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Forensic Gunshot Residue Distance Determination Testing Using Identical Make and Model Handguns and Different Ammunitions.

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ABSTRACT

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The determination of how far a firearm was from a victim or target when it was discharged is a frequent request to crime laboratories. This determination requires test firing the firearm at various distances to compare gunshot residue patterns made during the test with patterns on the victim or target. Crime laboratories stipulate that the same firearm and ammunition used in commission of the crime must be used for this testing; however, little empirical evidence exists supporting this requirement. It was the purpose of this study to determine if there were any significant differences using different firearms and different ammunition in distance determination testing. The findings indicated that no significant differences occurred with different firearms but there were significant differences with different brands of ammunition.

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CHAPTER 1

INTRODUCTION

Public interest in forensic science has gained popularity in the United States in recent years. Television networks have recently produced a variety of programming with the main plot being a group of individuals solving criminal activity through the use of actual and often fictitious types of forensic science investigational techniques. Given the wide popularity of these television programs, it is no surprise that this attention to the forensic sciences has affected the real world. In a recent defense team survey of 500 individuals selected to be in a jury pool, it was discovered that approximately 70% of those in the jury pool regularly viewed CBS' *CSI* and other similar television programming such as Court TV's *Forensic File*s or NBC's *Law&Order* (Willing, 2004). Colleges and universities across the United States, as reported in an article in the San Diego Union Tribune (Lemaine, 2007), have added classes of instruction in areas of forensic science. Due to the increased interest, advanced degree programs in the forensic sciences have been established at numerous colleges and universities. These offerings are in direct correlation to the requests and heightened interest of individuals wanting to make forensics a part of their career path (Lamaine). Also, in numerous other universities across the country the impact of the television program Crime Scene Investigation has made its presence known. Professor Edward Robinson of the Department of Forensic Sciences at George Washington University, commented that significantly more colleges are now offering classes of instruction in forensics in their curriculums (as cited in Lemanie). At George Washington University the number of individuals seeking advanced degrees increased from 113 to 190 between the years of 1999 and 2002

(Lemanie). Impaneled jurors in civil as well as criminal trials have made the presentation of forensic evidence more of a common occurrence. The increased occurrence can be traced to the media's prolific attention given to forensic science (Willing, 2004). Many jurors deem the absence of some kind of forensic type of evidence presented by either the prosecution or the defense as a negative aspect of their case presentation. An article in USA Today entitled "CSI effect has juries wanting more evidence" discussed the court case of Mr. Robert Durst.

> To the legal analyst Mr. Durst's case appeared to be a classic example of how television programs like Crime Scene Investigation have a definite effect on the actions taken place during the process of criminal proceedings taking place in court houses across the United States, Examples of these effected areas would include higher jury expectations of the evidence presented by prosecutors in a criminal proceeding. (Willing, 2004)

These types of attitudes towards forensic evidence at criminal trials has caused law enforcement and district attorney's offices to look for forensic type evidence merely to satisfy the expectations of jurors (Willing).

Television programming among media outlets is not the main cause for the general public's elevated interest in the forensic sciences. Over the past 15 years the court system has been increasingly more aware of inaccurate and non-constant methodologies used by some forensic scientists when examining forensic type materials (Solomon & Hackett, 1996).

Until the mid 1990s the standard for evidence to be admitted in a criminal proceeding was measured against the *Frye* test (United States Supreme Court, 1923). Testimony by experts was admitted at a criminal trial solely on the basis of the skill, reputation, credentials, status, experience, and qualifications of the expert giving the testimony. If there were any inconsistencies in the findings or determinations espoused

by the experts, it was assumed that they would be brought to light through rigorous cross-examination by the defense attorney (Frye v. United States, 293 F. 1013, 1014 (D.C. Cir. 1923). The wording in *Frye* gave individuals giving expert testimony and scientist who could be called to give expert testimony ample room for a margin of error when testimony was given in a trial may not be accurate.

In 1993, professional testimony permissibility standards were re-defined. The standard was changed due to a United States Supreme Court decision in *Daubert v. Merrell Dow Pharmaceuticals, Inc*., 509 U.S. 579, 113 S. Ct. 2786,125 L. Ed. 2d 496 (United States Supreme Court). Although the *Daubert* ruling applies to federal courts, most states refer to this ruling for precedence. The basic premise of the *Daubert* ruling is that a judge makes the determination on the admissibility of expert testimony (United States Supreme Court). The judge of record has the task of making the decision whether the situational requirements have been met by measuring it against the Federal Rules of Evidence No. 702. This federal provision states:

> If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.(Federal Rules of Evidence)

In the wake of the *Daubert* decision, assumptions that had always been made in the forensic sciences had to be reexamined and proven on an empirical level. Examples of some of these assumptions would be the assertion that no two individuals have the same fingerprint, or that no two individuals have the same type of handwriting. Neither of these statements had been substantiated or empirically founded. Scientists working in the area of fingerprint identification and forensic document examination were forced to

empirically provide support to these claims if the evidence was to be admissible in a court proceeding (Solomon & Hackett, 1996).

Firearms and ballistics is another one of the areas of the forensic sciences that have not fallen under the close scrutiny of the court system. Solomon and Hackett (1996) found that firearms and identification units are common areas in laboratories that specialize in the investigation and examination of firearms and related materials. Forensic scientists in firearms identification units are generally asked to match a suspect handgun with discharged bullets or shell casings. There could also be requests from investigators for these experts to establish trajectory paths by the examination of the flight paths of bullets at the scene of criminal activity where a firearm was discharged. These individuals are also sometimes tasked with determining the distance a firearm was being held from the point of impact when it was fired. This process is defined as a determination of distance test (Osterburg & Ward, 2004; Sigel, 2007; Solomon & Hackett).

Distance determination testing is important in cases where the distance a firearm was held from a target or victim becomes crucial in establishing what occurred during the commission of a crime or to establish self-defense (Osterburg & Ward, 2004). When a firearm is discharged, it releases not only a bullet but also flame, smoke, and burned and unburned powder particles from the muzzle. In addition, particles of lead and other elements contained in the bullet, casing, and primer are expelled from the muzzle of the gun. These particles, known as gunshot powder residues (GSR), create a circular pattern as they fan outward from the muzzle of the gun. In close distant gunshot cases, these GSR particles embed themselves onto the fabric or skin of the victim. By testing the suspected firearm at varying distances, firearms identification scientists can estimate the

distance a firearm was held from the target or victim when it was discharged (Hatcher et al., 1977; Osterburg & Ward; Schulz, 1977; Sigel, 2007).

Procedural manuals from every state and federal crime laboratory in the United States stipulate that the same firearm used in the commission of the offense must be tested with the same or similar ammunition. The assumption being that all firearms, even those of the same make and model, produce different GSR patterns. Until recently, the assumption that the same firearm used in the commission of a crime must be used for GSR testing had never been empirically proven (Osterburg & Ward, 2004; Sigel, 2007). In 2007, a study by Lewey indicated that the same make and model handguns were not statistically different in the manner in which they produced GSR patterns. This would challenge the assumption that the same firearm used in the commission of a crime must be used for GSR distance determination testing. Lewey's study, however, did not address the same or similar ammunition requirement of crime laboratories.

Background of the Problem

When determining the distance a firearm was held from the victim or target when it was discharged, determination of distance testing may be a very useful investigative tool. From what has been established from the literature, the distance test determination would be null and void if the suspect firearm in question was not used in the process of testing. Lewey's (2007) study indicated that the same make and model firearm may be used in lieu of the original firearm in such testing; however, she did not address whether the same ammunition would be required for such testing. Ammunition manufacturers use different techniques and compounds during their manufacturing processes. These differences in formulation could possibility cause differences in distance determination

testing results. On the other hand, there may be no significant difference found from the different types of ammunition. No empirical study has been made to date to provide evidence of this assumption (Hatcher et al., 1977; Osterburg & Ward, 2004; Schulz, 1977).

When law enforcement responds and conducts a crime scene investigation involving the discharge of a firearm, the determination of the distance the firearm was held from the victim may become an important aspect of the investigation. Such information could be vital to the investigator when the investigation centers around a reported suicide, a firearm discharged at close range, and statements of self-defense (Osterburg & Ward, 2004). In all of these incidences, determination of distances could very well have a dramatic impact on the case investigation and help determine the guilt or innocence of an individual. During the process of investigating and processing a crime scene, investigators often find that the firearm used in the commission of the criminal offense is not recovered or has been damaged beyond usability for comparison testing. If an individual has been charged with a criminal offense involving a firearm, the attorney conducting the individual's defense would have an obligation to give the individual the best representation possible. During the process of that defense, an independent testing of the evidence collected and presented at trial is a good possibility. Obtaining the actual firearm used in the commission of the criminal activity might be difficult or impossible if the firearm had been destroyed or damaged to the point of not being safe to conduct testing or simply unable to be located (Hatcher et al., 1977; Osterburg & Ward; Schulz, 1977; Sigel, 2007). As Lewey's (2007) study indicated, if it is possible to identify the firearm in question by its model, make, and caliber, it may be acceptable to acquire and

test an identical model and make firearm in determination of distance testing. However, Lewey's study only looked at one type of firearm.

Lewey's (2007) study did not address ammunition. As indicated, crime laboratories require distance determination testing be made with the same or similar ammunition as used in the commission of the firearms crime. While shell casings may be present at a crime scene that can readily identify the type of ammunition, sometimes no shell casings are found. This may be especially true of firearm discharges with revolvers where the shell casings are not ejected from the firearm. And, perpetrators have been known to collect spent shell casing and discard them after a shooting incident. This would leave the crime lab with little to go on as to the type of ammunition used in the crime.

Purpose of the Research

The purpose of the present study was to answer two basic questions. The first question is whether or not there will be a significant difference in the results of testing involving the use of different brand names of ammunition in forensic determination tests The second question is whether or not Lewey's (2007) study is valid and if there is a significant difference present between identical models and make firearms in distance determination testing.

Hypotheses

Formulation of the null hypotheses was based on the literature and purpose of the research and is as follows:

Ho1: There will be no significant difference in gunshot residue patterns using the same make-model handguns in distance determination testing.

Ho2: There will be no significant difference in gunshot residue patterns using different brands of ammunition in distance determination testing.

When planning to test these hypotheses, it was determined that three different but identical make and model type handguns would be used for testing purposes. This task was accomplished by making contact with a state law enforcement agency to obtain firearms in regular rotation as issue service firearms used by agents with the department. The state agency used in the present study issued to their special agents two models of Glock .40 caliber semi-automatic pistols. The Glock .40 caliber model 27 was selected for testing purposes. Three Glock weapons were selected from agent issued firearms and were put through testing using three different brand names and kinds of ammunition of the same caliber. The testing was conducted at the indoor firearms range facility at East Tennessee State University.

Limitations

Other handgun manufacturers could have different and varied standards of production that could have or possibility could not have a significant effect on determining distance tests. The use of one specific model and make handgun could be a limiting factor. Barrel length of firearms is a significant factor when determining distance determinations. There were no rifles or shotguns tested in the present study. Shotguns and rifles have a significantly longer barrel length than the handguns used in the present study and may be different in distance determination testing.

Basic Assumptions

For the purposes of this study, there was a basic presumption that the three handguns chosen for testing were an accurate representative of all same model and make firearms produced by this manufacturer. All of the handguns used in this testing procedure were examined and found to be suitable for the purposes intended. The ammunition was commercial grade ammunition and assumed to be representative of ammunition produced by the manufacturer.

Definition of Terms

Ballistics: The study of a projectile in motion. Three basic types of ballistics: terminal, the impact on a target; interior, within the firearm; exterior, after the projectile leaves the barrel (Wilber, 1977).

Bullet: Some commonly referred to names are wadcutter, semi-wadcutter, full metal jacket, round nose, or hollow point. The projectile that can be shaped and or composed for a variety of different purposes (Bennett & Hess, 1994).

Caliber: Usually expressed in hundredths of an inch (i.e., .22 cal) or in millimeters (i.e., 9mm). It is the diameter of the bore or muzzle of the firearm (Osterburg & Ward, 2004).

Casing: The tubular structure that encases the gunpowder, primer, and bullet (Osterburg & Ward).

Gunshot powder residue: non-burned gunpowder (nitrates), partially burned gunpowder, and smoke from fully burned gunpowder escaping from the end of the barrel of a firearm. Also known as Gunshot Residue (GSR) (Osterburg & Ward).

Muzzle: In distance test determinations, it is from the target to the muzzle that is being measured. The end of the barrel of a firearm where the bullet exits and is discharged (Wilbur).

Shell Casing: Same as casing (Osterburg & Ward).

Stippling-Tattooing: Reddish markings around the entrance hole of the bullet. Terminology used in the field of forensic pathology in the defining of damage to skin due to close gunshot wounds (Osterburg & Ward).

CHAPTER 2

REVIEW OF THE LITERATURE

Firearms are among the leading reasons for unnatural death in the United States. More than any other types of weapon firearms are used in the commission of aggravated assaults, suicide, and homicide. There are estimates reported by the Center for Disease Control (2002) that conclude approximately one fourth of all non-intentional deaths in the United States are from accidental shootings. Firearms testing, identification, and ballistics have become an increased and larger ingredient of federal and state criminal laboratories as a direct result of the number of injuries and deaths resulting from injuries sustained form the use of a firearm. From information obtained from the National Vital Statistics report in September 16, 2002,

> There were 28,663 individuals that died from injuries sustained with a firearm in the United States alone. Of all injuries sustained with a firearm in the year 2000, homicide and firearms suicide the two significant component causalities, accounted for 37.9 and 57.9 percent, of all of the deaths reported. Of the remaining documented areas, legal intervention involving the use of firearms, firearm injuries that were undetermined in intent, and lastly firearms accidents accounted for 0.9, 0.8, and 2.7 percent. (Center for Disease Control, p.10)

The Bureau of Justice Statistics reported that in 1993, "there were a reported 4.4 million crimes of violence including aggravated assault, rape, sexual assault, and robbery. The victims of these crimes of violence 29% or 1.3 million reported that they were faced with a suspect with a firearm" (United States Department of Justice, July 1995, NJC-148201). More recent information as reported from the Bureau of Justice Statistics that indicates in 1995 that as many as "477, 040 violent crime victims have reported that the person who committed the criminal act on them was armed with a firearm. These

reported incidents where a firearm was used represent approximately 9% of the reported 4.7 million violent crimes of simple assault, aggravated assault, sexual assault, robbery, and rape incidents reported in the year 2005" (United States Department of Justice).

As far back as the 1400s weapons such as cannons as well as small arms were loaded for discharge by the use of loose powder and shot. The non-contained powder was placed into the muzzle end of the firearm's barrel. The shot was then dropped down the barrel of the firearm and compacted with the powder. The powder was ignited from the closed end of the weapon's barrel sometimes referred to as a breech that contained a small opening for the use of an ignition source. In the late 1700s and early 1800s the culmination of several innovations to enclose these elements resulted in the paper cartridge. This invention enabled the ammunition to contain the exact right amount of mixed and measured propellant. In 1840 two American inventers Horace Smith and Daniel Wesson combined a series of inventions that included a reliable revolver type firearm as well as metallic or fixed cartridge ammunition. Gunpowder was placed into a cartridge case and this powder propels the bullet. When an ignition source is applied to the powder it burns very rapidly. This burning process produces hot gasses that expand inside the cartridge body. These expanding gasses push the bullet from the case mouth and launch it down the barrel of the firearm. The pressure inside the brass shell, coupled with the extreme heat, causes the shell to swell in the firing chamber, keeping most of the gasses from exiting the breach (Overview of Ammunition for the Novice Navigation, 2000).

There are numerous types of firearm powders. These powders are for the most part described by shape of the grains. Examples of these powders would be Ball Powders, Extruded Flake, and Flake Powder. All of the varying powders have unique burning rates

that internally cause varying and different firing chamber pressures. The amount of powder, which is measured by weight in grain, is varied in a shell in order to produce different velocities. Within these parameters, bullet performance is empirically measured. Attempting to mix powders of varying and different brands will not result in a positive outcome (Overview of Ammunition for Novice Navigation, 2000).

Knowledge of distances that a firearm was held from an individual when it was discharged could be a vital aspect of a case investigation of a suspected suicide or during a homicide investigation (Osterburg & Ward, 2004; Schulz, 1977)). An investigator who possesses the knowledge of how far the weapon was from a victim can make conclusions and can plausibly answer commonly asked questions regarding self-inflicted wound issues and self-defense claims. Additionally, this knowledge can assist in reconstructing the events leading up to and surrounding the shooting itself. In order to make a determination of the distance a victim was from the firearm when it was fired, testing regulates that the examination be conducted using the same firearm and the same type of ammunition in a series of controlled firings at a firearms safe range. The basic setup for such experiments include test firings that are accomplished from varied distances; the distances sometimes range form 36 inches at the outer most to actual contact with the target (Hatcher et al., 1977; Osterburg & Ward; Sigel, 2007. The intended target area is usually made up of white colored fabric or poster board of the same color makeup. After each discharge of the weapon, the residues of deposited gunpowder is compared form the firings in relation to an actual skin or piece of clothing of the victim. The information obtained form this comparison gives the investigator an estimate of the distance the victim was from the firearm when it was fired (Ermenc & Prijon, 2005; Osterburg & Ward; Schulz).

Most, if not all, documentation in this area advises that the same ammunition and firearm must be used when doing this comparison type of testing (Osterburg & Ward, 2004). Reasoning for this type of requirement is apparently so that the person conducting the experiment can identify whether the weapon has not been altered in some way (rusting in the lands and groves area in the barrel of the weapon and further to insure that the weapon has not had any alterations made to it, ect.), and that the weapon is in a good functioning order. There is not a single federal or state laboratory that deals in evidentiary issues involved in criminal investigations that will conduct distance determination testing without the same ammunition and the actual firearm used during the commission of the criminal activity. The results that are sent to an investigator after a crime laboratory has carried out distance determination testing are stated terms of bracketing and estimates usually not in distance specific terms (Osterburg & Ward). An example of what a report might state would read something like: residue patterns form the weapon that were displayed on the blouse of the deceased victim were consistent with the test firings, using the same type of ammunition and firearm, the distances were from 18-24 inches in length (Osterburg & Ward; Schulz, 1977; Sigel, 2007).. There have been no known identifiable studies conducted to determine if identical model and make weapons can reveal any significant difference in the way that they produce residues of powder using the same or different makes of ammunition.

Criminal investigators, very often, would be greatly assisted in knowing the distance a victim was from a firearm when he or she was shot, especially if the firearm involved in the incident has been destroyed or has not yet been located (Osterburg & Ward, 2004; Sigel, 2007). With the standing that laboratories that conduct testing in criminal type activities not performing distance tests without the actual firearm, criminal

investigators are unable to obtain distance determination information that can then be used to give credit to a suspect's statement or call it into question. Often the actual firearm used in the commission of an offense is disposed of by the suspect and may not be located. Sometimes suspects attempt to alter the markings of the barrel of the firearm by putting a file down the barrel. Rust from being in bodies of water as well as being subjected to changing weather conditions could also damage the weapon (Osterburg & Ward; Sigel). Law enforcement officials often know the make and caliber of the firearm used in a criminal act, but as is often the case the actual firearm is not locatable. It may be possible that law enforcement, with the knowledge of type of firearm and ammunition used, may have the ability to make a distance determination test with similar firearms and different makes of ammunition. If testing different firearms and different types of ammunition other than the original firearm were possible, it would have a significant impact on criminal investigative results and would have a positive result for the district attorneys who prosecute the cases and the defense teams as well (Ermenc & Prijon, 2005; Hatcher et al., 1977; Osterburg & Ward; Schulz, 1977).

Continuing furtherance of education in the area of the forensic sciences and research has become a large part of the training budget and for the most part a requirement throughout criminal investigative agencies across the United States. This can be directly related to the fact that individuals who take part in criminal activity are increasingly becoming more adept at ways of conducting criminal activity and these criminal actions are getting the attention of the print and media outlets that capture the attention of the general viewing public. The failure of an agency to acquire the ever advancing courses of instruction in the area of forensic science for its criminal investigative staff has unfortunately proven itself to have negative implications in several

criminal case investigations (Lewey, 2007; Osterburg & Ward, 2004; United States Department of Justice, 2007).

Examples of these occurrences can be linked to criminal investigations documented in the New York Times in the year 1879. The account stated that the victim Josiah Bacon was located on the floor of a hotel room in San Francisco with a pistol shot. The article continued to state "He had been dead for several hours. No fire-arm was found in his rooms, and as the hemorrhage was entirely internal, there were no means of judging his movements subsequent to the fatal shot" (New York Times, 1879). The article further stated "There is some ground for the opinion that the tragedy was a murder not a suicide. The clothing of the dead man was not burned where the ball entered" (New York Times).

From the statements contained in the report by law enforcement personnel involved in this investigation over a century ago, it is a definitive conclusion that there should be increased research in all of the sub-sections of the forensic sciences. In 1983 an article in the Journal of Forensic Sciences by DeHaan described a case of a white male found shot dead in the subject's own residence. DeHaan gave the absolute imperativeness of reconstructing the circumstances surrounding the criminal activity, as the weapon used by the assailant in the commission of the act was not able to be located. To carry out this process DeHaan wrote,

> Weapons similar to the one allegedly used were test fired under controlled conditions and residues from the muzzle and cylinder blast were compared to residues at the scene. Based on these comparisons, characteristics of recovered bullets, standard determinations of distance, and the pathological findings the dynamics of the perpetrator and the victim could be put back into place. The sequential firing of the bullets as well as probable positions of the individuals involved in the incident were able to be determined. The information obtained from the comparison examination in this particular investigation showed that revolvers that use black powder make great amounts of other than normal residues which

> add to the usual range of firearm evidence to make even complex reconstructions plausible. (p. 1)
> .

In an investigative study presented at the Second Indo-Pacific Congress on Legal Medicine and Forensic Science, Suwanjytha (1988) put forth the importunacy of target muzzle distances. Suwanjutha's writing titled "Direction, Site and the Muzzle Target Distance of Bullet in the Head and Neck at Close Range as an Indication of Suicide or Homicide" states "in order to determine whether it was suicide or homicide, the path of the bullet, the site, and the muzzle target distance must be considered" (p.1). One of the emphasis areas covered in the study was the importance of finding out target to muzzle distance determinations to properly reconstruct the scene of a criminal act. In a 2005 article by Ermenc and Prijon in the Journal of Forensic Science International a situation that showed the significance of a proper crime scene investigation was discussed. The writings reported that a 21 year old was found dead in her home, she had been killed by a gunshot. Ermence and Prijon stated

> Despite an intensive crime scene search the cartridge, projectile, and firearm have not been located. Traces of gunpowder were found to be present on the mother and daughter of the deceased, while the son was discovered to have traces of gunpowder on his vest and hands. (p. 1)

Criminal investigators theorized as to whether this shooting was intentional or accidental because of shot patterns at the scene of the activity. In the study Ermenc and Prijon detail a significant importance of conducting determination distance testing of firearms and the results that the crime scene itself can provide, even when the suspect firearm cannot be located.

Another example of this issue having an impact was the death of Commerce Secretary Ron Brown. As documented in an article in World Net Daily Exclusive (2001), Sperry stated "a handgun carried by a body guard assigned to protect Brown, was lost and

not recovered from the wreckage of the plane, which crashed in Croatia in 1996". The article further reported "the internal security report completed in the month of March 1999, an additional fifteen months after and Air Force pathologist revealed the fact that there was an unusual wound at the top of Brown's head that could have been a bullet entry hole" (Sperry). There was no follow-up investigation as to the possible location of the missing handgun form the bodyguard and further there was no autopsy preformed on Ron Brown's body. The reports in World Net Daily show that there were numerous and varied speculative reasons listed for the odd wound in Brown's head area and further why the missing .357 Magnum handgun was not recovered and its whereabouts not determined. The lasting questions about this case and the ensuing investigational follow-up also give rise to conspiracy and cover-up theories. If criminal investigators would have followed up on the bodyguard's missing handgun, the results of that follow up could have aided in putting to rest some of the lingering questions surrounding Brown's death. With the limited forensic investigational processes conducted at the time of the incident and little or no research conducted, those lasting questions will in all likely hood never be answered.

In an article in the Guardian Unlimited authored by retired police officer, Shoebridge (2002) describes the case of Barry George who was charged in the murder investigation of Jill Dando. Mr. George was convicted of the offense and attempted to gain an appeal of his conviction. The British Broadcasting Company employed Jill Dando as a television presenter for approximately 15 years. During the process of the criminal investigation, law enforcement was involved in a high-profile investigation in an attempt to locate Ms. Dando's killer. Reports documented in reference to the crime scene search indicate that the scene where the homicide occurred was thoroughly carried out;

no physical or trace evidence was recovered by investigators that would aid in the determination of the individual who perpetrated the criminal act. The British Broadcasting Company published information that investigators did recover a cartridge and a spent nine-millimeter bullet. The appeal that was filed by Barry George was found to be without merit and the conviction for murder was upheld. In the article Shoebridge elaborated further with his own ideas stating

> Despite the failure of George's appeal, the role of both the prosecution and the police in bringing him to trial deserve scrutiny, as do the findings of the police investigation. It should be remembered, however, that the decision to convict George was one for the jury alone. At a time of increasing pressure on the rights to jury trial, the key question may be how best to deliver justice when a jury insist on following its instincts, rather than the evidence before it. (p.3)

This case and the subsequent follow-up investigational process is yet another glaring example of the need for an advanced knowledge base by investigators of forensic sciences with an emphasis in the area of ballistics. A case lacking any physical evidence will not be looked on by a jury as being properly and thoroughly investigated. This opinion is based on the juror's knowledge of criminal investigative techniques they think they have learned form the media. The furtherance of training in forensic sciences should be completed so that criminal investigations can be completed in a thorough and complete manner that will result in better case presentation at the criminal proceeding that will follow.

An article in the West Toronto CityNews (2007) in Ontario Canada, a 9th grade student identified as Jordan Manners was shot and killed in a hallway of her high school in May 2007. From the follow up criminal investigational process there was no motive determined, no plausible suspect, and no firearm was found regarding the commission of the criminal conduct. This particular tragic incident should serve as a glaring determining

factor for the supervision of any criminal investigative unit to push for increased and advanced continuing knowledge base of empirical research and forensic techniques.

Joseph Diggs is in prison in the state of California along with two co-conspirators serving a sentence of 25 years to life on a criminal conviction for attempted murder, conspiracy to commit murder, and other related type offenses. Attorney for Mr. Diggs, Marc Zilversmit has been working on Mr. Diggs's appeals even 12 years after his conviction in the strong belief that his client is not guilty of the criminal acts for which he was convicted and sent to prison. In a brief filled on June 18, 2007, on the behalf of his client, with the Ninth Circuit U.S. Court of appeals. Zilversmit (2007) stated "No substantial evidence linked Mr. Diggs to these crimes, no motive was alleged for Diggs' participation in the crime, no physical evidence linked him to the crime, and there was no eyewitness evidence whatsoever that he played a role in it" (p. 5).

In a criminal investigation that may lead to a criminal prosecution the accused is innocent until proven guilty by reasonable doubt through the presentation of evidence. Cases like the one involving Joseph Diggs and ones similar in content and form should challenge students in the field as well as professionals in the field to expand this area of research.

A specific methodology of estimating the distance from which a handgun was discharged is illustrated by Wilber (1977) in his book entitled, *Ballistic Science for the Law Enforcement Officer*. He states the importance of "a required examination of the pattern of powder markings and smudginess left on the skin or on the clothing" (p. 217). When the weapon was discharged, the "firing of a cartridge from a gun drives out the bullet from the barrel along with a mixture of burnt powder, gases, lubricant, partially burnt powder, and metal dust" (Wilber, p. 217). Wilber further states,

> These concentric areas vary in diameter with distance of the muzzle to the target…. There is no way to establish reliable file standards for powder patterns as related to the distance of the shot. The firearm itself must be test fired, hopefully with the ammunition in question, in order to establish the soiling pattern for that particular combination of gun and ammunition. (p .217)

Given the stringent instructions, there was no method of a secondary testing method if the original weapon was not able to be located or was not in usable condition.

In the fourth edition book titled Scientific Evidence in Civil and Criminal Cases authored by Moenssens, Starrs, Henderson, and Inbau (1995) the authors indicate that gunshot residue deposits may vary with the actual firearm. Any distance testing performed would have to be approximations rather than exact measurements. Furthermore, the initial layers of the target were deposits first strike must be the point of measurement. In other words, if the victim was shot in an area covered by clothing, the clothing must be used to compare measurements rather than gunpowder burns on the skin under the clothing (Moenssens et al.).

There is no absolute or exact table or formula to use in the determination of the range or distance a firearm was held from the target when it was discharged. Even with distance determination testing using the same firearm produces only approximations (Moenssens et al., 1995). This implies that the same firearm might produce varying gunshot residue patterns at the same distance. This could easily be controlled by test firing the firearm three to five times at the same distance to insure reliable results. There are no standards nationally or on the state or local level for crime laboratories to test the firearm more than once in distance testing. Lewey (2007) did find the same handgun would produce varying powder dispersals at the same distance but these variances were not significantly different.

There are numerous prior documented case investigations that make clear the relevance of this particular piece of evidence. In *Williams v. State* (Williams v. State, 282 Ga. 561, 2007) an experiment conducted on shot dispersal was allowed into evidence by the trial judge after it was visually shown that the testing conducted was a standard matching of the shot dispersion with experimental test patterns. Results were obtained by the use of cartridges and loads that were similar to the same types located in the defendant's shotgun that was found at the scene of the criminal activity. At the point that such evidence is brought into the clear and is understood, an individual's assertion of his or her location during the time a homicide was being committed may be corroborated. This finding could have far-reaching and even life or death determinations for the suspect on trial for the intentional killing of another individual.

The significance of gunshot residue distance determination testing has been shown in many court cases. In the case of *Guerrero v. State* (Guerrero v. Commonwealth 46 Va. App. 366, 370, 617 S.E. 2d 410, 412, 2005) a homicide conviction was reversed by the appellate court concluding a reasonable possibility existed that the death was caused by accidental circumstances. There was testimony given that indicated a minimal burn from powder was located on one of the victim's index fingers. There was further testimony that the original firearm used when the victim was killed was fired while making contact with the victim's facial area. In the case of *State v. Atwood* (State v. Atwood 602 N.W. 2d 775, 784 (Iowa 1999), testing was completed with the use of the original firearm and ammunition that was of similar origin. The trial court consistently admitted the blotting paper sheets used during the testing process, into evidence.

Contained in and according to the workbook "Forensic Technology for Law Enforcement" used by the California Commission on Peace Officer Standards and

Training for a television type course that was shown May 13, 1993, testing for target to muzzle distance testing is very specific and special instructions for the process are administered. Those instructions are:

> For gunpowder or shot pattern tests to have any significance, it is essential to obtain ammunition identical in type, make, and age to that used at the crime scene. This duplicate ammunition is necessary for firing the weapon in question to determine the distance of the muzzle of the weapon form the victim or the object at the time the questioned bullet was fired. (p.8 of 12).

An obvious problem that should be considered is whether there is a valid reason for this specific type of testing and equally as important to consider is the possibility that the weapon used in the criminal activity is not locatable. Using different types of ammunition should be considered as well in order to conduct the testing.

The eighth edition of the Laboratory Field Manual of the West Virginia State Police (2007) describes different exams of firearms that could be conducted. A section on the manual titled, "Examinations and Possible Determinations", there is wording that states: "Distance Determinations: Determine approximate distance from impact to muzzle. (* Must have firearm used in the incident for determination)" (p. 1). It is furthermore provided: "in certain shooting cases, it may be important to know the approximate distance between the victim and the muzzle of the firearm" (West Virginia State Police, p. 9). Every criminal investigation deserves equal response from the investigative agency that has jurisdiction. Investigations of shootings should not be given greater significance than any other offense, this is to make absolute that the justice systems serves everyone equally. To further such a statement when a criminal offense involving a firearm takes place and the firearm involved in the incident cannot be located, there should be an alternate form of testing for distance determination available. The individuals who perpetrate these acts are becoming more knowledgeable and are

developing more intelligent plans when setting up and carrying out their criminal activities. With this being the situation, the criminal justice community must also make the same advancements.

In a handbook used by the Federal Bureau of Investigation (2003) entitled "Handbook of Forensic Science" the following is documented:

> The deposition of gunshot residue on evidence such as clothing varies with the distance from the muzzle of the firearm to the target. Patterns of gunshot residue can be duplicated using a questioned firearm and ammunition combination fired into test materials at known distances. These patterns serve as a basis for estimating muzzle-to-garment distances. (p. 54)

FirearmsID.com, a website known to have reliable information, details that a "shot pattern" is created when the testing of the muzzle to the target takes place. Further indicated on the website, "the unknown pattern is then compared to test patterns created with the suspect gun fired at known distances. This will allow for an approximate muzzle to target distance to be determined" (Hamby & Thorpe, 1999, p. 1). With the minimal amount of documentation available on the subject, the accumulated material dictates that individuals conducting testing to conduct tests by using the original weapon, and when the results of the testing are documented use the verbiage 'approximate'. By the use of non-exact terms the definition of which mean not accurate, inexact, estimation, rough, near, or fairly exact. With this in mind, if there is a criminal investigation of a crime involving a firearm, the use of the original firearm is not absolutely accurate. This being the case, if a criminal offense involving a firearm occurs, and the suspect weapon is not locatable, and the investigators have the knowledge of the make, model, and type of ammunition, the use of make, model, and ammunition should be given the same amount of creditability. The reason for this is because the testing of an original firearm is not an absolute answer to the question of distance determination.

The Forensic Science Firearms Unit of the Orange County Sheriff's Office in California (2004) gives specific examinations on firearms that are conducted by their unit with regards to distance determinations,

> By comparing these patterns to standard patterns generated in the laboratory, it is often possible to give an estimation, or range, of how far away the muzzle of the muzzle of the firearm was from victim. Similar examinations may also be preformed with shotgun pellet patterns. A more accurate distance estimation generally requires use of the firearm in question and ammunition equivalent to that used in the crime.

As director of the crime scene unit for the Los Angeles County Sheriff's Department and further as Adjunct Professor in the Criminal Justice Department at California State University, Barry A.J. Fisher provides somewhat similar courses of instruction for determinations of gunshot distance. Information contained in Techniques of Crime Scene Investigation, Fisher (2004) indicates there are similar types of investigative techniques.

> To make a distance determination, it is important to use both the same firearm and ammunition used in the crime. A series of test firings are made into paper or cardboard at different distances and the test patterns are compared with evidence (p. 427).

The documentation in the textbook continues to elaborate about the importance of this type of testing that it is "particularly important because of the large amount of useful information it can provide. Because this type of evidence is encountered so frequently, investigators must be familiar with the proper methods of handling this evidence and its value to the case" (Fisher, 2004, p. 426).

There are specific instructions provided for criminal investigators conducting evidence testing located in the Virginia's Department of Forensic Science Firearm/ Tool mark Procedures Manual (2007). Section 7.6.8. entitled "Test Pattern Production" states

> A systematic approach should be used in conjunction with a working hypothesis formed by observations based on previous testing to include

> visual, microscopic, and chemical tests to produce test patterns with the appropriate firearm and ammunition for the purpose of developing a range determination. (7.6.8)

There is further information stated in reference to the specific aspects of the procedure, "It is essential that the suspect firearm and appropriate ammunition be utilized for these tests" (Virginia Department of Forensics, Toolmarks and Procedures Manuel, 2007, 7.6.8). There is further information contained in the manual that states,

> By utilizing the suspect firearm and appropriate ammunition it may be possible to obtain a reproduction of gunshot residue pattern(s) and or shot pellet pattern(s) present on the questioned item… comparing the test patterns to the questioned pattern(s), a determination may be possible as to the approximate bracketed distance a particular firearm's muzzle was from the questioned item at the time of firing. (7.6.8)

Stated in Tools for Forensic Science Techniques, a publication by the FEI Company, key evidence in firearms forensics is determination of shooting distances.

> If residue patterns are detected then these are compared with test targets produced by firing the firearm in question at various known distances which allows the examiner to approximate the distance from the object that was shot to the muzzle end of the firearm. (2006, p. 6)

There is documentation contained in Missouri's Department of Highway Patrol training manual that states

> The suspect firearm and suspect ammunition is test fired into similar target material at varying ranges. These tests are then analyzed in the same way as the questioned bullet hole is. An approximate range can be concluded when the questioned pattern is compared to the test fired targets. (Missouri State Highway Patrol, 2007)

Specific guidelines are provided for evidence submission by law enforcement officials in Connecticut's Department of Safety training Manual (2001) In the Distance Determination section the procedures are "To preserve gunpowder patterns on clothing, package items flat and when possible on a hard surface, i.e. cardboard and wrapped in brown paper. The actual weapon must be submitted in order to conduct distance testing"

(p. 4). There was no reasoning given for documenting this as the only means of conducting such types of testing. When instructors are presenting training material in a law enforcement training setting and describe a certain method or procedure that the officers are to follow, the instructors further the instructional process by telling the personnel present why they should follow the instructed processes and further why other avenues of approach should be avoided.

As a retired Commanding Officer of the Massachusetts State Police Ballistics Section, Ronald R. Scott is identified as an expert in the area of firearms (Lewey, 2007). He is further reported to have in excess of 40 years of experience with ballistics-firearms across the United States. Mr. Scott has testified in State and Federal jurisdiction courts of law as a an expert in the field of ballistics in excess of 250 times. Scott discusses the significance of determining distance testing. Further the results of the testing can significantly assist criminal investigators when they are proof reading their case investigations looking for areas of weakness. Scott further commits:

> The goal is to conduct tests which will approximate the distance from the object/victim that was shot to the muzzle end of the suspect firearm. Certain facts of the case can be proven or disproven when these tests are performed correctly. The presence of intervening objects must be considered. The paramount factor is to duplicate the pattern of powder stippling, soot, and other markings in the exact manner as it appears on the victim or object by replicating the angle of the weapon, using the evidence weapon and same ammunition. (as cited in Lewey)

In the textbook "Forensic Science, The Basics" by Siegel (2007), there is a description of these types of testing procedures. " When a bullet is fired from a gun, hot gases containing residue from the primer and smokeless powder will be expelled from the barrel and will travel for short distances in a roughly conical pattern" (p. 235). This statement basically indicates that gas type materials exiting form the barrel of the firearm will extend a distance in a *non-exact* narrow direction. Siegel further reports that there is

further documentation to the fact: “Depending upon the distance from the weapon to the target, some of the residue may be deposited on the target. The size of the gunshot residue pattern can be used to determine the approximate distance between the weapon and the target when the bullet was fired” (p. 235). This documentation would give rise to the indication that there isn’t any type of ballistic testing that is completely accurate or absolute. Also indicated by Siegel is the fact that there limits to the assessment that should be taken into account when muzzle-to- target types of measurements are taken:

> Distance of firing determinations are done by test firing the same weapon and ammunition at various distances, and then comparing the size of the stippling and soot on the target. Not even another weapon of the same exact type will reproduce gunshot patterns, and serious errors can occur in interpretation if the exact same weapon is not used. (p. 236)

Siegel did not give any identifiable reasoning why the exact weapon must be used when testing is being conducted and further did not give a reference to further support his statement.

A Forensic Examiner and Physical Scientist in the Firearms/Toolmarks Unit of the Federal Bureau of Investigation, Brandon Giroux, has given the procedures followed, without variance, that should be followed to carry out such kinds of testing procedures: It is required that the contributor send the suspect firearm and some indication as to the type of ammunition that was used (cartridge, a cartridge case, and or bullet) (B. Giroux, personal communication June 5, 2007). If the contributor is unable to provide the firearm or there is no any indication as to the type of ammunition used, we are unable to perform this type of examination. During training, as well as in the FBI’s Gunpowder and Gunshot Residues course, as an instructor, we have seen variability in the GSR patterns when different firearms are used even if the same make and model (Lewey, 2007).

The U.S. Supreme Court in 1993 set admissible standards of forensics for most if not all states. The case that the court used to make this determination was *Daubert vs. Merrell Dow Pharmaceuticals* (509 U.S. 579, 1993). One of the requirements stated in the *Daubert* case is " …expert opinion based on scientific technique is inadmissible unless the technique is 'generally accepted'. While requiring the original firearm to be used for distance determination testing is a generally accepted" (United States Supreme Court). There is no scientific basis for this accepted technique.

From the documentation thus far there has been procedures discussed for distance determination testing; however, in the content of those procedures there is no explanation why certain procedures are part of the investigation. Certain procedures stating that investigators shall use the same ammunition and suspect firearm when conducting testing are repeatedly stated, but there is not any logical or scientific reasoning for this requirement. No empirical research or supportive documentation can be located that can give this requirement any plausibility for such a requirement to be in place. There is a significant amount of documentation that supports the idea that shotgun pellet and gunshot residue dispersion is different with identical model and makes of shotguns, no identifiable empirical information is present to make such a statement absolute for rifle and handguns or other firearms that use a single type bullet or projectile. When reviewing the literature that details distance determination tests, there was no information located that addressed discharging the test firearm numerous times at an identical distance to define reliability. There would seem to be some reasoning that if there were a basic idea that same model and make firearms produce results that are not identical gunshot residue deposits that some variation would be present with the original firearm tested over numerous tasting. The area that has not been adequately examined and a determination

made is why same model and make firearms result in differing residue patterns. Results for the testing are reported in approximate not exact distances, these marked differences would in all probability be of significant difference as to be noticeably non-identical.

Certain assumptions associated with forensic science testing and used by the criminal justice system have now been determined to be inaccurate.

> The Federal Bureau of Investigation put into the practice forensic science of bullet- led analysis more than four decades ago. The intended purpose was to link suspects to crimes in case investigations where a firearm was fired and the bullets had fragmented to the point where the traditional type of firearms tracing, based on gun-barrel grove markings, could not be utilized. The basic assumption of bullet-led analysis was that bullets produced from the same batch of lead would be comprised of the same composition of chemicals. In the early part of the analysis process bullet fragments were subjected to neutron beams that would allow for the measurement of a minimum of three chemical elements: antimony, arsenic, and copper. If two bullets contained similar amounts of those three elements, within a small margin of error, they were determined to be a match. (CBS News, 2007, p. 2)

"Bullet producers in the United States utilize lead from vehicle batteries and melt it down in vast amounts, there was the belief that each batch would produce bullets that would have the same trace elements in common" (CBS News, p. 1).

> In the beginning of the 1980's the Federal Bureau of Investigation was the only agency utilizing the Bullet-lead Analysis Science assisting numerous local and state law enforcement agencies in criminal investigations matching bullets located at the scene of a criminal act with those found and associated with a particular suspect found either in the suspects weapon or a box of ammunition connected to the same suspect. In 1996 the Federal Bureau of Investigation put into use another method of Billet-Lead Analysis identified as inductively coupled plasma optical emission spectroscopy. This process identifies and measures seven trace elements in bullets, adding bismuth, cadmium, tin, and silver. The intended goal was to increase precision of tests being conducted. Today the Federal Bureau of Investigation regards any and all such testimony, which has been espoused by bureau scientist in criminal trials for years, to be inaccurate. (CBS News, p. 2)

The information testified to in courts by scientist in criminal investigations has had dramatic and far-reaching implications.

> In 1997 just prior to starting a criminal trial for murder, Michael Behn's defense team was notified by the district attorney's office that the Federal Bureau of Investigation had evidence that showed ammunition located in Mr. Behn's residence were identical to the ammunition used to commit the murder. Without any other expert testimony to dispute the claims, Michael Behn received a sentence of life in prison. (NewScientistTech, 2002)

Other infuses areas related to forensic science have been used to secure convictions that have been proven to be flawed and inaccurate.

> In February 2004 Cameron Willingham was put to death by legal injection in Corsicana Texas. He was convicted of setting a fire that killed hid three daughters. Mr. Willingham was charged with the capitol offense after fire investigators came to the conclusion that an accelerant had been used to set three different fires inside the family residence. This conclusion was based on what investigators described as twenty or more indicators of an arson fire. Among these indicators was what is described as "crazed glass", weblike cracks through glass. For many years arson investigators believed that the presence of crazed glass was a clear indication that an accelerant had been utilized to fuel a fire that had became exceedingly heat intense. Now analysts have established that these cracks in glass occur when hot glass is sprayed with water, as when firefighters are spraying water on a structure to bring a fire under control. Of the nine hundred and forty-four men and women executed since the United States Supreme Court reinstated the death penalty in the mid-1970, only Camron Willingham has been put to death for a crime in which fire was the murder weapon. Many of the pillars of arson investigation that were commonly believed for many years have been disproved by rigorous scientific scrutiny. In the year 2004 Texas death roe inmate Ernest Willis was set free after serving seventeen years in prison. Willis had been convicted of setting a fire that killed two women. New scientific advances found that after a review of the original fire arson evidence that the fire was in all probability an accidental fire. (Death Penalty Information Center, 2004)

The purpose of this testing process is to determine how valid the requirement is for criminal investigators to have the original firearm and ammunition in distance determination testing. This will either substantiate the basic accepted practice of criminal type laboratories making it a requirement that the original firearm and or like ammunition be submitted or will allow for another avenue of approach for testing: testing the same

model and make firearm if the original is unavailable or has been destroyed. This examination will also examine the possibility of the use of different types or makes of ammunition in determination of distance testing procedures.

CHAPTER 3

RESEARCH METHODOLOGY

Introduction

The purpose of this study was two-fold. The first purpose was to determine if significant differences existed between different brands of ammunition in distance determination testing. Second, this study sought to validate Lewey's (2007) study by using three same make-model firearms in the distance determination tests. A null hypothesis was: There are no significant differences between different brands of ammunition in firearms distance determination tests. In keeping with Lewey's findings, the second null hypothesis was: There is no significant differences between same make-model firearms in conducting distance determination tests.

Procedure for Collecting Data

One of the more popular handguns for police and civilian use is the Glock semi-automatic pistol. Many law enforcement agencies issue Glock firearms and they are common with the general public. The Tennessee Bureau of Investigation (TBI) issues Glock Model 27 sidearms to its Special Agents (Assistant Special Agent in Charge D. Ogle, personal communication, March 7, 2007). The Glock Model 27 is a .40 caliber handgun with a 3.5 inch barrel length. Permission was obtained from the TBI to use three of these standard issue sidearms for testing purposes. Three handguns were selected from the TBI arsenal. All three firearms had seen moderate use (less than 3000 rounds fired) and were in good operating condition.

Three different brands of .40 caliber ammunition were selected based on popularity and availability. Winchester, CCI, and Remington were the brands selected. Each brand consisted of a brass case with a full metal jacketed 180 grain weight bullet and muzzle velocities averaging between 1,010 to 1,025 feet per second.

The three Glock firearms were test fired at three distances: 6 inches, 12 inches and 24 inches from the target. Replicating Lewey's (2007) study, all three firearms were fired 5 times at each distance using each of the 3 different brands of ammunition. Targets consisted of square white cotton fabric material measuring 40 by 40 inches and mounted on stiff cardboard backing. Each firearm was fired by TBI Special Agents who were trained with the Glock Model 27. The testing was supervised by a forensic examiner familiar with gunshot residue testing procedures to ensure weapons were held level and properly measured. Measurements were taken from muzzle to target in inches prior to each shot using a carpenter's steel tape measure.

Each target was examined for the presence of gunshot residue (GSR) and measured in inches from the center of the bullet hole. The diameter measurement was determined by finding the outermost single GSR deposit.

Procedure for Treating Data

The dependent variable, diameter distance measurements, was measured on an interval level. The two independent variables, ammunition and gun, were both measured on a nominal level. Because the dependent variable was interval and the independent variables were nominal with three attributes each, a Two-Way Analysis of Variance (ANOVA) was used to determine significant differences. The Tukey HSD (Honestly

Significant Differences) post-hoc test was used to determine where any significant differences occurred with ANOVA.

CHAPTER 4

ANALYSIS OF THE DATA

Descriptive statistics were used to compare the three firearms and the three brands of ammunition for each of the three distances. Two-way Analysis of Variance (ANOVA) was used to test the hypotheses of no significant difference between the firearms and the ammunition. Table 1 displays the measurements of the three firearms and three brands of ammunition for the five shot testing at 6 inches from the target. As the data indicate, the range of diameter measures of the gunshot residue (GSR) pattern was from a low of one and nine sixteenth inches (1.56 inches) to two (2.00) inches.

Table 1
Diameter Measurements of Gun by Ammunition at 6 Inches

		Winchester	Remington	CCI
Gun 1				
	Shot 1	1.88	2.00	1.94
	Shot 2	1.69	1.56	1.63
	Shot 3	1.75	1.84	1.78
	Shot 4	1.81	1.78	1.84
	Shot 5	1.88	1.63	1.88
	Mean	1.80	1.76	1.81
Gun 2				
	Shot 1	1.75	1.56	2.00
	Shot 2	1.75	1.78	1.88
	Shot 3	1.81	1.95	1.78
	Shot 4	1.88	1.78	1.84
	Shot 5	1.69	1.84	1.84
	Mean	1.78	1.78	1.87
Gun 3				
	Shot 1	1.88	1.84	1.78
	Shot 2	1.88	2.00	1.88
	Shot 3	1.81	1.63	1.94
	Shot 4	1.75	1.78	1.88
	Shot 5	1.68	1.56	1.63
	Mean	1.80	1.76	1.80

Table 2 shows the same data for the 12-inch distance testing. At 12 inches, the range of diameter measures was from a low of two and a quarter inches (2.25) to six and 15 sixteenths (6.94) inches. Table 3 depicts the same data for the 24-inch distance testing. At 24 inches, the diameter spread ranged from a low of six and a half inches (6.50) to a high of 13 and a quarter inches (13.25).

Table 2
Diameter Measurements of Gun by Ammunition at 12 Inches

	Winchester	Remington	CCI
Gun 1			
Shot 1	6.75	4.75	2.50
Shot 2	6.75	4.50	2.50
Shot 3	6.75	4.81	2.25
Shot 4	6.81	4.75	2.81
Shot 5	6.88	4.50	2.75
Mean	6.79	4.66	2.56
Gun 2			
Shot 1	6.50	4.50	2.50
Shot 2	6.75	4.25	2.50
Shot 3	6.81	4.50	2.75
Shot 4	6.88	4.50	2.50
Shot 5	6.50	4.50	2.50
Mean	6.69	4.45	2.55
Gun 3			
Shot 1	6.88	4.63	2.50
Shot 2	6.94	4.50	2.25
Shot 3	6.88	4.25	2.75
Shot 4	6.88	4.50	2.81
Shot 5	6.75	4.75	2.50
Mean	6.87	4.53	2.56

Table 3
Diameter Measurements of Gun by Ammunition at 24 Inches

	Winchester	Remington	CCI
Gun 1			
Shot 1	13.25	8.06	6.50
Shot 2	12.50	7.75	7.50
Shot 3	12.75	7.81	6.75
Shot 4	12.88	8.00	7.00
Shot 5	13.25	7.88	7.25
Mean	12.93	7.90	7.00
Gun 2			
Shot 1	12.88	7.88	6.81
Shot 2	13.25	7.75	7.00
Shot 3	11.94	8.00	6.75
Shot 4	13.00	7.81	6.88
Shot 5	12.50	8.06	7.06
Mean	12.71	7.90	6.90
Gun 3			
Shot 1	13.00	7.50	6.81
Shot 2	12.94	7.81	7.00
Shot 3	12.75	8.00	7.25
Shot 4	12.88	8.00	7.06
Shot 5	12.81	8.06	6.94
Mean	12.88	7.87	7.01

Table 4 depicts the Two-Way Analysis of Variance (ANOVA) results for all three distances. As the data indicate, the 6-inch distance test was not significant for the three firearms ($F = .076$. $p = .927$) or for the three brands of ammunition ($F = 1.113$, $p = .340$). Similarly, at the 12-inch distance test there was no significant difference between the three guns ($F = 2.01$, $p = .149$). However, there was a significant difference in the ammunition used at the 12-inch distance test ($F = 2703.99$, $p < .001$). The same was found at the 24-inch distance test. There was no significant difference between the three

firearms (F = .616, p = .546) but there was a significant difference with the three types of ammunition (F = 2032.59, p < .001).

Table 4
Two-Way Analysis of Variance Results For Three Distance Tests

Distance	Degrees of Freedom	Mean Square	F	Significance
Six Inches				
Ammo	2, 36	.017	1.11	.340
Gun	2, 36	.001	0.08	.927
Twelve Inches				
Ammo	2, 36	66.940	2703.99	.000
Gun	2, 36	.050	2.01	.149
Twenty-Four Inches				
Ammo	2, 36	149.393	2032.59	.000
Gun	2, 36	.045	.62	.546

Tukey's HSD post-hoc tests were conducted on the measurements for the 12-inch and 24-inch distances to determine exactly where significant differences were with the ammunition variable. Table 5 depicts the Tukey HSD multiple comparisons for the 12-inch distance test. As the data indicate, all three brands of ammunition were significantly different from each other in the GSR pattern measurements (p < .001). The Winchester ammunition had a mean diameter GSR pattern of 6.78 inches, the Remington ammunition had a mean diameter of 4.55 inches and the CCI ammunition had a mean diameter of 2.56 inches. Table 6 portrays the Tukey HSD multiple comparisons for the 24-inch distance test. Again, all three brands of ammunition were significantly difference from each other (p < .001). The Winchester brand had a mean GSR diameter of 12.84 inches, the

Remington brand had a mean of 7.89, inches and the CCI brand had a mean of 6.97 inches.

Table 5
Tukey HSD Post Hoc Multiple Comparisons Test for 12-Inch Distance*

Ammo Comparison	Mean Difference	Standard Error	Significance
1 with 2	2.23	.057	.000
1 with 3	4.22	.057	.000
2 with 3	1.99	.057	.000

Ammo Brand	Mean	N
1	6.78	15
2	4.55	15
3	2.56	15

*Ammo 1 = Winchester, Ammo 2 = Remington, Ammo 3 = CCI

Table 6
Tukey HSD Post Hoc Multiple Comparisons Test for 24-Inch Distance*

Ammo Comparison	Mean Difference	Standard Error	Significance
1 with 2	4.95	.099	.000
1 with 3	5.87	.099	.000
2 with 3	0.92	.099	.000

Ammo Brand	Mean	N
1	12.84	15
2	7.89	15
3	6.97	15

*Ammo 1 = Winchester, Ammo 2 = Remington, Ammo 3 = CCI

These findings support the findings in Lewey's (2007) study. The three Glock handguns were not significantly different in GSR distance testing. The null hypothesis of no significant differences with the handguns was not rejected. However, the type of

ammunition was found to be significantly different at muzzle to target distances exceeding six inches. While the null hypothesis of no significant difference between ammunition was not rejected at the 6-inch distance test, it was rejected at the 12-inch distance as well as at 24-inches. Each of the three brands of ammunition was nearly identical in bullet weight, powder charge, and muzzle velocity. However, the difference in the types of powder used in each cartridge may be the reason for the significant differences. The CCI ammunition showed a tighter GSR pattern than the Winchester and Remington ammunition. In addition, the Winchester brand showed the greatest dispersal of GSR pattern. This was true for both the 12-inch and 24-inch distance tests. An examination of the powder used in each brand of ammunition revealed that Winchester uses ball powder, Remington uses a pellet type of powder, and CCI uses a flake powder. This might explain the differences in GSR patterns with the three brands of ammunition. Ball powder is heavier in weight than flake powder and tends to travel further from the muzzle of the gun than the lighter flake powder. The pellet powder, as was found in Remington, is heavier than flake powder but lighter in weight than ball powder.

Based on these findings, gunshot residue distance testing should be made with the same brand ammunition or, at least, with the same type of powder. This is particularly true if the distances exceed six inches. However, as Lewey (2007) found, it may not be necessary to use the same firearm that was used in the commission of a crime to perform distance testing on. Using the same make-model firearm showed no significant differences with any of the brands of ammunition in the present study.

CHAPTER 5

DISCUSSION

It was the purpose of this study to expand and expound on a previous study that sought to find out if there was a significant differentiation of gunshot residue patterns when the same model and make firearms were discharged into a test target in forensic determination distance tests. The previous study (Lewey, 2007) used the same batch and box brand name ammunition in the distance testing procedures. The present testing procedures used three different brand name types of ammunition during the testing process to determine if the use of the three different brands of ammunition would reveal significant difference of gunshot residue patterns. Prior to the testing procedures there was a prediction that there would be a finding of no statistical differences using the same model and make firearms and different brands of ammunition and the gunshot residue dispersal patterns.

Hypotheses

The basic assumption in the area of forensic gunshot residue (GSR) distance determination testing has been that the same weapon used in the criminal activity must be used for testing procedures to be carried out. This mind set has found substantiation in the literature and in polices and procedure manuals drawn up by crime laboratories and individuals who specialize in firearms identification. The basic idea behind this line of thinking is that each and every firearm differs in the aspect of the way gunshot residue is dispersed when the firearm is discharged. With the exception of Lewey's (2007) study, this theory of differential dispersion of powder residue has never been empirically tested.

Lewey found that using different firearms of the same make and model were not significantly different in GSR distance determination testing. However, she only examined one brand of firearm and one brand of ammunition. It is also assumed by the forensic community that the same type of ammunition must be used in GSR testing that was used in the criminal event. This assumption has never been empirically tested.

Forensic testing and forensic technology in the area of criminal justice and criminal investigations has advanced the field of crime scene investigations and given the criminal investigator in the field assess to such a significant tool to significantly aid in the detection apprehension and hopeful conviction of the guilty party.

Even when a forensic technology that has been accepted as practice is later determined to be flawed, the advances in forensic technology far outweigh the negativity generated by these discoveries. It is imperative that basic assumptions made in forensic technology be scientifically examined and tested for accuracy. When a defendant's life is on the line, the court and the jury need to know that a forensic technology has been tested and is reliable. Gunshot residue distance testing is one of those areas in forensic science that has been given little attention in empirical research. The hypotheses for the present study were based on Lewey's (2007) findings and the basic assumptions made by firearms identification examiners. The first null hypothesis was formulated to determine if Lewey's findings would be the same for another make-model firearm. In her study, she used Heckler and Koch .45 caliber handguns. The present study used Glock .40 caliber handguns. The first null hypothesis was: there will be no significant difference in gunshot residue patterns using the same make-model handguns in distance determination testing. The second null hypothesis was based on the assumptions made by the forensic community that the same ammunition used in the criminal event must be used for

distance testing. The second null hypothesis formulated for the present study was: there will be no significant difference in gunshot residue patterns using different brands of ammunition.

Findings

Based on the findings derived form the Analysis of Variance (ANOVA) testing of the three firearms using three different brands of ammunition, gunshot residue distance testing should be made with the same brand ammunition or, at least, with the same type of powder. This is particularly true if the distances exceed 6 inches. Based on the findings of this study, the null hypothesis was rejected when different ammunition is used in testing. However, as Lewey (2007) found, it may not be necessary to use the same firearm that was used in the commission of a crime to perform distance testing on. Using the same make-model firearm showed no significant differences with any of the brands of ammunition in the present study. The present study confirmed the results of Lewey's and failed to reject this null hypothesis.

Implications

At the conclusion of this study the results give rise to the implication that forensic determination testing could still be carried out in instances where the firearm used in the commission of the criminal activity cannot be located or used for testing procedures. Noteworthy is the fact even when the circumstance is that the original firearm is located and available for testing purposes, the results determined by the firearms examiners are not defined in specific type measurements but instead they are an approximation.

Forensic firearm examiners as well as law enforcement crime laboratories should be very cautious about altering or changing their forensic firearm testing policies based on this particular study. This study was conducted by the use of same model and make firearms with the added effect of three different brands of ammunition. The firearms that were used in this testing process were same make and model semi-automatic Glock 23 handguns. Individuals who conduct other comparative type studies similar to this one should consider the use of shoulder type weapons such as shotguns or rifles.

REFERENCES

Bachrach, B. (2006). *A statistical validation of the individuality of guns using 3D images of bullets*. (NCJRS Document No. 213674). Retrieved March 8, 2008 from http://www.ncjrs.gov/pdffiles1/nij/grants/213674.pdf

Bennett, W. W.., & Hess, K. M. (1994). *Criminal investigation* (4th ed). St. Paul, MN: West.

BBC News. (2006). *Panorama, Jill Dando's murder transcript*. Retrieved February 25, 2008 from http://news.bbc.co.uk

California Commission on Peace Officer Standards and Training's workbook: "Forensic technology for law enforcement"Telecourse. May 13, 1993. Evidence Collection Guidelines. Retrieved March 1, 2008 from www.post.ca.gov

CBS News. FBI's forensic test full of holes, hundreds of convictions are in question now that FBI forensic evidence has been discredited. November 18,2007 Printed March 6, 2008. www.cbsnews.com/stories/2007/11/18/politics/washingtonpost/main3518043

Center for Disease Control (2002). *National vital statistics report*. Vol. 50, No. 15, September 16, 2002, 10.

CityNews. (2007). *No gun, no suspect, no motive-But police confident of justice for Jordan*. West Toronto Ontario, Canada. Retrieved March 25, 2008 from www.citynews.ca/news.

Connecticut Department of Safety. (2001). Forensic Science Laboratory, *Guidelines for evidence submission*. Retrieved March 6, 2008 from www.ct.gov/dps/scientific-services_files/evidence-guidelines.pdf

Death Penalty Information Center. (2004). Texas man executed on disproved forensics. Retrieved March 6, 2008 from http://www.deathpenaltyinfo.org/article.php

DeHaan, J.D. (1983). Homicide with a black powder handgun. *Journal of Forensic Sciences*. *28,* 468-481

Ermenc, B.,& Prijon, T. (2005). Suicide, accident? The importance of the scene investigation. *Forensic Science International*. 147, S21-S24.

Federal Bureau of Investigation. (2003). *Handbook of forensic services.* Retrieved August 10, 2006 from www.fbi.gov/gh/lab/org/ftu.htm

Federal Rules of Evidence (Article VII). Retrieved March 26, 2008 from http://expertpages.com/federal/a7.htm

Fei Company. (2006). Tools for nanotech. *Quanta Flexible SEM Solutions for Forensic Science*. Retrieved August 10, 2007 from www.fei.com

FirearmsID.com. Shotgun pattern testing, distance determinations. Retrieved March 6, 2008 from www.firearmsid.com/A_disthotpatt.htm

Fisher, B.A.J.(2004). *Techniques of crime scene investigation* (7th ed.). Boca Raton, FL: CRC Press.

Giannelli, P. C. (1991). Ballistics evidence: Firearms Identification. *Criminal Law Bulletin 27,* 195-215.

Guerrero v. Commonwealth, 46 Va. App. 366, 370, 617 S.E. 2d 410, 412, (Va. Ct. App. 2005)

Hamby, J.E., & Thorpe, J.W. (1999). The history of firearms and toolmark identification. *The Association of Firearm and Toolmark Examiners Journal.* (*31*, 3,) Retrieved March 6, 2008 from www.firearmsid.com/A_historyoffirearmsID.htm.

Hatcher, J. S., Jury, F. J., & Weller, J. (1977). *Firearms investigation identification and evidence.* Harrisburg, PA: Stackpole.

Lemaine, A. (2007). 'CSI' spurs campus forensics scene. *San Diego Union-Tribune*. Retrieved march 6, 2008 from www.signonsandiego.com/uniontrib/20040913/news_1c13csi.html.

Lewey, H.G. (2007). *Examining significant differences of gunshot residue patterns using same make and model of firearms in forensic distance determination tests*. Un-published master's thesis, East Tennessee State University, Johnson City, Tennessee.

Missouri State Highway Patrol. Department of safety. Retrieved march 6, 2008 from www.mshp.dps.missouri.gov/MSHPWeb/PatrolDivisions/CLD/Firearms/Distance Determinatin.

Moenssens, A. A., Starrs, J. E., Henderson, C. E., & Inbau, F. E. *Scientific evidence in civil and criminal cases* (4th ed). New York: The Foundation Press, 336-340; 361-375.

Murphy, D. (2006). Murder in the moonlight, 'shots in the dark'. *MSNBC Dateline* Retrieved March 8, 2008 from www.msnbc.com/id/14738060.

NewScienceTech. (2002). *Chemical matching of bullets fatally flawed*. Retrieved March 6, 2008 from http:// technology.newssctist.com/article.ns

Orange County Sheriff-Coroner Department. (2004). Forensic science services. Firearms Unit, Santa Ana, CA. Program Brochure. Retrieved March 6, 2007 from www.sherif-forensics.ocfov.com

Osterburg, J. W., & Ward, R. H. (2004). *Criminal investigation: A method of reconstructing the past* (4th ed). Dayton, OH: Anderson.

Overview of Ammunition for the Novice Navigation. (2000). Retrieved March 12, 2008 from http://members.aol.com/vaquero760/ammo/anavigation.htm.

Richmond County Sheriff's Department. Forearms Analysis Section. Retrieved March 6, 2008 from http://www.rcsd.net/cid/forensicsciences.htm.

Rico, J. M. U.S. World factbook of criminal justice systems: *Department of Justice*. Retrieved March 6, 2008 from www.ojp.usdoj.gov/bjs/pub/ascii/wfcjscr.txt.

Schulz, D.O. (1977). *Crime scene investigation*. Englewood Cliffs, NJ: Prentice-Hall, 244.

Shoebridge, C. (2002) Appeal failure lacks conviction. *Guardian Unlimited*. Retrieved March 6,2008 from www.guardian.co.uk

Sigel, J. A. (2007). *Forensic science, the basics*. Boca Raton, FL: Taylor & Francis Group, 235-237.

Solomon, S. M., & Hackett, E. J. (1996). Setting boundaries between science and law: Lessons from Daubert v. Merrell Down pharmaceuticals, inc. *Science, Technology, & Human Values, 21*, 131-156.

Sperry, P. (2001). All the president's scandals; Revealed: Gun lost on fatal brown flight. *WorldNetDaily Exclusive*. Retrieved March 6,2008 from www.worldnetdaily.com

State v. Atwood 602 N.W. 2d 775, 784 (Iowa 1999)

Steck-Flynn, K. (2005). Bullets and guns. Get more bang from your firearms evidence. *Law Enforcement Technology. 32,* 46-51.

Suwanjutha, T. (1988). Direction, site and the muzzle target distance of bullet in the head and neck at close range as an indication of suicide or homicide. *Forensic Science International. 37*, 223-229.

Tennessee Administrative Office of the Courts. Firearms definitions. Retrieved March 6, 2008 from www.tsc.state.tn.us/geninfo/publications/forms

Tennessee Bureau of Investigation Firearms Identifications Unit. (2000) Section 15: Gunshot residue and/or shotgun pellet pattern examination protocol, issue date April 1, 2000. *Standard Operating Procedures Manual*. Facsimile received March 3, 2008.

Tennessee Bureau of Investigation. Firearm and toolmark unit, *Evidence Guide*. Retrieved March 6, 2008 from www.tbi.org.

The New York Times. (April 15, 1879). *The New York Times*.

United States Department of Justice (2007). Firearms and crime statistics. *Bureau of Justice Statistics.* Retrieved March 6, 2008 from www.ojp.usdoj.gov/bjs/guns.htm.

United States Department of Justice. Random gunfire problems and gunshot detection systems. *National Institute of Justice*. Retrieved March 6, 2008 from http://www.ncjrs.gov/pdffiles1/nij/179274.pdf

United States Supreme Court. *Daubert v. Merrell Dow Pharmaceuticals, Inc*. 509 U.S. 579 (1993). FindLaw For Legal Professionals. Retrieved March 7, 2007 from http://caselaw.findlaw.com.

United States Supreme Court. *Frye v.United States*. 293 F. 1013, 1014 (D.C. Cir. 1923). Findlaw For Legal Professionals. Retrieved March 7, 2007 from http://caselaw.findlaw.com.

Virginia Department of Forensic Science. (2006). Section 12 gunshot residue examination and distance determinations. *Firearm/Toolmark Training Manual*. Retrieved March 6, 2008 from www.dfs.virginia.gov/firearmsAndToolmarks/manuals/training.

Virginia Department of Forensic Science. (2007). Section 7 Range Determinations. *Firearm/Toolmark Procedures Manual*. Retrieved March 6, 2008 from www.dfs.virginia.gov/services.firearmsAndToolmarks/manuals/training

West Virginia State Police. (2007). Firearms and toolmarks. *Laboratory field Manual (8th ed)*. www.wvstatepolice.com/firearms.

Wilber, C.G., (1977). *Ballistic science for the law enforcement officer*. Springfield, IL: Bannerstone House, 217-226.

Williams v. State, 282 Ga. 561 (2007) (LEXIS, Genfed Library, Dist file).

Willing, R. (2004). 'CST effect' has juries wanting more evidence. *USA Today*. Retrieved March 6, 2008 from http://www.usatoday.com/news/nation/2004-08-05-csi-effect_x.htm?loc=interstitialskip.

Zilversmit, M. J., & Wilder, N. (2007). Summary argument: Twelve years and still fighting a murder case. Attorney's for petitioner/appellant Joseph Diggs. Retrieved March 6, 2008 from www.legalpad.typepad.com

Zwaitz, M.W. BJS Statistician. (1995). Selected findings, guns used in crime. Bureau of justice statistics. *United States Department of Justice.* NCJ-148201

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