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Different Factors Influenced and Distorted Regular Transfer Stains in Bloodstain Pattern Analysis

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Abstract: Transfer stains in a crime scene are often difficult to interpret. Given the large number of events that take place each year, this work is largely aimed at analyzing the different factors that influence and distort regular transfer stains. Different physical mechanisms under identical conditions influence the formation of distinct transfer stain patterns.

Keywords: Bloodstain Pattern Analysis, Transfer Stain, Hammer, Imprint in Blood, and Porcine Blood.

Introduction

In the scene of violent crimes bloodstain provides vital clues in respect of the occurrence of events. Bloodstain pattern analyst always relies on the experience of investigator and presents an idea based on the examination of blood at the crime scene and evidence allows him to see what happened in the incident scene based on the flow of blood. This is possible since blood will obey certain laws of physics. After careful observations on bloodstain patterns it is possible to interpret the following things:

1. Nature of the offence
2. Possible sequence of events
3. Disturbance to the scene may occur
4. Position of individuals and objects
5. Prove beneficial in refuting or corroborating eyewitness accounts.

The appearance of a bloodstain can depend on a number of factors, including the velocity at which it was travelling, distance travelled, the amount of blood, the angle of impact, and the type of target onto which it lands. Next it needs to define the meaning of crime in general.

The Oxford Dictionary defines ‘Crime’ as ‘an action or omission which constitutes an offence and is punishable by law’. The Uniform Crime Reporting program conducted by the Federal Bureau of Investigation (FBI) divides offences particularly into 3 broad categories based on the seriousness of the crime. They are – Part I offences, Part II offences and Other Offences. Part I offences as the FBI records are serious crimes that occur with regularity in all areas of the country and are likely to be reported to the police. Part I offenses include Criminal homicide, forcible rape, aggravated assault, burglary (breaking or entering), Larceny-theft (except motor vehicle theft), motor vehicle theft, arson. Part II offences include, other assaults (simple), Forgery and Counterfeiting, Fraud, Embezzlement, Stolen property: buying, receiving, possessing, Vandalism, Weapons: carrying, possessing etc., Prostitution and Commercialized vice, Sex offenses (except forcible rape, prostitution, and commercialized vice), Drug abuse violations, Gambling, Offenses against the family and children, Driving under the influence of an intoxicant, Liquor laws, Drunkenness, Disorderly conduct, Vagrancy. Other offenses include Suspicion, Violations by juveniles (under the age of 18) of local curfew or loitering ordinances, runaways by juveniles (under the age of 18) taken into protective custody under the provisions of local statutes. Figure 1 provides a graphical description of the crime classification system endorsed by the UCR program conducted by the FBI.

As per the UCR program conducted by the FBI, Violent Crime primarily comprises of murder and non-negligent manslaughter, forcible rape, robbery and aggravated assault. The UCR program defines Violent Crime as those offenses which involve force or threat of force. In coherence with the crime definitions put forward by the UCR program, the National Crime Record Bureau, India, categorizes violent crime under the following heads – Murder, Attempt to Commit Murder, Culpable Homicide not amounting to murder, Rape, Kidnapping and Abduction, Dacoity, Preparation and assembly for dacoity, Robbery, Riots, Arson and Dowry Deaths. These crimes are under most

circumstances accompanied by bloodletting events. It is this subset of crimes that we intend to work on this particular project.

The 'Crime in India Report 2013'published by the National Crime Record Bureau, suggests that there has been a subsequent yet persistent increase in violent crime rate over the last 20 years. The ever increasing number of unsolved criminal cases within the Indian juridical setting makes this project particularly timely in the present scenario.
'A bloodstain resulting from contact between a blood-bearing surface and another surface' has been termed as 'Transfer Stain' by the International Association of Bloodstain Pattern Analysts (IABPA)[2-4].We intend to create a database of drip stains on non-absorbent paper and thereby record how the stain patterns vary owing to difference in flow aperture, height of liquid column, angle of impact, fall height, paper creases and temperature humidity. [Fresh pig blood was preserved by addition of anticoagulant as per requirement.]

The bloodstains are classified as follows:

1. Single drop
2. Impact spatter
3. Cast-off stain
4. Transfer bloodstain
5. Projected pattern/arrival damage stain
6. Pool stain
7. Insect stain
8. Expiration stain

A single blood drop falls perpendicular to a surface it maintains a spherical form until impacting. It is by observations that blood drops that have fallen vertically, whether it be from an injured person or another object, and landed onto another surface.The size and appearance of this stain will depend on a number of factors. The volume of a single drop of blood will vary depending on the quantity of blood present and the surface area available from which the drop is falling. As would be expected, a larger surface area would allow for larger drop of blood to form before falling. The height from which the blood falls will affect the size of the stain, with greater heights tending to result in larger bloodstains.The nature of the target can alter the appearance of the stain. The target surface itself will cause an effect, with absorbent surfaces usually producing smaller stains than non-absorbent targets. A rough target surface can result in increased distortion to the stain and even satellite stains are additional stains radiating outwards. A drop of blood falling into an existing bloodstain will result in a drip pattern. Impact spatter may provide insight into the relative position of individuals and objects during an incident and the nature of the incident. A forceful impact between an object and wet blood, causing the blood to break into smaller droplets. A greater force will typically produce smaller droplets, with the density of blood drops decreasing moving further away from the initial blood source.

In Cast-off stain the blood flung from a blood-stained object, such as a weapon, may produce characteristic patterns of numerous individual blood drops forming a curved or straight line. It occurs due to centrifugal force causes blood drops to fall from a bloodied object in motion. It can also be happened for cessation cast-off patterns may result from the sudden deceleration of an object. The nature of the motion of the bloodied object, cast-off blood will at least produce relatively linear stains. If an object is repeatedly moved, each subsequent swing will result in less cast-off as less blood remains on the object. It is difficult to interpret as there is a great deal of possible variation in patterns produced. Transfer bloodstain proves particularly beneficial in establishing a sequence of events at the incident scene and tracing the movement of objects or individuals. It results when a bloodied surface comes into contact with another surface, transferring blood to that secondary target. When a bloodied surface comes into contact with another surface, transferring blood to that secondary target. Such bloodstains may be left by the hands of an individual, thus opening the possibility of fingerprint evidence

Projected Pattern/Arterial Damage Stain produced will usually represent the beating of the heart as blood is expelled in periodic spurts. It depends on a variety of factors, including whether the victim was stationary or moving as blood was being ejected, where on the body the injury occurred and the extent of the wound. It results from the discharge of pressurised blood onto a target surface, for instance the ejection of blood from a punctured artery. If a wound is smaller in size, naturally smaller blood drops will be produced, which can subsequently be expelled further from the injury site than larger blood drops. Bloodstains produced usually represent the beating of the heart as blood is expelled in periodic spurts. If a body is not present at the incident scene pooling bloodstains on a particular surface identifies blood lost based on bleeding of blood from a wound. It may even be possible to roughly estimate whether the victim is likely to be dead or alive.

Flies may feed on blood and tissues at the scene and then, following regurgitation or excretion, produce small circular stains known as flyspeck. Spreading the blood due to flies may feed on blood and tissues at the scene and then,

following regurgitation or excretion, produce small circular stains known as flyspeck. The presence of insects such as flies at an incident scene and is known as insect stain.s

Expirated blood occurs at the spot.
When blood is expirated from the mouth, it will often produce a pattern of small, round stains that could be likened to a fine mist. The expiration stains will often be slightly diluted in appearance due to the additional presence of saliva or mucous. This type of bloodstain is caused by blood being coughed or otherwise expelled from the mouth.

Factors undertaken for interpreting bloodstain

1. Behaviour and appearance of the stain depend on surface

2. It is possible to study the state of the bloodstain may be able to shed light onto how much time has passed since the blood was shed, as over time blood will naturally coagulate

3. **T**he extent of drying or coagulation will depend on the quantity of blood present

4. Bloodstains at an incident scene may not always be visible to the naked eye, either due to low amounts of blood present or an individual cleaning in attempts to remove signs of bloodshed.

5. Chemical reagent tests are often presumptive, meaning that they can only indicate that the stain is possibly blood. In reality, other substances may react with the reagent in the same way.

A lack of a bloodstain can be just as revealing. The absence of blood in a continuous bloodstain is known as avoid, and may suggest that something or someone was present in that area when the bloodstain was caused. This could indicate an object present at the time of the incident has been removed from the scene, or an individual (or even multiple individuals) were present in specific locations when blood was shed.

It can easily be incorrectly assumed that blood found at an incident scene belongs to a victim, however it must be taken into account that some bloodstains may have resulted from the perpetrator being injured at some point. Either way, the information available from the presence of bloodstains is not limited to bloodstain pattern analysis, but also DNA analysis.

Point of Origin – Directionality and Angle of Impact

In the reconstruction of an incident scene involving bloodstains, it is often beneficial to establish the point of origin of bloodstains, based on directionality and angle of impact.

The examination at the crime scene reveals:

1. The direction of travel of blood as it impacted the target.
2. A drop landing perpendicular to a surface (depending on the type of surface) will tend to produce a more circular pattern, those landing at an angle will result in an elongated stain.
3. The tapered end of this stain will generally point in the direction in which the droplet was travelling. Small amounts of blood may break away from the parent stain entirely – these are known as satellite stains.
4. It may be possible to estimate area of origin
5. It may be possible to establish the angle at which a blood droplet hit a target, referred to as the angle of impact.
6. It may be possible to determine the area of convergence in case of multiple bloodstains and through stringing techniques and establish the area of origin

Documentation and Collection

Documentation of bloodstain evidence will most typically be carried out using

1. Photography, including photographs of the wider scene along with close-up images of particular bloodstains.

2. A ruler or other form of scale may be placed in the photograph in order to give perspective as to the size of a bloodstain. Sketches and even videos may also be utilised for further documentation.
3. Collection of bloodstain evidence can be a complex matter, as the evidence will not likely be confined to a small object that can be easily removed from the scene. After rigorous documentation of the evidence, ideally the bloodstains themselves will be collected. This can involve simply removing objects from the scene or, more problematically, sections of carpet or large pieces of furniture.
4. Evidence removed should be packaged in such a way that the stains are not altered or damaged. Collection of blood evidence for the purpose of DNA profiling will generally be conducted using a swab.

Literature Review

In 2011, the Federal Bureau of Investigation(FBI) reported that the number of individuals killed(496) by blunt objects which might include a hammer, golf stick, a coconut shell (ripe, unripe), a wooden box, a candlestick/stand etc. by far outnumbered the number of individuals killed by rifle shot[1]. It's not just 2011 recorded such figures, since 2005 to 2011, the number of individuals who have been killed by a blunt object hit have by far outnumbered the number of individuals killed by a rifle shot[1].'The bloodstain resulting from contact between a blood bearing surface and another surface' is defined as Transfer stain by the International Association of Bloodstain Pattern Analysts (IABPA) [2]. Identification of a murder weapon can be done by analyzing weapon transfer stains(if any) together with other circumstantial evidence at a crime scene .Hand transfer stains, shoe transfer stains as also weapon transfer stains left at a crime scene play an integral role in the reconstruction of the crime scene, hence proper documentation of such stains is mandatory.

In this regard, the case of the ex-FBI agent in 2010 is particularly relevant. On December 13, the Sun News reported how the imprint of hammer in the blood pool could influence the court's understanding of the case as a case of successful attempted murder or a murder committed in self defense [3]. It is the proceedings of the aforementioned case that make the study of hammer imprints in blood pool together with weapon transfer stains particularly relevant and indeed timely. As rightly put forward by the defense attorney, Thomas Pitaro, the claimed hammer imprint theory with reference to the hammer imprint lying close to the hand of the victim was not recorded in the police report and was only added much later under the able guidance of a certified bloodstain pattern analyst Daniel Holstein[3]. In Forensic Science evidences can particularly be classified under two heads- Associative Evidence and Reconstructive evidence. Bloodstain patterns obtained at/from a crime scene are used in sequencing of events in a crime scene [4].

In particular, Professor MacDonell's contribution to the research and interpretation of bloodstain pattern analysis since 1971 stands commendable till date [5a-5 b]. The Association of Crime Scene Reconstruction defines reconstruction as "the use of scientific methods, physical evidence, deductive and inductive reasoning and their inter-relationships to gain explicit knowledge of the series of events that surround the commission of a crime."[4] T. Bevel and M. Gardener in their book on 'Blood Stain Pattern Analysis 3rd edition- An Introduction to Crime Scene Reconstruction' have explicitly explained the different types of bloodstain patterns as described by the International Association of Bloodstain Pattern Analysts [4]. The book also contains a detailed classification of bloodstain patterns. How patterns vary with difference in angle of impact, fall height, temperature, surface texture, surface absorption capability etc. has been neatly documented in the book [4].

Experiments Conducted and Results

At the very onset, a hollow coconut with a hair wig(refer Figure **1**) was used to simulate the head hit event in a crime scene. The authors particularly attempted to reconstruct the event of back head hit in a crime scene. The hair wig was soaked in 20cc. of pig blood in order to create the bloody hammer transfer stains one might expect to see after head hit. By way of study of the juridical proceedings for several criminal cases and by conducting a brief survey of the available hammers at the local market, the authors prepared a list of 6 different hammers to be used in the study. The authors used porcine blood for the experiments because porcine blood is quite similar to human blood. Blood was legally procured from Kolkata Municipal Pig Slaughter House, Tangra Kolkata, India. Given that fresh blood coagulates over time, 1100 IU of Heparin Injection was added to fresh pig blood to preserve the colloidal consistency of blood. It might be interesting to mention that adding anticoagulant does not alter the viscosity and specificity of the Non-Newtonian fluid, blood.

Figure 1: Experimental Setup replicating the event of a head hit. As the authors were not inclined towards recording the stains (particularly cast off and impact spatter patterns) formed on the walls and ceilings for a particular height of thevictim, perpetrator, number of hits made by the perpetrator, hence this setup was constructed.

In order to minimize or control property damage the hammer was dropped on a paper sheet (A3 size) placed on a thermocol sheet (refer Figure **2**).

Figure 2: Thermocol sheet placed on the floor to avoid damage of the floor tiles. Paper sheet is placed on the thermocol sheet and hammer is dropped on the paper sheet by measuring the fall height from the top of the thermocol sheet.

The height of the victim/perpetrator was not taken into account in the study as the authors did not want to record the cast off, fingerprint transfer stain patterns that might be formed as a result of head hit. It is shown below in Figure 3.

Figure 3: Dried up 30 cc blood pool created on a plastic sheet. The blood pool was not created on paper as the paper surface would cringe on the drying of the 30 cc(ml) blood pool.

Paper is much softer than iron (the material the hammer head is made up of) hence when hit with a certain amount of Initial impact velocity that is not large it sags with crease formation on the surrounding. For an even larger initial Impact velocity it tears off (refer Figure 4).

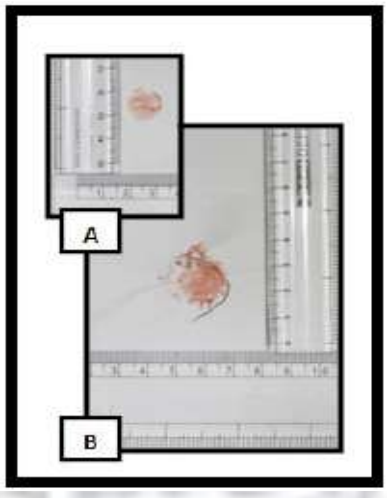

Figure 4: A) Stain formed when round edge of cross peen and straight hammer was used for 10 head hits and then placed on plain, non-absorbent paper. B) Stain formed when the same edge after 10 head hits was used to hit plain, non-absorbent paper surface with a comparatively larger initial impact velocity thereby leading to rupture of paper surface.

When it comes to substances that are harder than paper and again softer than the material with which the hammer head is built (cast iron in this case)such as certain flooring marble slab, scratches are formed when hit by the hammer with a certain initial impact velocity. For larger initial impact velocities cracks are formed (refer Figure **5**).

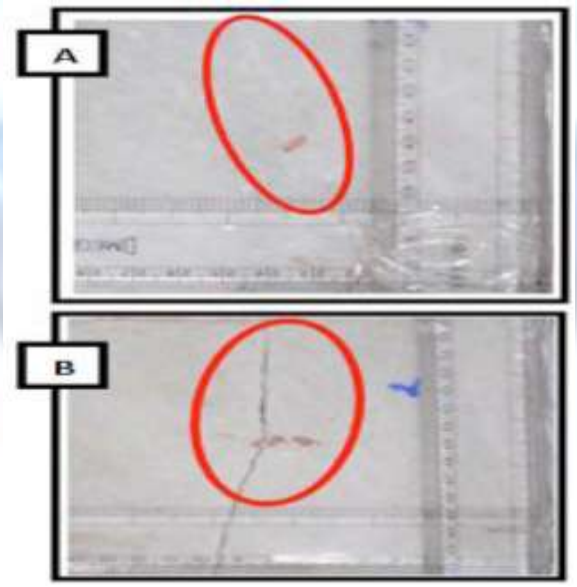

Figure 5: A) Marble slab used for flooring when hit with a particular velocity by a bloody ball peen hammer edge after10 consecutive head hits results in scratch formation B) Marble slab hit with higher initial impact velocity by the same edge of the ball peen hammer after 10 consecutive head hits results in formation of a crack.

Conclusions

It is difficult to develop an automated computerized tool for analyzing transfer stain patterns. To develop a tool that is efficient at analyzing and probabilistically predicting possible tools that could have created a particular sort of transfer stain, development of a dataset consisting of a large variety of weapon transfer stains formed by different angle of inclination of tool drop, dimension of tool edge, fall height, velocity of hit etc. stands integral. However for development of a tool, development of a database that has sufficient variation and comparable representation of each possible class type stands out to be the biggest challenge. Once a dataset has been drawn up, semi-supervised learning techniques could be used to develop an appropriate tool.

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