**EXAMPLE 1:**

**Title: THE EFFECTIVENESS OF BIOROBOTS IN FORENSIC DNA ANALYSIS**

**Background of the Study**

DNA is an indispensable forensic tool. Although it cannot absolutely identify a person, it can provide probabilities of exponential proportion that point to a specific individual as a potential donor. There is also an ease with which DNA can be left behind, such as simply touching or wearing an object, that makes DNA a great investigative tool. Because of the ubiquity and specificity of DNA, many forensic labs rely on a biology section to perform DNA analyses.

 With DNA analysis becoming more and more common, investigators are more likely to request it for nonprobative applications, such as providing investigative leads (Varlaro & Duceman, 2002). As a result, many labs face increasing backlogs (Montpetit, Fitch, & O’Donnell, 2005; Varlaro & Duceman, 2002). Automation of this step is an attractive possibility for labs that perform organic (commonly PCI) purification, which uses hazardous chemicals. Besides eliminating the use of such chemicals, automation frees the analyst to perform other tasks while the purification takes place.

 Two companies, Beckman Coulter and Qiagen, have developed technologies to automate the purification of DNA samples. The biorobots created by these companies are designed to enable analysts to perform other tasks and work more efficiently in the lab while the DNA purification takes place. Both companies boast biorobots that can purify DNA as well, if not better than, organic purification. In addition, their automated systems are designed to purify problem samples encountered in organic purification.

**Problem Statement**

With automation entering the purification stage of forensic DNA analysis, little research exists on the effectiveness of robotic purification methods. It is important for DNA labs to know how well a robotic system works and on what types of samples in order to justify the decision to spend money on the instrument. Even after purchasing the robot, labs must extensively validate it before using it in casework. This thesis will compare two robotic DNA purification systems and manual purification and discuss the capabilities and limitations of each method.

**Purpose and Objectives of the Study**

The purpose of this study is to compare three DNA purification methods and determine which, if any, is best suited for forensic DNA analysis. The results of this research should answer the following questions:

1. Is a robotic system as sensitive as PCI purification?

2. Does a robotic system recover more DNA than PCI purification?

3. Does a robotic system produce DNA that is free of inhibition or less inhibited

 than PCI purified DNA?

4. Is PCI purification or robotic purification more consistent?

5. Is there a significant difference in overall performance between the BioRobot

 EZ1 and Biomek® 2000?

**EXAMPLE 2**

**Title: A UNIFORM PROTOCOL TO ADDRESS THE RAPIDLY ACCUMULATING**

**UNIDENTIFIED REMAINS AND MISSING PERSONS IN THE UNITED STATES—**

**OUR NATION’S SILENT MASS DISASTER**

**Background of the Study**

In 1946, the United Nations Declaration of Human Rights declared that all human beings have a right to an identity, in life and death. In an organized, stable, and modern society, such as that which exists in the United States, the identification of the deceased is imperative under both legal and humanitarian reasons. The ability to confirm and support human biological identity is crucial to the identification of the deceased as pertaining to medico-legal investigations and will always remain a crucial part of the medical examiner or coroner’s role. Proper identification is necessary for issuance of a death certificate, which is required by law, as well as release of the remains and interment according to family wishes and religion. Moreover, identification introduces relief and closure to relatives and friends of missing persons that have remained as unidentified persons.

Furthermore, identification of a homicide victim is a vital clue in directing and advancing a criminal investigation, as well as a necessity in charging a potential suspect with a crime.

In many unidentified person cases, the identity of the deceased may be difficult to confirm due to many variables, such as the condition of the remains and lack of persons who knew the decedent and would be able to confirm identification. Legally certifying an individual’s identity is most often based on two major parameters—circumstantial and physical evidence. Circumstantial evidence includes personal effects, as well as visual recognition by relatives or friends of the deceased. Physical evidence includes medical information such as healed fractures, examination of external features such as tattoos or scars, and scientific information such as DNA profiles or fingerprints. Presumptive identification occurs when there is only a combination of factors that can establish a possible identification. On the other hand, positive identification methods consist of performing comparisons of antemortem and postmortem characteristics that are considered as unique to the individual and there are no unexplainable differences between the sets of information. Credibility of confirming a positive identification tends to increase with the collection of matching specific unique data markers, especially when they include more physical than circumstantial evidence. As a result, scientific methods of identification are established as valid, reliable, and objective; thus eliminating any concern of misidentification.

“Forensic identifications by their nature are multidisciplinary team efforts relying on positive identification methodologies as well as presumptive or exclusionary methodologies” (Wagner, 1997). Successfully identifying remains and solving missing persons cases is heavily dependent upon collaboration and coordination between many different agencies and individuals including law enforcement officials, medical examiners and coroners, pathologists, serologists, toxicologists, anthropologists, criminalists, odontologists, family member cooperation; as well as the proper collection, handling, and analysis of evidence.

**Problem Statement**

As of 2007, according to the Office of Justice Program’s Bureau of Justice Statistics (BJS), there are approximately 40,000 sets of unidentified human remains (UHR) currently being held within medical examiner/coroner’s (ME/C) offices throughout the country. BJS estimated that during any given year, as much as 4,400 UHR cases are investigated by ME/C offices, of which 1,000 remain unidentified and become “cold” cases. Due to these enormous numbers that continue to accumulate with the passage of time, many experts have referred to this predicament as a "silent mass disaster over time" (Ritter, 2007). As of 2004, BJS estimated that more than half of the

ME/C offices in the United States did not enforce policies on retaining records on unidentified human remains prior to disposition and burial. X-rays, DNA, or fingerprints were not retained from many of these cases and countless numbers of UHR have already been buried or cremated. Even with exhumation, a very costly process, there is no guarantee that there will be any remains available that are suitable for any sort of testing.

Without retention of any specimens that can be utilized for further testing, such as DNA analysis, chances of identifying these individuals are severely diminished, if not eradicated. This only further impedes the efforts to solve these cases and link them to unsolved missing persons cases, whose numbers can reach as much as 100,000 per any given day. As a result, families of these cases will continue to wonder what happened to their loved ones and struggle with the agony of possibly never having the ability of laying their loved ones to rest.

Although many different ME/C offices and LE agencies contain unofficial protocols or procedures for the identification of unidentified and missing persons, an inconsistency exists between different jurisdictions on a local and state level. In the National Association of Medical Examiner’s (NAME) *Forensic Autopsy Performance* *Standards*, a short protocol lists short procedures to follow prior to the disposition of unidentified persons; however, the protocol does not go into extensive detail (2007). In addition, the Disaster Mortuary Operational Response Team (DMORT) follows a protocol regarding unidentified persons as it pertains to mass disasters. However, DMORT does not possess a procedure to pursue the identification of specific unidentified person cases that occur at most ME/C agencies. Therefore, no uniform protocol has been written listing every possible step and avenue that can be pursued to identify unidentified human remains in a particular ME/C office.

Moreover, while various forensic techniques are available for the identification of UHR and are currently used in many ME/C offices, many of them are unknown to some ME/C offices due to the lack of information sharing. If the most advantageous forensic identification techniques could be researched and combined, a uniform protocol could be created to address every available avenue and thus, streamline the identification process. This study, coupled with further research involving the identification of unidentified and missing persons, could aid in linking these cases to one another.

**Purpose and Objectives of the Study**

The rapid progression in forensic and scientific technology has allowed the possibility to link unidentified persons cases and unsolved missing persons cases by means other than investigative leads. No longer are these cases dependent solely on information from circumstantial evidence because pure science has allowed hidden clues to surface and solve difficult cases that would have otherwise been left unsolved. One would assume that with this technological advancement and the availability of funds within the United States today, a consistency would exist amongst agencies that are tasked with the identification of unidentified human remains. However, the identification process differs on a national, state, and local level. Many jurisdictions lack consistent procedures for pursuing the identification of unidentified persons. In addition, many law enforcement agencies continue to be unaware of the vast resources available to aid their investigations. Moreover, there is no centralized database in existence that can store both missing and unidentified person information, which would allow multiple jurisdictions to compare and review cases that could be linked to one another. Therefore, no uniform protocol or procedure exists describing every avenue currently available to facilitate the identification of unidentified human remains. The purpose of this study is to examine every possible approach that is currently available to aid in the identification of unidentified human remains, thus creating a comprehensive and universal procedure that can be followed by any agency or organization in the forensic science community tasked with the identification of UHR. Every aspect will be discussed in further depth, describing the advantages and limitations of each method, as well as the plethora of resources that are currently available to aid in pursuing identification. The objectives to meet through this study included:

1. To research databases (ie. fingerprint) and other resources available that can aid in the investigation of unidentified and missing persons.

2. To research the various forensic techniques used for the identification of unidentified and missing persons in various ME/C offices.

3. To research legislation and protocols currently enforced in various jurisdictions regarding unidentified and missing persons.

4. To collect survey data from various ME/C offices in the United States regarding current methods, protocols, and legislation as pertaining to unidentified and missing persons.

5. To combine all advantageous research and create uniform protocol to expedite and streamline the identification process as pertaining to unidentified and missing persons.

6. To educate the forensic and law enforcement community of current technology and resources available to aid in the identification process.

**Research Hypotheses**

*Hypothesis 1*

Submission of fingerprints from unidentified human remains to multiple local, state, and federal agencies will increase the chances of identification.

*Hypothesis 2*

Identification of unidentified and missing persons has remained constant, even with the advancement of forensic identification technology.

*Hypothesis 3*

Submission of unidentified and missing person information to multiple local, state, and federal databases will increase the likelihood of identification.

*Hypothesis 4*

A uniform protocol can be created to assist in the identification of current and "cold case" unidentified human remains.

*Hypothesis 5*

A significant difference exists between Medical Examiner's offices, Coroner's offices, and law enforcement agencies as pertaining to fingerprint database submission procedures regarding unidentified and missing persons.

**EXAMPLE 3**

**Title: BURNING DOWN THE HOUSE: THE BIOMETRIC RECOVERY OF FRICTION RIDGE PRINTS AND BLOOD IN ARSON.**

**Problem Statement**

Arson is nearly as old as fire itself and recorded history, but it is the elements of the crime that constitutes what is considered arson. Arson today is defined as the, “willful and malicious burning or charring of property. There are many types of arson crimes, including setting fire to one's property with fraudulent intent--such as to collect insurance money. While the majority of arson crimes involve damage to buildings, arson can also be committed by a person who sets fire to forest land or a boat (Arson, 2013).”

If taken into account the monetary value of arson to include job loss, possession loss, and insurance premium increases, it becomes evident that not only is arson a crime, but a social problem as well, that requires more attention and using modern evidence recovery techniques that ability should become easier (Martin, 2004).

**Purpose and Objectives of the Study**

This study serves to examine the ability of an investigator to find usable fingerprints and blood to reasonably identify a person that may have caused arson to take place. This study will look at (a) the distance from the point of origin, (b) the three most common material used to house accelerants, (c) intensity of fire, and (d) time exposed to fire.

An experiment will be conducted in which a mock arson will be set with common materials, plastic, glass, carpet and metal, will be spaced at different intervals during different intensities and time of exposer to determine if usable fingerprints and blood is able to be recovered to reasonably identify a person that may have caused arson to take place. Each series of tests will use the exact materials each time at the same distances under each of the variable test located under (Appendix A), which detailed information regarding the information, to include distance, times, materials, heat and point of origin. The objectives of this experiment are to determine (a) the detail of usable fingerprints and blood, (b) the detail of recovery zone, and (c) the best material for recovery.

**Rationale for the Study**

The primary rationale for this study is to better understand if there is a “best” recovery zone for investigators to focus on in reference to how the mind processes information when observing traumatic situations. The myth that arson fires destroy all evidence is just that a myth, with modern advances in forensic sciences and techniques arsonist should be able to be identified much easier than in the past. The study serves to explore why some suspect identification can be found and a “best recovery area for reliable evidence recovery.

**Definition of Terms**

**Accelerant** – A substances that can bond, mix, or disturb another substance and cause an increase in the speed of a natural, or artificial chemical process.

**Catalyst** – A substance that promotes chemical reaction without itself being significantly consumed.

**Combustion** – A self-sustained, high temperature oxidation reaction.

**Cool flames** – Slow combustion reactions which occur only under limited conditions and produce temperatures of only 200-300°C.

**Endothermic reaction** – A chemical reaction which requires that energy be supplied to the system from an external energy source for the reaction to occur.

**Exothermic reaction** – A chemical reaction which releases energy. The opposite is *endothermic reaction*, which denotes that the reaction requires an external heat source in order to take place. It must be borne in mind that, if the temperature of a substance is progressively raised, many substances will show both endothermic and exothermic reactions. Exothermic reactions encountered in self-heating problems may be oxidative, that is, needing oxygen. But they may also be decomposition reactions that do not require oxygen.

**Fire** – ASTM E 176 defines it as: “Destructive burning as manifested by any of the

following: light, flame, heat, smoke.”

**Flame** – Babrauskas defines it as: “A rapid, self-sustaining propagation of a localized

combustion zone at subsonic velocities through the gaseous medium. Since they are

rapid, flames also represent high-temperature combustions. In gaseous medium to the

flame is identical to a *deflagration*. A slow form of combustion which can exist under

certain conditions is differentiated as a *cool flame*.”

**Flammable** – NFPA 921 defines it as: “Capable of burning with a flame.”

**Flammable liquid -** According to NFPA 30 a flammable liquid is any liquid that

has a closed-cup flash point below 100°F (37.8°C) and a *Reid vapor pressure* not

exceeding 276 kPa at 100°F (37.8°C) Flammable liquids are further subdivided as:

• Class IA liquids have flash points below 73°F (22.8°C) and boiling points

below 100°F (37.8°C).

• Class 1B liquids have flash points below 73.°F (22.8°C) and boiling points at or above 100°F (37.8°C).

• Class IC liquids have flash 'points at or above 73°F (22.8°C), but below

100°F (37.8°C).

**Flash fire -** Rapid combustion of a flammable gas cloud which does not result in a

significant overpressure.

**Flash point -** The NFPA 325 definition is: "The flash point of a liquid is the minimum

temperature at which the liquid gives off sufficient vapor to form an ignitable mixture

with air near the surface of the liquid or within the test vessel used.

**Flashover -** This term is used in two different, unrelated contexts. In fire safety

science, it means the full involvement in flames of a room or other enclosed volume.

In electrical engineering, it means the electrical breakdown of insulation along a

surface.

**Heterogeneous reaction -** A reaction in which the reactants are not all in one phase,

for instance, a gas and a solid. In combustion systems, this is often illustrated by a

reaction at a surface, e.g., air + charcoal. This type of combustion exhibits a glow or

a bright light, but not flames.

**Homogeneous reaction -** A reaction in which the reactants are all in the same phase, an example is homogeneous combustion in the gas-phase, where flaming combustion occurs throughout a volume of space.

**Hypergolic -** A reaction is hypergolic if two substances ignite directly upon contact.

**Ignitability –** ISO defines it as a: "measure of the ease with which an item can be ignited, under specified conditions."

**Ignitable -** ISO defines it as: "capable of being ignited."

**Ignitable liquid -** An ignitable liquid is a liquid which is either a *flammable liquid* or a *combustible liquid.*

**Ignite -** ISO defines it two ways: "(Intransitive verb): To catch fire with or without

the application of an external heat source. (Transitive verb): To initiate combustion."

**Ignited –** ISO defines it as: "The state of a body undergoing combustion."

**Ignition -** ISO defines ignition as: "Initiation of combustion."

**Ignition source –** ISO defines it as "Source of energy that initiates combustion."

**Ignition temperature –** ISO defines "ignition temperature (minimum): (Minimum)

temperature at which combustion can be initiated under specified test conditions."

**Ignition time -** The time from beginning of exposure to heat, until ignition occurs,

the ignition time is highly dependent

on the conditions of the test or the experiment.

**Incendivity.** The ability to cause ignition.

**Initiation -** The start of detonation, as applied to explosives.

**Laminar flame speed –** Glassman defines it as: "The velocity at which unburned

gases move through the combustion wave in the direction normal to the wave

surface." T h i s i s a lso called burning velocity, flame velocity, normal combustion

velocity, and fundamental flame speed.

**Layer ignition temperature -** For a layer of dust upon a hot surface, this is the lowest

temperature of the hot surface that can cause ignition.

**Limit flame temperature -**The flame temperature at the lower flammability limit.

**Lower flammability limit -** The lowest concentration of a gas or vapor that will just

support the propagation of flame away from a pilot ignition source.

**Lower temperature limit -** It is the minimum temperature to which a saturated fuel

vapor-air mixture must be heated for flame propagation to be possible.

**Smoldering -** A propagating, self-sustained exothermic reaction wave deriving its principal heat from heterogeneous oxidation of a solid fuel.

**Upper flammability limit -** The highest concentration of a vapor or gas that will ignite and burn with a flame in a given atmosphere (air, pure oxygen, etc.).

**Upper temperature limit -** The maximum temperature for which a saturated fuel vapor-air mixture can show flame propagation.

**Limitations of the Study**

The limitations that are involved in this study are that the ideal conditions for this test would be: Under controlled conditions a mock crime scene was set up with items of glass, metal, and plastic in a standard recreation of a 10-foot by 10-foot room where a fire is started from a corner of the room.

Each item is placed at the same height.

Each item is place along radiant of 3 feet 6 feet and 9 feet from the point of origin.

All items are identical in shape, size and material.

Due to some fire regulations in the county the experiment will use a propane torch to control temperature and simulate distance from point of origin. All other controls remain the same as the original experiment.

Each item is placed at the same height.

All items are identical in shape, size and material.

Other limitations are the lack of a complete laboratory facility to test further results on the blood specimens to confirm the ability to extract DNA to complete an identification process of an individual.

**Research Hypotheses**

**Hypothesis 1**: The placement of each piece of material and its distance, flame and heat from the point of origin will determine the first significant factor of usable friction ridge detail or blood, for possible DNA extraction to be recovered.

**Hypothesis 2:** The type of material, plastic, metal, glass which are the most common transportation devices for arson accelerants and the recovered locations from different points of origin will determine if there is sufficient biometric data that can be recovered or not.

**Hypothesis 3:** The time or duration of the fire play a significant and critical role in determining the type of the sufficient biometric data that can be recovered.

**Summary of Remaining Chapters**

The remaining parts of the thesis consist of four chapters. Chapter II is a Literature Review that will explain about the topic by using scholarly works to support the topic of fire, arson, and their effects on blood and fingerprints. Chapter III is the Methodology of the study, this will describe how the study is conducted, materials used and other technical aspects of the study and how data will be analyzed to allow decision to accept or reject each hypothesis. Chapter IV provides the results of the study that were found using the methodology in Chapter III. Chapter V provides for the Discussion, Conclusions, and Recommendations for future research.

**EXAMPLE 4**

Title: LATENT PRINT TRAINING TO COMPETENCY: IS IT TIME FOR A UNIVERSAL TRAINING PROGRAM?

**Background of the Study**

The field of fingerprints has evolved tremendously over the past 100 years. The fingerprint unit, once a dumping ground for troubled police employees or a light duty assignment for the injured, is now occupied by dedicated and professional applied scientists. The latent print practitioner is considered to be invaluable to any law enforcement operation. But, while the field of fingerprints has progressed tremendously with regard to technology, training of new latent print examiners has remained very traditional in practice, still relying primarily on on-the job training. On-the-job training, in and of itself, isn’t necessarily a negative thing as long as the training is based on a quality program. However, each individual agency is left to their own devices as to what constitutes training to competency and how to get there.

Many people point to the latent print certification program administered by the International Association for Identification (IAI) as a means to determine competency. This is not an appropriate measure however, for two primary reasons. First, one is not required to be certified in order to practice in the field of latent prints in the United States, although individual agencies and courts may have their own such requirements. In fact, for a long time more than 50% of the examiners who qualified for and took the exam, failed it. The time limit on the exam has recently been increased however, which has resulted in an increase in the passing rate to just over 70% (The International Association for Identification, 2008). Most who do not pass though continue to conduct examinations. Secondly, a person does not qualify to sit for the certification exam until they have a minimum of 2 years of experience along with a 4-year degree. With any less than a 4-year degree, the experience requirements increase. This means that for at least two years, often more, it isn’t possible for an examiner to become certified. Thus, certification cannot be used to measure competency, as many people who are doing actual case work don’t qualify to test, many competent people who do take it fail, and many more simply choose not to take the exam since it is voluntary.

People also assume that laboratories that are ASCLD/LAB (The American Society of Crime Laboratory Directors / Laboratory Accreditation Board) accredited must also have adequate programs for training to competency. It is assumed, especially by courts, that agencies who meet accreditation standards have inherently better operating standards and therefore a higher quality work product. However, in the area of training, according to the ASCLD/LAB manual, an agency need only have a documented training program and follow it. Again, it is up to them what the training curriculum actually consists of; there are no specific standards or guidelines that ASCLD/LAB puts forth in this regard.

Most often, people refer to SWGFAST (Scientific Working Group on Friction Ridge Analysis Study and Technology) guidelines when referencing training guidelines. They have two related guidelines in this area: “Training to Competency for Latent Print Examiners” (SWGFAST, 2002b) and “Minimum Qualifications for Latent Print Trainees” (SWGFAST, 2002a). Both however, appear to be lacking in specific detail and there are many who question whether there is sufficient information to allow agencies to put together adequate training programs.

**Problem Statement**

Since 1999, beginning with US v. Byron Mitchell, there has been an influx of challenges to the field of latent prints. Most often, these challenges cite a lack of standards within the industry, with training being just one area of focus. ASCLAD/LAB accreditation, SWGFAST guidelines, and IAI certification are the counters to these arguments. With the weight given to fingerprint evidence in US court cases, it is imperative that latent print examiners be competent and errors be minimized as much as possible. A single fingerprint identification can deny a person their freedom or even result in a death sentence. The foundation for quality latent print work, of course, is laid in initial training. Many industries have college degree programs; this is not the case when it comes to latent fingerprint examination. While there are more and more forensic science degree programs available, very few of them focus on one particular area, such as latent prints. There is also a lack of focus on practical application and examination skills, as most of the instructors are themselves deficient in these skills. Still many other fields have standardized training programs, licensure, or training accreditation. Again, there is no such thing in the field of latent prints. How is one to determine that an examiner is trained to competency and have the foundation necessary to perform work that can have such a significant impact on an individual’s life? Are the training guidelines sufficient enough that agencies throughout the United States can institute consistent and sufficient training?

**Purpose and Objectives of the Study**

The primary focus of this study is to determine whether or not there needs to be a universal training program and standardized hiring qualifications instituted in order to ensure citizens and the courts that latent print examiners, especially those that are not IAI certified, are receiving consistent training. Although analyzing the quality of individual agency’s specific training programs are beyond the scope of this study, an attempt will be made to determine (a) whether or not agencies do, in fact, have formal written training programs at all, (b) whether or not these training programs adhere to SWGFAST training to competency guidelines as written, (c) if there is consensus as to how these guidelines are interpreted and, (d) whether there is a difference in training standards between ASCLD/LAB accredited agencies and non-accredited agencies.

**Rationale of the Study**

By examining the actual prevalence of formal training programs, the implementation and interpretation of SWGFAST guidelines, and the impact of ASCLD/LAB accreditation, it is expected that a baseline understanding of actual training practices can be determined. Should there be agreement and consistency in these areas, the next logical step for further study would be to assess whether what is being done currently is enough. In order to determine if a universal training program is needed in the latent print field, consistency, which is what this study will attempt to examine, must be the assessed prior to any meaningful inquiry into quality. Should there be baseline inconsistencies in the basic elements addressed here, it must be assumed that quality is also inconsistent and a solution such as a universal training program must be explored.

**Research Hypotheses**

Hypothesis 1. The majority of U.S. latent print units have formal training programs with a written curriculum.

Hypothesis 2. The training programs of most U.S. latent print units adhere to guidelines published by SWGFAST.

Hypothesis 3. Interpretation of training to competency guidelines, as reflected in resultant training programs, is consistent throughout U.S. latent print units.

Hypothesis 4. There is no significant difference between the training programs of ASCLD/LAB accredited agencies and non-accredited agencies

EXAMPLE 5

**TITLE: RECONSTRUCTION OF BLOODSTAIN IMPACT PATTERNS:** **ERROR RATES**

Background of the Study

Bloodstain pattern analysis (BPA) is the examination of the size, shape, directionality, location, and distribution of bloodstains and bloodstain patterns that assist with the reconstruction of events that occurred at a crime scene. BPA classifies various patterns that are created by certain events. One such pattern is the impact pattern, which is created when a force breaks up liquid blood into droplets that radiate away from the force (Bevel & Gardner, 2008). These droplets travel on a trajectory away from the force until they strike a target or fall to the ground.

A bloodstain pattern analyst examines impact patterns, which consist of spatter stains in a radiating pattern. The ultimate goal of examining the spatter stains is to reconstruct an area of origin that is “the three-dimensional location from which spatter originated” (SWGSTAIN, 2009, p. 1). One reason for performing an area of origin analysis is to determine the origin of an impact pattern within an area. An origin analysis assists in identifying, for example, whether the victim was standing, on the ground, or somewhere in between while blows were being delivered (Bevel & Gardner, 2008; MacDonell, 1997).

Unfortunately, error will always be associated with an area of origin reconstruction due to multiple factors that may affect the analysis. For example, if someone was beaten about the head with a blunt object and it was desired to ascertain the victim’s posture, an area of origin within 12 inches would assist in answering the investigative question (Bevel & Gardner, 2002). If the error rate of origin reconstruction is greater than a foot, the question of body posture and location within an area might become problematic.

Both bloodstain experts and novices can reconstruct an area of origin, as it is a technical skill. Novices include crime scene technicians, crime scene investigators, criminalists, and homicide detectives. It is very likely that novices calculate a greater number of origin reconstructions than experts due to the significantly larger number of novices than experts. The importance of this study is to ascertain the error rate of origin analysis among novices and determine if the accuracy and precision of the analysis are within acceptable parameters to be of investigative value in case work and a courtroom setting.

Problem Statement

No studies were found in the literature review that address the error rate of origin analysis among novices. MacDonell (1997) placed a volumetric limit on origin analysis from the size of a grapefruit to the size of a basketball. Bevel and Gardner (2008) placed limits on the area of origin of up to a maximum of 12 inches (30.5 cm). Are novices able to reconstruct areas of origin within this parameter to be acceptable and of value?

There are multiple causes for an area of origin reconstruction to have errors and be some distance from the actual origin. Some of these causes are (1) the incorrect measuring of spatter stains resulting in miscalculated impact (alpha) angles, (2) incorrectly determining the center and long axes of stains which affects the directionality (gamma angles), (3) gravity and air resistance causing the droplet to travel in a parabola and not a straight line, and (4) the choice of stains for analysis.

Alpha angle error. Incorrectly measuring a stain’s alpha angle will contribute to error in an area of origin analysis. Most beginners are taught to use a scale (small ruler) to measure the long and short axes of stains. Another method employs a drafting divider technique to assist in determining the long and short axes of a stain (Bevel & Gardner, 2008). Some experts use forensic software to aid them in measuring bloodstains; however, most novices will use either the manual scale or drafting divider method to determine a bloodstain’s alpha angle.

The drafting divider method is shown in Figure 1.1, where the first two steps are to ascertain the center of the stain’s widest points or width of the stain. Steps 3 and 4 consist of doubling the distance from the stain’s leading edge to the center of the stain’s width, which produces the length or long axis of the stain.



Figure 1.1. Drafting divider method. This method starts with finding the widest portion of the stain (steps 1 and 2). A measurement from the center of the stain's widest portion to its leading edge creates half of the stain's length. Doubling this distance will produce the length of the stain, or the terminal end of the stain's ellipse (steps 3 and 4).

The primary problem with measuring bloodstains is generally with the long axis or length of the stain. A bloodstain has deformation at its terminal end that is outside the stain’s ellipse. A bloodstain’s ellipse at its leading edge is easy to determine as it is well defined, but the difficulty resides in the location where the terminal end of the ellipse closes. If a stain’s length is incorrectly measured as being long or short of its true ellipse, error in the alpha angle calculation occurs. Nothing in the research literature provides information on the measurement inaccuracies of novices with known alpha or gamma angles. Figure 1.2 is an example of how an ellipse fits over a bloodstain while excluding its terminal deformation.



Figure 1.2. Spatter stain. The stain has been superimposed with an ellipse. Note that the ellipse does not include the deformation at the stain's terminal end. Measuring the length and width of the stain outside of or within the ellipse creates error in the alpha calculation.

Gamma (directionality) angle error. Erroneously determining the center of the long axis of a stain will cause error in area of origin calculations. If the centers of long axes of stains are not adequately determined, the reconstructed trajectories will cause the origin to shift to the left or right, or closer to or away from the true origin. Davison and Palmbach (2014) addressed the gamma angles of spatter stains with forensic bloodstain software by shifting them in positive and negative directions. No research studies to date in the literature have evaluated the gamma angle error rates among novices.

Error due to gravity and air resistance. Bloodstain experts and novices use straight-line trajectories to ascertain the area of origin in a process called stringing (James et al., 2005). The straight lines are created with string and meant to indicate the droplets’ paths while in flight. An issue with stringing is that a droplet’s path may initially start as a straight line, but eventually it travels in a parabola due to gravity pulling the droplet downward and air resistance in the opposite direction of the droplet’s trajectory causing it to slow and begin to fall. Due to gravity and air resistance, the reconstructed area of origin will always be somewhere above the actual impact location (James & Eckert, 1998; Wonder, 2007).

Error due to improper stain selection. The choice of improper stain selection can create error with origin analysis, while proper stain selection can improve accuracy. Research suggests that stain selection should encompass stains with widths greater than 1.5 mm, stains with elliptical shapes, stains from multiple walls, and stains closer to the suspected location of the true origin, usually indicated by a concentration of circular stains (De Bruin, Stoel, & Limborgh, 2011).

Purpose and Objective of the Study

The purpose of the current study was to determine the error rates in areas of origin analyses among law enforcement BPA novices and to ascertain if they are within acceptable limits. This type of reconstruction has value in determining, for example, where a victim was located and what his or her general posture was during a beating. This reconstructive information may be relevant when determining possible self-defense claims by a defendant. A self-defense claim may be more problematic if the reconstructed origin indicates that the victim was lying on the floor while blows were being received.

The primary objective of the current study was to determine the alpha error rates among novices when measuring bloodstains with known alpha angles. Another objective of the current study was to determine the error rates among novices when measuring known gamma angles. In other words, how precise are novices when creating straight lines that are in line with the long axis of a bloodstain? The alpha and gamma angles play a primary role in the outcome of an origin reconstruction. No studies located in the research literature have addressed the known alpha and gamma angle error rates.

Another objective of the present study was to examine which manual method, scale or drafting divider, provides more accurate results concerning alpha angle measurements. This objective has not been studied according to the reviewed research literature. The current study will address the gaps related to the error rates of alpha and gamma angle measurements among novices. The more precise manual method of alpha angle measurement will also be examined in the current study.

Research Hypotheses

**Hypothesis 1: The measuring of alpha and gamma angles of diverse bloodstains by novices produces means that are within ± 3° of the known with the drafting divider and scale methods.**

A review of the literature did not address the error rates using manual methods for calculating both alpha and gamma angles among novices. One study applied a randomly chosen error rate for alpha angles between 5° and 15° for use in its model without any basis for its selection (Connolly, Illes, & Fraser, 2012). Bevel and Gardner (2008) stated that they generally accept that measurements of stains with alpha angles of 60° or less produce an error rate up to ± 3°. The authors gave no evidence or reasoning to back up this statement. The limit of ± 3° was chosen based on Bevel and Gardner’s belief coupled with a lack of data in the literature review that address the accuracy of alpha angle measurements.

**Hypothesis 2: The drafting divider method is more precise than the scale method for measuring a bloodstain’s alpha angle among novices.**

The vast majority of novices uses the scale method to determine a stain’s alpha angle; however, the drafting divider method is hypothesized to provide more accurate results. A review of the literature found no studies that compared the manual methods for precision. Computer forensic software that assists in fitting an ellipse to a bloodstain may be more accurate (Reynolds, Franklin, Raymond, & Dadour, 2007), but novices do not generally have access to forensic bloodstain computer software and rely on manual methods.

**Hypothesis 3: Bloodstains with more acute alpha angles produce more precise alpha and gamma angle measurement results among novices with the scale and drafting divider methods than stains that are less acute.**

More acute spatter stains have a more defined elliptical shape, allowing for measurement errors to have a lower impact than on less acute stains. Also, the more elliptical a spatter stain, the more defined its center point along its long axis is as compared to stains that have a more circular shape. The current study will collect data from novices who measured bloodstains from photographs with alpha angles from 10° to 60°. This hypothesis has implications for crime scene personnel as it will assist with stain selection that may yield more accurate alpha and gamma angle measurements and origin reconstruction results.

**Hypothesis 4: Data from novices measuring alpha and gamma angles of photographed bloodstains combined with reconstructed origins of real impact patterns result in a deviation from the known area of origin of less than 30.5 cm.**

The measurement of alpha and gamma angles will be collected from novices and combined with origin reconstructions from real impact patterns to introduce the effects of gravity and air resistance. Research studies among experts using computer forensic software and laser scanners have demonstrated that reconstructed origin calculations are within 30.5 cm (Connolly, Illes, & Fraser, 2012; Davison & Palmbach, 2014; Forident Software Technical Paper, 2009; Hakim & Liscio, 2015). The current study examined the use of manual measurements among novices and not among experts using computer modeling.