo

Dr. Shashi Jasra with student, Kristina Marrella
Dr. Shashi Jasra with student, Danielle Lachance
Dr. Pardeep Jasra with student, Victoria Panecaldo

Best Mentorship Pair Award:

Danielle Lachance & Michelle Dao

Rebecca Glover, Dr. Pardeep Jasra, Brooke Frisby, Danielle Lachance, Michelle Dao, Martin Yancy, Dr. Shashi Jasra, Nadia Stephanuik

Visit the Trends in Forensic Sciences website for more information: http://www1.uwindsor.ca/tifs/
Determining an Effective Method to Enhance Fingerprints on Rusted Metals

Ryan Dodich*, Constable John Lasorda 2, and Shashi K. Jasra

Abstract:

This paper aims to determine an effective method, if any, if it is possible to enhance fingerprints on rusted metals such as tin and steel. This will be accomplished using common enhancements techniques such as Redwop, cyanoacrylate glue fuming, Dragon’s Blood, and black magnetic powder. Redwop proved to be an effective method on both the tin and steel samples tested. The other methods were also successful to a degree on the remaining tin samples except for cyanoacrylate glue fuming. The results show that to a degree, it is possible to visualize fingerprint ridge detail over varying heavily rusted portions of metal with multiple techniques. The study does not attempt any extraction methods, but it does effectively show that fingerprints may be enhanced on varying degrees of rusted metals.

Keywords: fingerprints, metal, rust

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2 Forensic Identification Branch, Windsor Police Service, Windsor Police Headquarters, 150 Goyeau Street, Windsor Ontario

Communicating Author contact: Ryan Dodich, email: dodichr@uwindsor.ca
Introduction

It has been thought in the past that obtaining a fingerprint from a rigid or non-linear surface would be a difficult if not impossible task. This paper aims to show that this is not the case with all objects. This paper and subsequent research aims to determine if it is possible to enhance a fingerprint from a ferrous rusted surface, such as the ones found on tin or steel.

There is little to no academic literature on this subject and the papers that do comment use methods of cleaning the rust away, or a similar method of rust removal. A large amount of the papers are also focused on metal that has not been rusted, such as Bond, who focuses on obtaining a fingerprint from an older, clean piece of metal. There is even some research furthering Bond’s techniques with alternative methods. There are few papers showing different development processes on metallic surfaces some using alternate methods of enhancement. Recent work has been done to link fingerprints on metallic surfaces with other possible substances that could be found in a crime scene, such as gunshot residue. These are all a far stretch from the original work of simple powders on all substances.

With this being a proof of concept as well as our limited time and resources, it was not feasible to be spending the time to fully examine minute ridge detail on the fingerprints if they are found. Although it would be beneficial to perform this in later research, the focuses will be finding a method that does show a visible fingerprint. If the methods are successful and repeatable, then this opens up a new line of research down the road to find the most efficient method or the method that displays the best results. This paper can also show the need for further research into the field of obtaining and enhancing fingerprints on rigid and non-linear surfaces.

Materials and Methods

Four pieces of metal had been obtained from an auto dealer called J&B Auto Parts. These metal pieces work well to simulate how a metal piece of evidence would be found in the environment. To remove dirt and other non-ferrous debris from the metal, each piece of metal was washed in Liqui-Nox detergent and hydrogen peroxide. It was determined two of the four pieces of metal were not suitable for testing due to the lack of non-rusted surface area. This was an issue because the non-rusted portions of metal were used as controls for the experiment. With only two pieces of metal (A steel disk and a tin cup) it was determined this was not enough samples to properly conduct the test. The portable jigsaw was used and cut the tin cup into four nearly identical pieces.

Following the separation of the tin, the next step was to put the tin samples and the steel disk under all of the available forensic light sources (375-900 nanometers) and take pictures using a Canon D60 camera. An orange ultraviolet filter was used on the camera to be able to take the photos while using the alternate light sources as well as orange glasses to protect the eyes. A photo of each wavelength was taken by setting the shutter speed on the camera to thirty seconds.
and “painting with light”, in other words, shining the forensic light source all around the samples.

The first tin sample and the steel disk were then coated with fingerprints donated by the authors. Both samples were brought to the fingerprint dusting room and used an extremely fine fluorescent powder called “Redwop”. Breathing masks and latex gloves were needed for safety. A ventilation shaft was also present to help intake the excess fine powder. After applying the Redwop powder, the samples were carefully transported to the dark room that contained the forensic light sources (375-900 nanometers). Every available light source was used and photos were taken regardless if fluorescence was noticed or not. If any fluorescence was noticed, whether it is on the control or the sample, a close up would be taken of that area. When the process was complete the samples would be carefully taken back to the fume hood where they have been stored.

Since there was only the one steel sample, the rest of the experiments will only be used with the tin samples. The second tin sample will undergo the technique of CA or cyanoacrylate fuming. This is the most commonly used method with Windsor Police for detecting fingerprints from a non-porous surface. This process heats superglue containing cyanoacrylate until it is in a gas state. The cyanoacrylate reacts with the oils left behind by the fingerprints and adheres to them. To perform this, fingerprints were placed all over the tin sample and it was placed along with a tray of superglue into a specialized venting chamber. The vent was heated and left to sit for 45 minutes. After the 45 minutes the ventilation portion was opened and this allowed the excess gas to be removed for another 45 minutes. The samples were then taken out and photographed them in the same way as the first samples.

As a second portion to the cyanoacrylate method, and after photographing the sample, it was then put it back into the venting chamber and sprayed the sample with rhodamine. This is a dye that is commonly used with cyanoacrylate. After that another wait period 45 minutes for the vented chamber to finish and retrieved the sample had taken place. This sample was again photographed in the dark room as mentioned earlier. The reason why these two methods can be combined in one is that the rhodamine is simply a dye that is used to enhance the fingerprint. Another dye could have been chosen to stain the print but it suggested rhodamine would yield the best results. The suggestion came from other constables at the Windsor Police Service Headquarters.

The third sample was brought to the fingerprint dusting room and similar procedures to the Redwop were used. The breathing masks and latex gloves were worn and the experiment was performed under the safety of a ventilation shaft. The fluorescent powder that was chosen to use for sample 3 was known as “Dragon’s Blood”. This functioned very similar to Redwop in the sense that the red powder is applied in the same manner and fluoresces under the same light wavelengths.
The fourth and final sample was brought into the fingerprint dusting room at the same time as the third sample. The author’s fingerprints were also placed all over the samples covering the rusted parts as well as the non-rusted control portions of the sample. The last choice in fingerprint enhancing powder was black magnetic powder. It was unclear if this method would produce any valid results due to the magnetic properties of the metal interfering with the powder adhering to the fingerprints. Regardless, the sample was dusted much in the same methods as the previous samples.

List of Materials Used:

- Canon 60D Camera
- Orange UV Camera Filter
- Redwop Fingerprint Powder
- Dragon’s Blood Fingerprint Powder
- CA Glue
- Rhodamine
- Black Magnetic Fingerprint Powder
- Fuming and Venting Chamber
- Fingerprint Dusters
- Steel Disk
- Tin Cup
- Jigsaw
- Liqui-Nox
- Hydrogen Peroxide
- Water
- Sharpie Marker
- Adobe Photoshop
- MCS-400 Forensic Light Source

Results

Figure 1: Shows the fingerprint dusting station mentioned earlier, this is where most of the experiments were conducted.

Figure 2: Shows the original unmodified samples that have just been cleaned using Liqui-Nox and Hydrogen Peroxide. These are simply for reference.
Figure 3a (left) and 3b (right): Both show the samples under normal visible light and under UV light. This gives a clear reference of what the samples would look like without any kind of enhancement.

Figure 4a and 4b: Depict the Redwop tin (left) and steel (right) under normal light. Figure 4b shows the samples under 300-400 nm UV light.

Figure 5: Is a close up of 390 nm of UV light. Although difficult to tell in this photograph, figure 5 does depict small ridge detail while under the rusted pieces as well as on the non-rusted control sections.
In the second experiment, several photos of the sample were taken with just CA glue fuming and then CA and Rhodamine together.

Under ultraviolet light there are numerous fingerprints visible. Very detailed samples of the control prints can be seen, but the real importance in the fingerprint seen in the top left of figure 8b. This shows ridge patterns while overtop of the rusted surface. A close up of this example is the print under 390 nm of light.
The fourth and final sample has shown some interesting results. The magnetic powder did not make very much of an impression on the control prints, however it did make a significant impact on the rusted target prints. The fingerprint in the center is the most notable, being completely over a rusted portion of the tin cup. A closer look shows how the use of lighting from a flash can help to properly illuminate the black magnetic powder.

Now that the experiment has been completed, future replications might have more success by using a substance such as white magnetic powder to help bring out a better contrast. Regardless, these results show a visible fingerprint over the rusted portions as well as a small portion over the control prints as well.

Discussion

While reviewing over all of the photos that were taken on the experiments, it is clear that fingerprints can indeed be enhanced on rusted surfaces using existing enhancement techniques. The Redwop powder showed promising results albeit not being able to fully distinguish minute ridge detail. The best wavelengths for viewing the samples were under ultraviolet light. (300-400
It is unlikely that the fingerprints used in this experiment could be used in a forensic investigation, but it is worth noting that Redwop is capable of being used on rusted surfaces.

When the results came back for the CA glue fuming it was quite unexpected. CA is the staple method used by the Windsor Police Service for all non-porous surfaces and has a track record for producing usable results. The test provided some uncertainty as the control fingerprints did not show up, although this is not entirely unheard of for metallic surfaces. This could be due to the fact that the experiment did not function correctly, although to help remove some of the doubt the cup’s surface was checked to see if it was coated in glue. It was indeed covered in glue, signifying that the experiment was performed as intended. It would have been useful to retest this portion of the experiment to see if similar results would be produced but due to lack of available testing material this was not done. The rhodamine portion of the experiment did outline some small portions of ridges but not enough to validate it being considered a fingerprint.

When the Dragon’s Blood was tested it was visible on the prints without an alternate light source if illuminated at certain angles (roughly 60 degrees). The fluorescence from the ultraviolet light provided the best results out of all of the experiments performed. With the photos taken under ultraviolet light ridge detail can clearly even over the rusted portions. The quality of the fingerprint would still most likely not be suitable for forensic purposes but this does shed light that the concept of enhancing fingerprints on rusted metals is possible and should be further looked into. The best results overall between the Redwop and Dragon’s Blood florescence seems to be a wavelength of 390 nm.

The final method involving the black magnetic powder was also a success. As shown in the photograph, ridge details are present on the rusted surfaces over the tin. These results were very interesting because the metallic powder had only clung to the rusted surfaces very well, and it did not cling to the control surfaces very well at all. This method was originally thought of as going to be the least effective out of the four tested. It was determined that if white or other metallic powder was tested instead then it would yield much better results. This idea not able to be tested because of limited resources and available testing samples.

Conclusion

Overall the experiment would be counted as a success. Three out of the four methods tested produced some form of results, while not all of them would be considered useable in a forensic setting; it definitely does show that fingerprints can leave behind valuable information on rusted surfaces. This preliminary research could possibly open the door for further studies into revisions on techniques, and to possibly introduce new methods to be tested.
Acknowledgments

We would like to give a special thank you to the Windsor Police Service for allowing us to use their equipment and resources to perform this experiment.
References


The Effect of Food on the Absorption of Rohypnol using the RIVM in vitro Digestion Model

Nicole McLeod¹, Jayden Mayville¹, Shashi K. Jasra*¹

Abstract: The goal of this study is to compare levels of flunitrazepam in an in vitro digestion system with and without the presence of food. Food and a spiked drink were combined with simulated intestinal juice mixture, designed by RIVM, for a set duration. A colourimetric reaction was then carried out to quantify the amount of flunitrazepam in the sample. The concentration of flunitrazepam in the control sample and experimental sample are 8.802 ppm and 1.900 ppm respectively; this shows that food decreases the amount of flunitrazepam available in the small intestine to be absorbed into the bloodstream.

Keywords: alcohol, digestion, flunitrazepam, forensic science, food, RIVM, rohypnol, sexual assault

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401 Sunset Avenue, Windsor, Ontario N9B 3P4, Canada

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Introduction

Several studies have considered the use of drugs in sexual assault cases. Elsohly et al. found a strong association between drugs and alleged cases of sexual assault\(^1\). Alcohol was often found to be the most common substance used in sexual assaults\(^1,2\). However, it was suggested that least 20 different substances can be associated with sexual assault, and they are often combined\(^1\). For instance, alcohol can act as a delivery system and enhance the effects of other drugs, such as gamma-Hydroxybutyric acid (GHB) and flunitrazepam (rohypnol), two of the more commonly used “date rape” drugs\(^2,3\). Both these drugs alone act rapidly, reducing inhibition and causing anterograde amnesia\(^3\).

Flunitrazepam is a benzodiazepine, a tasteless, colourless, odorless drug that acts as a central nervous system suppressant, causing temporary cognitive impairment. It is frequently used in Europe to treat insomnia and anxiety. However, a dose as small as 1 milligram (mg) can cause impairment for 8-12 hours\(^4,5\). When combined with depressants, such as alcohol, it can cause acute sedation and unconsciousness\(^4\), which is why it has a tendency to be abused, such as in cases of sexual assault. The studies conducted by Eloshly, Slaughter and Schwartz all support the concept that drug-facilitated sexual assault is common and suggest that more measures need to be taken to test for drugs in alleged cases of sexual assault\(^1,2,3\).

When a drug-facilitated sexual assault occurs, it is unrealistic to believe that all victims will file a report and go to the hospital for sexual assault testing promptly. The detection window for flunitrazepam depends on the dosage and the bodily fluid analyzed. It has been found that a 2 mg dose was detected in a urine sample in a 14-28 day window\(^6\), and a 1 mg dose was detected in urine 3-5 days after consumption and less than 6 hours in oral fluids\(^7\). The longer victims wait, the more the evidence becomes degraded, decreasing the available samples for collection as with drugs that are eliminated from the body through metabolic processes.

Studies have found that the presence of food in the stomach prior to alcohol consumption can slow the absorption rate of ethanol in the body\(^8,9,10,11\). The decreased absorption rate means that the peak concentration of alcohol is lower but the alcohol remains in the body for a longer period, creating a larger detection window. With a larger detection window, victims of drug facilitated sexual assault that don’t immediately come forward would still be able to provide samples of their bodily fluid for drug testing and it could still be used as viable evidence. The aim of this research project is to determine if the consumption of food prior to drinking an alcoholic beverage laced with rohypnol will affect its absorption into the body. A slower absorption rate may lengthen the duration that the drugs can be detected from bodily fluids.
Materials

- SnCl₂ (5%)
- HCl (4%)
- 4-(Dimethylamino)cinnamaldehyde (DMAC)
- Ethanol (95%)
- Distilled Water
- Flunitrazepam solution (1.0 mg/mL)
- Spectronic 20D+ by Thermo Scientific
- Beefeater London Dry Gin (40.0% alcohol)
- President’s Choice® Club Soda - Low Sodium
- Tostitos® Scoops!® tortilla chips
- President’s Choice® Medium Salsa
- NaCl (175.3 g/L)
- CaCl₂ • 2H₂O (22.2 g/L)
- HCl (37% g/g)
- NaHCO₃ (84.7 g/L)
- KH₂PO₄ (8 g/L)
- KCl (89.6 g/L)
- MgCl₂ (5 g/L)
- Urea (25 g/L)
- Bovine serum albumin
- Pancreatin
- Lipase
- Bovine Bile
- Stirring hot plate
- Magnetic stir bars
- Scale
- 2 - 600mL beakers
- Test tubes

Methods

Beverage Preparation

The beverage utilized in this experiment was gin and tonic because it is colourless solution like the gin that was used in Friedman’s experiment allowing a similar colour to be expressed. The gin and tonic beverage was composed of 25 milliliters (mL) of gin and 75 mL of tonic water. The amount of flunitrazepam added is enough to create a 10 ppm flunitrazepam solution.
Colorimetric Reaction

A coloured product was required in order to measure the absorbance of solutions at a particular wavelength. The colour reaction chosen was designed by Arthur J. Friedman, where flunitrazepam was hydrolyzed by 4% hydrochloric acid and reduced by 5% tin (II) chloride\textsuperscript{12}. The colouring reagent Friedman utilized was 0.25% 4-dimethylaminocinnamaldehyde (DMAC) in 95% ethanol\textsuperscript{12,13}.

This colour reaction can be done at room temperature and requires 1 mL of the reducing/hydrolyzing agent to be mixed with 1 mL of sample for 5 minutes. Then 2.5 mL of the DMAC visualizing agent was added and the colour is allowed to produce for 10-15 minutes.

Maximum Absorbance Determination

The wavelength at which the colour reaction can display maximum absorbance must be determined in order to quantify the concentration of flunitrazepam in the test and standard solutions. The Spectronic 20D+ was used to analyze the 10 ppm sample, measuring the absorbance in the visible spectrum from 350 nm to 825 nm in 25 nm increments to narrow down the range of the maximum absorbance. The range was narrowed down within 50 nm of the maximum absorbance reading to determine the precise wavelength that would be used in the colorimetric determinations of flunitrazepam.

Flunitrazepam Standard Solutions

Standard solutions of flunitrazepam with known concentrations were used to create a Beer’s Law graph as a reference to compare the experimental and control absorbance readings and approximate their concentrations. The standards were created by diluting a 10 ppm solution with distilled water to concentrations of 9 ppm, 8 ppm, 7 ppm, 6 ppm, 5 ppm, 4 ppm, 3 ppm, 2 ppm and 1 ppm as well as a sample with a concentration of 0 ppm to create an absorbance curve for flunitrazepam at the determined peak wavelength.

Mechanical Food Disruption and Intestinal Cavity

The food used in the experiment was represented by 15 g of tortilla chips and 30 mL of salsa. Chewing was simulated by a mortar and pestle; the food was grinded down for one minute.

The chemical mixture for the intestinal cavity (Table 1) was the duodenal juice and bile mixtures developed by RIVM (Rijksinstituut voor Volksgezondheid en Milieu), the National Institute for Public Health and Environment of the Netherlands\textsuperscript{14}. For the experimental trial, the duodenal and bile mixtures were combined with 100 mL of 10 ppm flunitrazepam gin and tonic.
solution and the chip and salsa mixture. The control trial contains the duodenal and bile mixtures, combined with 100 mL of 10 ppm flunitrazepam and gin and tonic solution. Once the trial mixtures were created, they were mixed on a stirring hot plate, kept at approximately 37°C for two hours. After the trials ran, the contents were allowed to settle, separating the liquid and solid phase before a sample of the trials were taken for analysis. The samples were analyzed in the same manner as the flunitrazepam standards.

Table 1: Chemical Components of the duodenal juice and bile from Development of an in vitro digestion model for estimating the bioaccessibility of soil contaminants

<table>
<thead>
<tr>
<th></th>
<th>Duodenal Juice</th>
<th>Bile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic Solution</td>
<td>40 ml NaCl 175.3 g/L</td>
<td>30 ml NaCl 175.3 g/L</td>
</tr>
<tr>
<td></td>
<td>40 ml NaHCO3 84.7 g/L</td>
<td>68.3 ml NaHCO3 84.7 g/L</td>
</tr>
<tr>
<td></td>
<td>10 ml KH2PO4 8 g/L</td>
<td>4.2 ml KCl 89.6 g/L</td>
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<tr>
<td></td>
<td>6.3 ml KCl 89.6 g/L</td>
<td>200 μl HCl 37% g/g</td>
</tr>
<tr>
<td></td>
<td>10 ml MgCl2 5 g/L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>180 μl HCl 37% g/g</td>
<td></td>
</tr>
<tr>
<td>Organic Solution</td>
<td>4 ml urea 25 g/L</td>
<td>10 ml urea 25 g/L</td>
</tr>
<tr>
<td>Enzymes</td>
<td>9 ml CaCl2 2H2O 22.2 g/L</td>
<td>10 ml CaCl2 2H2O 22.2 g/L</td>
</tr>
<tr>
<td></td>
<td>1 g BSA</td>
<td>1.8 g BSA</td>
</tr>
<tr>
<td></td>
<td>3 g pancreatin</td>
<td>6 g bile</td>
</tr>
<tr>
<td></td>
<td>0.5 g lipase</td>
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</tbody>
</table>

*Trial Concentration Determination*

The absorbance for three samples was tested for both the experimental and control solution, the average of each was used in conjunction with the linear regression of the Beer’s Law graph to calculate the concentration of the experimental and control solution.

*Results*

In the first set of wavelengths utilized in analyzing the 10 ppm flunitrazepam standard from wavelengths of 350nm to 825nm, peak absorption was observed at 400nm (Figure 1). Because of this peak, the refined wavelength range was based on a wavelengths ±25nm around 400nm, resulting in a range of 375nm to 425nm.
Figure 1: Absorption of 10 ppm flunitrazepam standard solution from wavelengths 350 nm to 825 nm; peaking at 400 nm.

Within the range of 375nm and 425nm, the wavelength with the highest absorption reading from the 10 ppm flunitrazepam sample was 413 nm (Figure 2). This is the wavelength that is used to analyze the control and experimental samples and the 11 standard flunitrazepam samples (Table 2).

Figure 2: Absorption of 10 ppm flunitrazepam standard solution from wavelengths 375 nm to 425 nm; peaking at 413 nm
The absorbance values measured from the 11 standard samples were used to create a Beer’s Law graph (Figure 3). While creating the linear regression the standard solutions of 1 ppm, 3 ppm and 4 ppm were excluded to give a linear regression with a coefficient of determination ($R^2$) value closer to 1. The linear regression of the Beer’s Law graph with an equation of: \( y=0.0126x + 1.692 \), where \( x \) represents the concentration in parts per million and \( y \) represents the absorbance at 413 nm.

Table 2: Absorptions of the 11 standard flunitrazepam samples at $\lambda = 413$ nm.

<table>
<thead>
<tr>
<th>Concentration (ppm)</th>
<th>Absorbance</th>
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<tbody>
<tr>
<td>0</td>
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</tr>
<tr>
<td>1</td>
<td>1.740</td>
</tr>
<tr>
<td>2</td>
<td>1.720</td>
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<tr>
<td>3</td>
<td>1.700</td>
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<tr>
<td>4</td>
<td>1.780</td>
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<tr>
<td>5</td>
<td>1.760</td>
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<tr>
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<td>1.760</td>
</tr>
<tr>
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<td>1.760</td>
</tr>
<tr>
<td>8</td>
<td>1.780</td>
</tr>
<tr>
<td>9</td>
<td>1.800</td>
</tr>
<tr>
<td>10</td>
<td>1.850</td>
</tr>
</tbody>
</table>

Figure 3: Beer’s Law Graph of Standard Flunitrazepam Samples at $\lambda = 413$ nm with calculate control and experimental data plotted. The linear regression has an equation of: \( y=0.0126x + 1.692 \); where \( x \) represents the concentration in parts per million and \( y \) represents the absorbance at 413 nm.
Using the linear regression equation and the average absorbance of the samples (Table 3), the concentrations of the experimental and control solutions were calculated to be 1.900 ppm and 8.802 ppm, respectively.

Discussion

The results show that the experimental sample, containing food, had a lower concentration than the control sample; this implies that the presence of food assists in absorbing the flunitrazepam present in the small intestine, decreasing the amount of flunitrazepam in the liquid portion of the intestinal contents to be absorbed into the bloodstream. Food consumption has a similar effect on alcohol metabolism in the human body\textsuperscript{15}, where the presence of food decreased the amount of alcohol detected in the bloodstream, resulting in a lower peak of blood-alcohol level compared to the consumption of alcohol without the addition of food. This addition of food has the potential to reduce the peak levels of flunitrazepam in the bloodstream that in turn would reduce the effect that flunitrazepam would have on the central nervous system, as it did in the study by Jones and Jönsson\textsuperscript{15}.

This research could be improved upon by the inclusion of the mouth and stomach cavity to observe how the inclusion of those cavities influences the level of flunitrazepam available to be absorbed into the bloodstream. As well, the large intestine and colon could also be included to determine how much of the flunitrazepam that was absorbed by the food would migrate to the bloodstream to give a better idea of the detection window of flunitrazepam.

Conclusion

This evidence supports the concept that the absorption of drugs into the system can be decreased by the consumption of food, although, more research is required in order to get a more detailed understanding of how food affects the absorption of flunitrazepam into the human body. With more knowledge about this topic, more support and assistance may be given to those who have fallen victim to drug facilitated sexual assault.

Acknowledgements

We would like to thank the University of Windsor and the Forensic Science program for funding and providing the resources for this research. Special thanks to Alicia DiCarlo and Sheldon Corcoran for the assistance and support provided throughout the duration of this research.

\begin{table}[h]
\centering
\caption{Absorption readings of the control and experimental samples.}
\begin{tabular}{|c|c|}
\hline
Control & Experimental \\
\hline
1.800 & 1.660 \\
1.850 & 1.640 \\
1.760 & 1.850 \\
\hline
\textbf{Average: 1.803} & \textbf{Average: 1.717} \\
\hline
\end{tabular}
\end{table}
References


The Effectiveness of Common Fingerprint Techniques to Visualize Latent Fingerprints on Tim Horton’s Cups

Brooke Frisby 1*, Steve Hubley 2, and Melinda Mravik 1

Abstract: Tim Horton’s cups are commonly found at crime scenes, but are not usually collected for fingerprint analysis, as there has been no previous research on visualizing fingerprints on Tim Horton’s cups. The effectiveness of common fingerprint techniques, black magnetic powder, fluorescent magnetic powder, 2,2-Dihydroxyindane-1,3-dione (Ninhydrin), 1,2-Indanedione, and 1,8-Diazafluoren-9-one (DFO), was evaluated in this study using alternate light sources to visualize latent fingerprints on Tim Horton’s cups after 24 hours of being laid. Magnetic powder, Ninhydrin, and Indanedione were not found to be effective methods to visualize fingerprints on Tim Horton’s cups. Fluorescent powder developed low quality visible prints. Whereas, DFO developed the highest quality fingerprints on most areas on cup.

Keywords: black magnetic powder, DFO, fluorescent magnetic powder, Indanedione, Ninhydrin,

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Introduction

Tim Horton’s is a popular brand in Canada and their cups have been left at various crime scenes, though not collected to be analyzed for fingerprints by many investigators. There has been no previous research to determine which fingerprint method is best to visualize and analyze fingerprints left on Tim Horton’s cups. These cups are unique due to the fact that they are multi coloured and depending on the time of year the cup design changes, as well as the inner surface of the cup is a waxy material. Our goal was to determine which, if any, common fingerprint methods show the best results, to create awareness and encourage investigators to collect these cups, which will allow them to have another surface to investigate. If prints are found on the cup, and there is a match, the individual will have to explain why their prints were present on the cup and why the cup was located at the crime scene.

Five common fingerprint techniques will be tested on Tim Horton’s cups; DFO (1,8-Diazafluoren-9-one), Ninhydrin (2,2-Dihydroxyindane-1,3-dione), Indanedione (1,2-Indanedione), black magnetic powder and fluorescent magnetic powder. Alternate light sources will be used to enhance the prints; UV, and five different wavelengths; 415nm, 450nm, 505nm, 530nm, 545nm, along with red, orange, and yellow goggles.

Every individual has a unique fingerprint, due to the ridge detail, which allows investigators to use this as a tool in identifying people. There are two common fingerprint types, latent and patent. Latent prints are invisible and need an alternate light source to visualize the print, such as fingerprint powders, chemical reagents, or alternative light sources. Patent prints are prints that are visible and are formed when the impression is made in blood, dirt, ink, paint, etc. Forensic investigators use an ACE-V (analysis, comparison, evaluation, and verification) method for identification of fingerprints. Analysis is used to examine the document and prints. Comparison is when the examiner finds features in the unknown prints and the known prints separately. Evaluation is when the examiner compares the unknown print to the known print and determines whether there is an identification, exclusion, or if it is inconclusive. Verification is when a second qualified expert repeats the process to come up with their own identification, exclusion, or determines if it is inconclusive.

DFO is a chemical that reacts with amino acids present in the fingerprint impression to create a red-coloured visible product. To create maximum fingerprint development the object is heated, for an example in an oven, at 200°F. Since DFO is usually used before Ninhydrin, it is believed that DFO does not react will all types of amino acids, which allows Ninhydrin to produce further results. DFO is used on porous surfaces, such as paper or unpainted wood.

Ninhydrin is another chemical that reacts with amino acids that are present in the fingerprint impression, but forms an intense purple called Ruhemann’s purple. To make sure the
fingerprint is at its maximum development, the object is heated in an oven, with water present to create humidity, at 200°F. This process is also used on porous surfaces, such as paper or unpainted wood.

Indanedione reacts with amino acids and is considered a substitute for DFO, as in some tests it produces a more detailed fingerprint impression. It is also used on porous surfaces and produces a pale pink colour when treated and placed in an oven at 200°F for at least 10 minutes.

Magnetic powders can be used on porous or non-porous substances, such as rubber, Styrofoam and plastics. Using a magnetic wand, the iron filaments connect with the oily residues that are left on the surface of the object to create a visible print. Fluorescent magnetic powder is typically used on multicoloured, textured, and non-porous surfaces. UV light or an alternate light source should be used when viewing the results for fluorescent powders.

In the present research prints were left on the Tim Horton’s cups for 24 hours to be analyzed during this experiment to see if these chemicals will work for “fresh” prints. Three individuals placed three prints (strong, medium, weak) to be processed by three chemicals (DFO, Ninhydrin, and Indanedione) and two powders (black magnetic and fluorescent magnetic) then photographed.

**Materials**

- 20 Large Tim Horton’s Cups
- DFO HFE-7100 Solution (spray)
- Ninhydrin (spray)
- 1,2-Indanedione (spray)
- Black Magnetic Fingerprint Powder
- Magnetic Brush x2
- Fluorescent Magnetic Fingerprint Powder
- Fingerprint scales
- Printer Paper
- Flashlights of different wavelengths (UV, 415nm, 450nm, 505nm, 530nm, 545nm)
- Goggles (Red, orange, yellow)
- Scalpel
- Fingerprint pencil (black)
- Black Permanent Marker
- Digital Camera- Nikon D300 DSLR
- Computer

**Methods**
Five methods will be discussed to correspond with the five different chemicals/powders that we used; to compare DFO to Ninhydrin two cups will have their fingerprints cut in half, DFO and Ninhydrin (as Forensic Identification Officers would normally do), Indanedione, magnetic powder, and fluorescent magnetic powder. Before the chemicals are used the three subjects must lay three fingerprints (strong, medium, weak) down on the 10 cups, which have labelled sections with the subject’s initials. These three impressions are to show the results of different oil compositions that could be laid. For example, a person with a very “sweaty” fingerprint impression may be smudged, or have little to no ridge detail in the print. The deposition force and the time the print makes contact with the cup should be as consistent as possible. 24 hours after the prints have been laid, they were processed with their respective chemicals. Two cups were used for each chemical, while the overall experiment was replicated once. In order to show realistic results, we used prints from groomed, sweaty and natural prints. Groomed prints were used from our sebaceous glands, sweaty were from keeping hands in non-latex gloves, and natural were as prints are. For the first trial Melinda’s prints were the groomed prints, Steve’s prints were natural prints, and Brooke’s prints were sweaty prints. For the second trial Melinda’s prints were sweaty prints, Steve’s prints were the groomed prints, and Brooke’s prints were natural prints.

Comparing DFO to Ninhydrin (D/N)

1. Divided the cup into three sections by labelling the top with the initials of the three subjects
2. Placed three circles in each section (9 on each cup)
3. Each subject touched the cup three times in the designated areas
4. Cups were stored in a closed box for 24 hours
5. After 24 hours, the cups were taken out of the box
6. Cut the fingerprint impressions in half by cutting the cup into 4 sections, as shown in Figure 1

![Figure 1: Diagram of D/N Cup](image-url)
7. Divided and labeled the sections- For the First cup (Cup A) into 4 sections- 1,2,3,4 and the second cup (Cup B) into 4 sections- 1,2,3,4; 1B, 3B, 2A, 4A were processed with DFO and 1A, 3A, 2B, 4B were processed with Ninhydrin
8. Using proper personal protection equipment (PPE) we sprayed the designated strips and test papers with DFO and the others with Ninhydrin, twice
9. Placed the DFO strips and test paper into an oven at 200°F for 20 minutes
10. Let the DFO strips and test paper sit for 24 hours, by placing them in a closed box
11. Place the Ninhydrin strips and test paper into an oven with a cup of water (to produce humidity) at 200°F for 20 minutes
12. Let the Ninhydrin strips and test paper sit for 24 hours, by placing them in a closed box
13. After 24 hours we looked at the test paper and determined the wavelength and goggles that produced the best result; DFO- 505nm with orange goggles, Ninhydrin- 450nm with yellow goggles
14. Photographed all results and enhanced any visible prints that show using Photoshop CS6

**DFO then Ninhydrin (D-N)**

1. Divided the cup into three sections by labelling the top with the initials of the subjects
2. Each subject touched the cup three times in the designated areas
3. Cups stored in a closed box for 24 hours
4. After 24 hours, we took the cups out of the box
5. Using proper PPE, sprayed the two cups with DFO, twice
6. Placed cups in oven at 200°F for 20 minutes
7. Allowed the cups to cool
8. Using proper PPE, sprayed the two cups with Ninhydrin, twice
9. Placed in oven with a cup of water at 200°F for 20 minutes
10. Allowed the cups to sit for 24 hours
11. Determined which wavelength and goggles produces the best results which was 450nm with red goggles
12. Photographed all results and enhanced any visible prints using Photoshop CS6

**Indanedione (I)**

1. Divided the cup into three sections by labelling the top with the initials of the subjects
2. Each subject touched the cup three times in the designated areas
3. Cups stored in a closed box for 24 hours
4. After 24 hours, took the cups out of the box
5. Using proper PPE, sprayed the two cups with Indanedione, twice
6. Placed cups in oven at 200°F for 20 minutes
7. Allowed the cups to sit for 24 hours
8. Determined which wavelength and goggles produces the best results; 505nm with orange goggles
9. Photographed all results and enhanced any visible prints using Photoshop CS6

**Magnetic Powder**

1. Divided the cup into three sections by labelling the top with the initials of the subjects
2. Each subject touched the cup three times in the designated areas
3. Cups stored in a closed box for 24 hours
4. After 24 hours, took the cups out of the box
5. Using proper PPE, dusted the two cups with a magnetic brush
6. Allowed the cups to sit for 24 hours
7. Analyzed the prints with the naked eye
8. Photographed all results and enhanced any visible prints using Photoshop CS6

**Fluorescent Magnetic Powder**

1. Divided the cup into three sections by labelling the top with the initials of the subjects
2. Each subject touched the cup three times in the designated areas
3. Cups stored in a closed box for 24 hours
4. After 24 hours, took the cups out of the box
5. Using proper PPE, dusted the two cups with a magnetic brush
6. Allowed the cups to sit for 24 hours
7. Determined which wavelength and goggles produces the best results; 450nm with yellow goggles
8. Photographed all results and enhanced any visible prints using Photoshop CS6

To further show how the prints were laid for each method refer to Figure 2.
<table>
<thead>
<tr>
<th>Method 1</th>
<th>Method 2</th>
<th>Method 3</th>
<th>Method 4</th>
<th>Method 5</th>
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<tbody>
<tr>
<td>D</td>
<td>N</td>
<td>D-N</td>
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<td>M</td>
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<tr>
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</tbody>
</table>

*Figure 2: Table of how the prints were laid on each cup for all methods.*

**Results & Discussion**

**Trial 1:**

1) Magnetic Powder:
   a. Cup 1: strong, medium, and weak groomed prints were visible, though no ridge detail was observed, as shown in Figure 3. No prints were observed for sweaty or natural prints on this cup.
   b. Cup 2: no indication of visible prints on groomed, sweaty, or natural prints on this cup.
Figure 3: Trial 1 Cup 1 Magnetic powder method showing all three of groomed prints laid by Melinda.

2) Fluorescent Powder (using yellow goggles and 450nm wavelength):
   a. Cup 1: strong, medium, and weak groomed prints were visible with a little ridge detail visible, as shown in Figure 4. No sweaty or natural prints were detected on this cup.
   b. Cup 2: no indication of groomed, sweaty, or natural visible prints.

Figure 4: Trial 1 Cup 1 Fluorescent powder method showing all three prints for groomed prints laid by Melinda.

3) Indanedione (using orange goggles and 505nm wavelength):
   a. Cup 1: strong sweaty print visible, though no ridge detail was observed, as shown in Figure 5. No other sweaty, groomed, or natural prints were detected on this cup.
   b. Cup 2: no indication of groomed, sweaty, or natural visible prints.
Figure 5: Trial 1 Cup 1 Indanedione method showing a strong sweaty print laid by Brooke.

4) DFO-NIN (using red goggles and 450nm wavelength):
   a. Cup 1: strong, medium, and weak groomed prints visible. Weak groomed prints showed high level of ridge detail, as shown in Figure 6. Strong, medium, and weak sweaty prints were visible, though little to no ridge detail present. No natural visible prints.
   b. Cup 2: no indication of groomed, sweaty, or natural visible prints.

Figure 6: Trial 1 Cup 1 DFO-NIN method showing ridge detail in the weak groomed print (left) laid by Melinda in comparison to the enhanced print (right) using Photoshop CS6.

5) DFO/NIN (using orange goggles and 505nm wavelength and yellow goggles and 450nm wavelength, respectively):
   a. Cup 1: Strong sweaty print with minimal ridge detail, using orange goggles and 505nm wavelength. No other sweaty, groomed, or natural prints were visible.
   b. Cup 2: Strong sweaty print with high ridge detail, using orange goggles and 505nm wavelength, as shown in Figure 7. No other sweaty, groomed, or natural prints were visible.
Trial 2:

1) Magnetic Powder:
   a) Cup 1: no indication of groomed, sweaty, or natural visible prints.
   b) Cup 2: strong, medium, and weak groomed prints, with strong and weak having ridge detail visible. No sweaty or natural prints visible.

2) Fluorescent Powder (using yellow goggles and 450nm wavelength):
   a) Cup 1: strong, medium, and weak groomed prints visible with little ridge detail. No sweaty or natural prints visible.
   b) Cup 2: strong and medium sweaty prints visible with minimal ridge detail. Strong, medium, and weak groomed prints visible with ridge detail, with medium groomed prints shown in Figure 9. No natural visible prints.
3) **Indanedione** (using orange goggles and 505nm wavelength):
   a) Cup 1: no indication of groomed, sweaty, or natural visible prints, as seen in Figure 10.
   b) Cup 2: no indication of groomed, sweaty, or natural visible prints.

4) **DFO-NIN** (using yellow goggles and 505nm wavelength and orange goggles and 505nm wavelength, respectively):
   a) Cup 1: no indication of groomed, sweaty, or natural visible prints, as seen in Figure 11.
   b) Cup 2: no indication of groomed, sweaty, or natural visible prints.
5) DFO/NIN (using orange goggles and 505nm wavelength and yellow goggles and 505nm wavelength, respectively):
   a) Cup 1: no indication of groomed, sweaty, or natural visible prints, as seen in Figure 12.
   b) Cup 2: no indication of groomed, sweaty, or natural visible prints.

Further research needs to be conducted to determine a better way to lay the fingerprints down, so that not all the oils in the prints are used up right away, as well as making the circles smaller to lay the prints in, so that the cut will be more directly in the middle of the prints. Interference of prints from employees of Tim Horton’s did not seem to be a factor while this research was conducted. Deposition force and time should continue to be taken into consideration while research is being conducted. A combination of methods could be used to produce results, such as with DFO in the areas which lacked results, due to the high intensity of colour.
Conclusion

In conclusion, DFO showed the most ridge detail on Tim Horton’s cups in the first trial, though no prints were visible in the second trial. Fluorescent powder was the next promising method, followed by magnetic powder. Indanedione and Ninhydrin did not produce any visible prints during both trials.

Acknowledgements

A huge thanks are given to Cst. Steve Hubley and the Chatham-Kent Forensic Identification Unit for allowing us to use their resources to conduct this experiment and also for helping us to analyze the final results. Thank you to Melinda Mravik for collaborating with me on this project. We wish to thank the Forensic Sciences Program at the University of Windsor for providing the necessary funding for this research.
References


A Qualitative Evaluation of the Effect Cleaning Products Have on the Bluestar Test for Latent Blood

Alicia DiCarlo 1*, Dr. Shashi Jasra 1

Abstract:

In violent crimes, blood is one of the most common physical evidence that may be found. However, with the interest of forensic investigation being on the forefront for many years, criminals have become more knowledgeable about the necessity of cleaning their scene. Due to the attempted clean up, the effects of household chemical cleaners on presumptive tests might cause false positive or negative results. In order to assess this, cleaners (Clorox, Green Works, Lysol, and Windex) were used on floor surfaces (carpet, ceramic tile, and press-on vinyl tile), and their effects were qualitatively examined with relation to the Bluestar test for latent blood detection. This resulted in no effect by Windex and Green Works, a false-positive by Clorox, and a false-negative by Lysol.

Keywords: Blood detection, Blood detection change, Bluestar, Clean up, Clean up effects, Crime Scene, Forensic Science, Household cleaners.

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Introduction

Blood is one of the most common types of physical evidence in violent crimes, and its analysis can provide very useful information. Today, there are many presumptive tests for the detection of this very important bodily fluid, including the forensic luminol test. Luminol has been used in the field of forensic sciences for over 60 years as a presumptive test for blood stains, starting from its creation by Walter Sprech in 1937. This chemiluminescent product has enabled investigators to visualize, evaluate, and collect latent, or invisible, bloodstains.

Chemiluminescence is the production of light from a chemical reaction. The reactants form a high-energy intermediate, which breaks down releasing some energy as photons, a quantum of light energy. When these photons have a wavelength that is found in the range of visible light, the change from high-energy intermediate to ground level is perceived as light of a particular colour.

The chemiluminescence of luminol is based directly on the availability of haemoglobin in bloodstains and creates a blue-green colour with no need for a light source. Since luminol is a presumptive test it is clear that it can release chemiluminescence without the presence of haemoglobin producing a false-positive result.

Bluestar is a luminol based presumptive reagent for the detection of latent bloodstains. However, the properties of this reagent make it more convenient to use on crime scenes. Unlike luminol it does not require complete darkness and it can be sprayed several times without an effect on its chemiluminescence. Dr. Loic Blum discovered this solution in 2000. Bluestar takes on the mechanism depicted in Figure 1 to produce chemiluminescence with blood. Chemiluminescence requires a catalyst, which in the case of luminol and luminol based products, is the iron in the haemoglobin.

![Figure 1. Reaction mechanism of Bluestar with haemoglobin from blood.](image)

J.I. Creamer, et al, completed an experimentation of the interferences on the luminol test for blood in 2003. To do so a wide variety of substances were chosen and the chemiluminescence of each was tested.
with luminol to determine the shift in peak chemiluminescence.\textsuperscript{4} This was done very thoroughly for luminol, however only resultants giving a change were released.\textsuperscript{4}

In the experiment by A. Nilsson, it is acknowledged that cleaning can affect the chemiluminescence of luminol.\textsuperscript{1} However, it is not shown past the use of bleach-based cleaners.

Lisa Dilbeck completed an experimentation in which she compared luminol to Bluestar. With this experimentation it was determined that Bluestar has distinct advantages in comparison.\textsuperscript{2} These advantages were determined in the following categories: ease of mixing, lack of complete darkness, and intensity after initial spray.\textsuperscript{2} Moreover, Dilbeck noted that Bluestar is as sensitive in detecting dilute concentrations of blood as luminol.\textsuperscript{2} However, where this study fell short was in determining the limitations of this presumptive reagent and there was no reference to any effects brought on by Bleach (the only household cleaning product used).

In the following study the effects of four common household cleaners will be tested with the Bluestar test for latent blood. By focusing strictly on cleaning products, the research will aid in determining if a crime scene has been cleaned of blood. Since this has not yet been an exclusive study in the past, it will be completed qualitatively. In that regard, it will expand the knowledge we have on the effects of clean up on the visualization of latent blood and will go to directly show how each product changes the chemiluminescence to the naked eye, as well as to a cameras exposure. This will therefore determine whether specific cleaners will cause a false-positive, false-negative, or have no effect on the Bluestar test for latent blood detection.

**Materials and Methods**

In order to complete the laboratory experiment one used the household cleaners Lysol Power & Free Multi-Purpose Cleaner With Hydrogen Peroxide, Green Works All Purpose Cleaner, Clorox Clean-Up Disinfectant Bleach Cleaner, and Windex Original Glass & More Cleaner With Ammonia-D, four ceramic tiles, four vinyl stick on tiles, one bathroom rug cut into four sections, six multi-purpose cellulose sponges cut in half, 2 Bluestar kits, water, spray bottle, blood, and tape.

In starting the experiment one created the test surfaces. To do so, each tile and carpet piece was divided into four sections using strips of tape to visually show the division. Blood was then taken into a sponge and impacted onto the three of the four quadrants and left for 24 hours minimum to dry (as per T.I. Quickenden and Paul D. Cooper).\textsuperscript{5} Following this drying period, two quadrants of blood and the blank section were wiped with one of the household cleaners such that the test surfaces had the following pattern depicted in Figure 2.
Q1 and Q2 act as a control where Q3 and Q4 are the experimental portions. Q3 is wiped only once such that blood is still visible to the naked eye where Q4 is representative of the area cleaned in a way that the naked eye cannot see any residual blood. Following this cleaning, the test surfaces were left in order to dry for a minimum of 2 hours (in this time, carpet samples were repositioned halfway through to move from wet spot created by cleaner seeping onto table). In the drying time the luminol solution was created. To do so one followed the instructions on the kit.

They read,

“1. Open spray bottle; add 125mL (4 fl. Oz) of distilled water. Then add a pair of BLUESTAR FORENSIC “TRAINING” tablets. If you need more working solution use 125mL (4 fl. Oz) per pair of tablets.
2. Mount the plunger onto the spray bottle head and screw on the head of the bottle firmly.
3. Allow about 1 to 2 minutes for complete dissolution and mixing of chemicals, stirring gently with a circular motion of your hand. Do NOT shake the container upside down.”

Following the completion of the drying, test surfaces were sprayed with the Bluestar solution. Once sprayed, the results were photographed using a shutter speed of 30 seconds, and F13 stop with an ISO of 800. These methods were followed for all 12 of the test surfaces.

**Results**

In completing the initial tests with the Clorox cleaning product it was shown in Q1, the cleaner control, that there was streaking. This was mainly observed in person, however is not as notable in the photographs captured. These tests are depicted in Figure 3, Figure 4, and Figure 5.
Figure 3. Carpet cleaned with Clorox

Figure 4. Ceramic tile cleaned with Clorox
The next tests were completed using Lysol. In Q3, the blood wiped once with cleaner, there is hints of the brightness being depleted when compared to Q2, the blood control. However when viewed, the naked eye detected no light in the Q3 section. This is depicted in Figure 6, Figure 7, and Figure 8.

Figure 5. Press on tile cleaned with Clorox

Figure 6. Carpet cleaned with Lysol
Figure 7. Ceramic tile cleaned with Lysol

Figure 8. Press on tile cleaned with Lysol
Finally in the trials with Green Works and Windex it can be noted that there is no difference in the appeared brightness between Q2, Q3, and Q4, the blood wiped visibly away with cleaner in the figures Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, and Figure 14. However, in Q1 of Figure 12, Figure 13, and Figure 14 some streaking is noted in the photographs that were not visible in person.

Figure 9. Carpet cleaned with Green Works

Figure 10. Ceramic tile cleaned with Green Works
Figure 11. Press on tile cleaned with Green Works

Figure 12. Carpet cleaned with Windex
Figure 13. Ceramic tile cleaned with Windex

Figure 14. Press on tile cleaned with Windex
Discussion

After viewing the resultant images there is a clear difference between the cleaners. In the experiments completed using Green Works and Windex it is noted that there is no difference between Q2, Q3, and Q4. This gives rise to these cleaners not having an effect on the Bluestar test for latent blood detection. However, in Q1 of the Windex trials streaking can be viewed in the images. At this stage of the experimentation there can be no comment made on why this has occurred.

In the experiments cleaned with the Lysol there was a clear difference between Q2 and Q3 in Figure 6, Figure 7, and Figure 8. In these images it is noted that Q2 is significantly brighter than Q3. This was extremely visible to the naked eye where no chemiluminescence was visible in the Q3 section. Since the light entering a cameras sensor is additive the slight chemiluminescence is shown more in the resultant images. This decrease in chemiluminescence is a slight false-negative result showing that the use of Lysol will affect the Bluestar test. An experiment by Enika Nagababu and Joseph Moses Rifkind in 2000 shows a reaction between hydrogen peroxide and the haem

\[
\text{Hb(II) + H}_2\text{O}_2 \rightarrow \text{HbFe(IV)=O + H}_2\text{O}_2} \\
\text{HbFe(III) + O}_2^\cdot \rightarrow \text{heme degradation}
\]

Figure 15. Haem degradation by hydrogen peroxide

This can be modeled by the reaction mechanism in Figure 15. Because of the hydrogen in the Lysol cleaner degrades the haem group in the blood it quenches, or partly quenches, the ferryl haem needed to catalyze the reaction with Bluestar. This means there will be little to no chemiluminescence produced after cleaning.

This is the reverse of what happens with the Clorox cleaner in Figure 3, Figure 4, and Figure 5. In these images it is noted there is streaking in Q1 as well as slight brightening of Q3 when compared to Q2. In the observation of the experiment taking place the streaking was very bright for a short amount of time. This is indicative of false-positive reaction. These results are consistent with testing completed by Dilbeck and Nilsson.

Conclusion

It can be concluded that the results obtained were successful in determining the false-positives or false-negatives due to household cleaners on the Bluestar test for latent blood. This was observed through using three test surfaces and cleaning blood stains off of them with household cleaners. It was shown that Lysol has a false-negative result, Clorox has a false-positive result, and Green Works and Windex show no change on the Bluestar test.
Acknowledgements

Thanks are given to Dr. Shashi K. Jasra for her advisory during the time of this research, the provision of all chemical reagents, and the assistance in choosing the best reagent to visualize the results for the experiment. I would also like to thank Forensic Sciences at the University of Windsor for providing funding for this research.
References


The Forensic Biometric Analysis of Emotions from Facial Expressions and Physiological Processes from the Heart and Skin

Azeza Al Masri 1* and Shashi K. Jasra 1*

ABSTRACT:

Decision-making, perception, memory and social interactions are greatly driven by emotion. Emotions can be measured from facial expressions through the facial muscles. A group of four students were exposed to emotionally loaded stimuli (videos and images) in its full complexity to assess the valence of the emotional expression, the associated arousal, skin respiration and the heart rate. The i-Motions software has the capability to detect voluntary as well as involuntary physiological responses of the different individuals. The responses of the participants when shown different stimuli were personalized. The software has great potential in the forensic sciences for analyzing the responses.

Keywords: Biometrics, physiological processes, emotions, forensic science, skin, GSR, heart, brain

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Introduction

Emotions are one of the factors that make humans different from other species and they aid greatly in criminal investigations. There are three critical components of an emotion; the first component is how a person experiences the emotion, the second component is how this person’s body reacts to the emotion, and the third component is what behavior is in response to the emotion. Some respondents in the research may be able to control some of their facial expressions and emotions, but they may not be able to control their skin sweating nor their heartbeat. Facial expressions are grouped into two categories; voluntary and involuntary facial expressions. The brainstem controls involuntary and unconscious expressions that occur on the face. On the other hand, the motor cortex controls the intentional and conscious facial expressions. This is why a fake smile does not appear genuine. A fake smile does not trigger neurological, emotional and physiological responses from the body as a genuine smile. In the brain, the amygdala controls the threatening, fearful, high sexual appeal or body pleasure and autonomic functions associated with arousal. Therefore, the motor cortex controls some of the voluntary facial expressions, while the amygdala controls voluntary functions including facial expressions, pupil dilation, respiration, skin conductance and heart rate.

Humans are able to produce varying sets of facial expressions, but the universal facial expressions that everyone can make are joy, anger, surprise, fear, contempt, sadness and disgust. Galvanic skin response (GSR) originates from the activation of the excretion of sweat from sweat glands. The sweating in the arms and soles of the feet is triggered by emotional arousal. Therefore, the galvanic skin response can detect patterns associated with emotions that can be quantified statistically. The density of sweat glands varies in the body, but the densest areas with sweat glands are the forehead, cheeks, palms, finger and the soles of the feet.

When sweat glands become activated, they secrete moisture through the pores to the surface of the skin. The changing positive and negative ions in the sweat causes a current to flow and changes in skin conductance. As skin conductance increases, skin resistance decreases. GSR is measured in Micro-Siemens or Micro-Mho. GSR sensors have a 1-cm² measurement site made of silver/silver-chloride and are placed in Velcro straps. In a research paper with the title “Forensic psychology: Violence viewed by psychopathic murderers”, they did an Implicit Association Test, which is a measure of the hidden attitudes and beliefs that a person may not be willing or unable to report. They used this research to prove that psychopathic murderers have abnormal cognitive traits to boost their violent actions. In their research, they stated that violent murderers lack remorse, they are emotionless, lack sympathy, excellent lying abilities and can control their emotion. Not every facial expression is voluntary and this research there is the ability to find out which of the respondents are able to control their facial expressions and feeling, but at the same time, the respondents cannot control their heart rate nor their skin (the amount of sweat). Another device used in this research is the PPG (photoplethysmography) which are light sensors that sense the rate of blood flow by the heart’s pumping action.
In another research paper, they used the concept when people view certain documents; they have emotions associated with this document. They had 763 volunteers and they studied the results aggregated or collectively. They tagged basic emotions such as anger, disgust, fear, happiness, and sadness and analyzed their intensities. They retrieved the images from Flickr.com and each image caused an emotion and analyzed their data using SPSS. Hence, it seems possible to apply collective image emotion tagging to present a new search option for basic emotions. Their analysis was based on emotional surveys based on PHP and HTML.

Using i-Motions software, the facial expressions are detected depending on the head orientation. It has six facial landmarks (eye and nose position). There are seven basic universal emotions, valence; and gives the ability to analyze complex states such as frustration, confusion, in addition to twenty Action Units, regardless of the respondent’s sex and whether or not respondent wears glasses. It can give live analysis of the emotions as well.

This research in biometrics are aids investigating offences, individualizing a perpetrator, and describe the forensic evaluation of the activity of an individual. This research can introduce a useful tool to the forensic world as it could be used to avoid wrongful convictions, in airport security to indicate potential terrorism threat. It can greatly aid in lie detection and help police officers in investigation interviews. It could also be used to analyze the true emotions and intentions of witnesses and suspects in court or in a lineup.

Materials

i-Motions software. A quiet office at the University of Windsor to avoid distractions with comfortable seating and great lighting. A shimmer kit that includes; a galvanic skin response and heart rate. Logitech HD camera and a fast laptop for mobility and simplicity of use with Bluetooth connection.

Methods

1. In the office the temperature has to remain between 20 to 24 degrees Celsius to avoid any changes in the results due to environmental stress
2. The temperature was 22 degrees Celsius
3. Open the window slightly to allow for air flow
4. Download and install the i-Motions software on a laptop
5. Connect the webcam to a USB and launch the software
6. Configure the device from the global tap, then preferences, then video and select the camera as Logitech HD, select the audio device and click preview. Check allow the webcam to collect data.
7. Connect the shimmer dock to the laptop using the USB port; make sure the shimmer device is fully charged and ready to be used.
8. Configure the device from the global tap, then preferences, then sensor. Add the shimmer sensor and select the USB port of the shimmer dock. Click on configure. Let it load and select the GSR, In A13 (optical heart rate). Enable Heart rate conversion, set it at 2 and select Internal ADC channel A13 from the drop down menu. Enable sampling rate at 102.4Hz and set GSR at auto range. Click apply.
9. Confirm that the shimmer sensor connection is high and it is at 102.4Hz. Make sure there is a green square around the face in the camera allowing for facial detection.
10. Start a new study in iMotions software
11. Add the stimuli (pictures and videos)
12. Each picture and video is associated with one of the seven basic emotions. Choose to show the pictures and videos in a random order. The pictures are shown to the respondent for 8 seconds.
13. Add a respondent
14. Type the date, name, age, gender and any comments
15. Record and calibrate the neutral emotion of the respondent (this step is called recording a baseline). It is 6 seconds long. The purpose of this step is to remove any bias during the analysis.
16. The stimuli will appear right after the baseline
17. Shown or given specific stimuli, such as a videos and pictures.
18. Each of the following stimuli is associated with an emotion.
19. Have the respondent sit on the comfortable seat
20. Make sure there is proper illumination of the face with a dark background
21. The respondents must relax and not talk
22. Informed the respondent about the consent ethics form and explained the procedure
23. If long hair, make sure face is not occluded.
   - No hats
   - No sun glasses
   - No talking on mobile phones
   - No chewing gum
   - No beverages
24. Head position in relation to the camera is frontal and straight for all respondents, but + or -20 degree angle is acceptable.
25. Inform the respondent not to move their limbs to avoid any discrepancies in the results
26. The GSR Velcro strap is wrapped around the respondent’s index and middle finger
27. The PPG Velcro strap is wrapped around the respondent’s ring finger
28. For both the GSR and PPG, the device has to be to the inside of the palm on the finger
29. The participants see the stimuli for the very first time and then they react to it.
30. Click record when ready.
31. Their reaction is recorded using the iMotions software
32. The data is analyzed from the colored graphs for each of the emotions. The data of the skin and heart are also analyzed.

33. The raw data is exported to be further analyzed and downloaded in an excel file.

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Stimulus Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Picture</td>
<td>A grasshopper in the mouth of a human</td>
</tr>
<tr>
<td>2 - Picture</td>
<td>Factories polluting the environment</td>
</tr>
<tr>
<td>3 – Video – length 1:04 sec</td>
<td>Sharks eating and attacking humans</td>
</tr>
<tr>
<td>4 – Video – length 1:48 sec</td>
<td>News report about two friends stabbing and violently trying to kill their third friend</td>
</tr>
<tr>
<td>5 – Picture</td>
<td>Homeless child sitting in the street with a toy</td>
</tr>
<tr>
<td>6 – Picture</td>
<td>Poor child looking for food in the trash</td>
</tr>
<tr>
<td>7 – Picture</td>
<td>Laughing infant with eyelashes as his eyebrows</td>
</tr>
</tbody>
</table>

### Results

Even though some of the participants tried to control some of their facial expressions when exposed to some stimuli, their galvanic skin response as well as their heart rate and optical heart rate gave a clear idea of whether they were happy or joyful, threatening or fearful. To avoid any biases of reactions, in case any of the participants sees the labelling of the pictures and videos, they were labelled by numbers. The respondents were exposed to the stimuli for the first time. The respondents reacted to the stimuli based on their knowledge and experiences. There were similar reactions between the respondents, but some reaction to the stimuli were more intense than others.

<table>
<thead>
<tr>
<th>Stimulus Label</th>
<th>The Associated Emotion With the Stimulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Emotion – baseline</td>
</tr>
<tr>
<td>1</td>
<td>Disgust</td>
</tr>
<tr>
<td>2</td>
<td>Contempt</td>
</tr>
<tr>
<td>3</td>
<td>Fear</td>
</tr>
<tr>
<td>4</td>
<td>Surprise</td>
</tr>
<tr>
<td>5</td>
<td>Sadness</td>
</tr>
<tr>
<td>6</td>
<td>Anger</td>
</tr>
<tr>
<td>7</td>
<td>Joy</td>
</tr>
</tbody>
</table>

To analyze the emotions first, the participants had personalized emotions. A facial expression does not have to be a representative of a single emotion; it could be a representative of two emotions or more. For all stimuli, when there is an increase in Galvanic skin response
there is a peak in PPG. The facial expressions of Male 2 remained neutral for around 50% of the time, but there were great changes in the heart rate PPG and GSR. There was an increase in the heart rate, peaks in PPG and an increase in GSR. Even though there was a decrease of GSR at the end of the stimuli, the heart rate and PPG still increased. There was a reaction when exposed to stimulus 2, which is disgust, there was an increase in heart rate, the peaks of PPG became more prominent and there was an increase in GSR. For Female 1, there was a decrease in heart rate, a decrease in GSR, but the peaks for PPG became more prominent, this may be an indicator of stress when watching stimulus 3. All respondents have similar responses to the stimuli, but each response varies in intensity.

The results of the different stimuli with emotional reactions such as joy, surprise, anger, fear, contempt, disgust and sadness by individual respondents are depicted in the Figures 1-7. Comparison of the neutral, positive and negative time percentage to all the stimuli by the respondents are shown in Figure 8-10.

The analysis of the GSR for stimulus 1, 2 and 3 for all the respondents are shown in Figures 11-13.

![Comparison of Joy Time Percent Aggregate](image)

*Figure 1: Female 2 spent 2 percent of the time in joy and male 1 spent 10 percent of the time in joy when shown stimulus 1. Change in emotion was visible in stimulus 3, 4, 6 and 7*
Figure 2: Female 2 had a surprise emotion for 6% of the time when shown stimulus 6 and 5% when shown the baseline

Figure 3: Male 1 showed anger in stimulus 4
Figure 4: None of the participants showed a facial expression of fear to any of the stimulus.

Figure 5: Many of the participants had the emotion of contempt. Mainly in stimuli 1, 3, 4, 5, 6, and 7.
Figure 6: Zero disgust time percent for all respondents.

Figure 7: Female 1 was sad at 2 percent of the time.
Figure 8: Male 2 had around 50 neutral time percent for all stimuli, Male 1, female 1, female 2 had varying emotions depending on the stimulus.

Figure 9: Male 1 and Female 2 showed positive time spent with stimuli 1, 4, 5 and 1, 2 and 5 respectively.
**Figure 10:** Male and Female 2 showed negative time spent mainly with stimuli 1, 2, 4 and 1, 3, 4, 5 respectively.

**Figure 11:** Increased GSR for Male 1 and decreased GSR for Male 2.
Figure 12: Increased GSR for Male 1

Figure 13: There is an increase in GSR for MALE 1
Discussion

The heart rate is not directly proportional to the GSR. At some points of the analysis, there was an increase in the heart rate, but there was a decrease in GSR. This is because the respondent has no idea what may happen in the next stimulus. In other cases, there was an increase in heart rate, GSR and PPG, indicating a highly stressful condition for the respondent. There is no cardiovascular or cardio respiratory change because of this change in heart rate; it is simply the effect on the heart of chemicals and nerves responding to an external experience. The sympathetic components increase heart rate by releasing the neural hormone catecholamines - epinephrine and norepinephrine. The cardiovascular control center for the body is located in the ventro-lateral medulla. Here heart rate slows if activated by the cardio inhibitory center in the medulla or speeds up if activated by the cardio accelerator. Some of the respondents focused on keeping their neutral facial expression and forgot about keeping the neutral heart rate and galvanic skin response.

The results would vary if the respondents saw the stimuli for the first time versus respondents who already saw the stimuli then their reactions were recorded.

The Implicit Association Test is used to measure beliefs that people are not willing to report. They may feel fear to report something they believe in due to the consequences that it may lead. The i-Motions software can analyze the true emotions live and record them based on physiological, neurological and emotional processes.

It is important to know the limitations of the research. Part of this research is the study of emotions; there are factors that affect emotions such as lack of sleep, taking medications and the experiences of each person. The intensities of the emotions may be exaggerated or decreased when the person is exhausted. Certain medications may cause certain emotions such as depression. Therefore, all the emotions will be negative. To eliminate this issue, the respondent has to be relaxed, had enough sleep. The research has to be very focused on the variables tested and exclude any unnecessary variables. The respondents for the present study are four volunteers from the same age group. The volunteers are two males and two females. For future studies it would be better to have respondents from different age groups and recording the different emotions based on their experience.

Conclusion

The emotions of the participants varied, from someone who had a completely neutral face, someone who had some facial expressions, and someone who responded to the stimuli
moderately, to someone who reacted to all of the stimuli to some degree. The responses of the participants could vary if they knew the objective of this research or not. The i-Motions software is able to give detailed analysis on each frame of the facial expressions, GSR and heartbeat.

Acknowledgements

This research was supported by Forensic Sciences program at the University of Windsor. Thanks are due to the i-Motions team for support and training and also for providing insight and expertise that greatly assisted the research. Azeza Al Masri thanks her parents and sister, Rama for sharing their pearls of wisdom during the course of this research.
References


Analysis of Ridge Characteristics of Fingerprint from Different Fingers of Monozygotic Twins

Maria Boxwala1*, Mubaraka Boxwala1, Dr. Pardeep K. Jasra1

Abstract: In this research paper, fingerprints, of twins were compared to find any similarities and differences between them. Fingerprints are impression left by the friction ridges of a human finger. During the research the prints were photographed using a video spectral comparator and then compared using CSIpix4 Matcher. The software was very effective in enhancing the print and then marking all the minutiae present. The results indicate that although the overall pattern of the print is different in identical twins, still many similarities in the ridge characteristics exist. These similarities in the ridge characteristics along with the marked differences can play a significance role in identification and other forensic investigations.

Keywords: fingerprints, monozygotic, ridge characteristics, twins

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Introduction

It is well known that identical twins share the same DNA but have different fingerprints\(^1\). The difference in these fingerprints arise because of the development of the embryo in the womb. The interactions of the digit with the wall of the uterus provides the folds that later develop into fingerprints hence they are unique\(^2\). Fingerprints are the phenotypic characteristic of the individual because each finger on each hand grows in a completely different microenvironment.

DNA makes up the genotype of the individual. So in monozygotic twins a sperm and egg combine to form an embryo which then splits to form two fetuses\(^3\). These fetuses are formed from the same genetic makeup of the initial embryo. Therefore DNA is an exact copy in monozygotic twins

Materials and Methods

- Black Fingerprint Ink
- Fingerprint Backing Card
- CSIpix4 Matcher
- Foster+Freeman VSC40/HD

We took prints of both the individuals using black fingerprint ink. These were printed onto a fingerprint backing card. Then photographs of the prints were taken using a video spectral comparator. Images were uploaded into the CSIpix4 matcher software. This software was used to enhance the print and then mark the different minutiae on each print respectively. The matcher option was used to match both the prints at different angles.

Results

It was found that in the fingerprints from almost all the fingers of both the twins there were marked similarities. The minutiae like delta ridge endings, bifurcations etc. were found to be present at exactly the same positions. The maximum points of similarities were found in the **left ring finger**.

*Table 1: Characteristics of the fingerprints on both left and right hands*
Figure 1: Twin 1 and Twin 2 fingerprints of the left ring finger depicting minutiae present at similar positions in both prints. These prints also had the greatest matching score according to the software.
Figure 2: Twin 1 and Twin 2 fingerprints of the left index finger depicting minutiae present at similar positions in both prints. These prints also had the second greatest matching score according to the software.

Figure 3: Twin 1 and Twin 2 fingerprints of the left middle finger depicting minutiae present at similar positions in both prints. These prints also had the third greatest matching score according to the software.

Discussion and Conclusion

The fingerprints development is affected by the environmental factors during embryonic development\(^4\). Our results show that the fingerprints develop differently in identical twins which can be used to differentiate them\(^5\). However there are still many ridge characteristics which are similar in identical twins as shown in this research. In the left ring finger bifurcations and deltas were present at the same location in both the prints. The next two highest matching scores were also present on the left hand indicating that the fingers of this hand had similar minutiae on more than one finger. These similarities can be useful for the identification purposes\(^6\). Also the investigators should consider this aspect of identical twin fingerprints. Further work is being planned to include more characteristics with a larger data set. Toe prints and Palm prints are also being considered a research interest.

Acknowledgements

We would like to thank the Forensic Sciences program at the University of Windsor for providing the resources and funding for our research.


