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Examining Significant Differences of Gunshot Residue Patterns Using Same Make and Model of Firearms in Forensic Distance Determination Tests.

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ABSTRACT

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In many cases of crimes involving a firearm, police investigators need to know how far the firearm was held from the victim when it was discharged. Knowing this distance, vital questions regarding the re-construction of the crime scene can be known. Often, the original firearm used in commission of a suspected crime is not available for testing or is damaged. Crime laboratories require the original firearm in order to conduct distance determination tests. However, no empirical research has ever been conducted to determine if same make and model firearms produce different results in distance determination testing. It was the purpose of this study to determine if there are significant differences between the same make and model of firearms in distance determination testing. The findings indicate no significant differences; furthermore they imply that if the original firearm is not available, another firearm of the same make and model may be used.

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CHAPTER 1

INTRODUCTION

In recent years there has been an increase in interest in the forensic sciences in the United States. The proliferation of television programs on forensic science and crime scene investigation is generally seen as the reason for this increased interest. Furthermore, it is provided that "in a survey of the 500 in the jury pool, the defense found that about 70% were viewers of CBS' *CSI* or similar shows such as Court TV's *Forensic Files* or NBC's *Law & Order* (Willing, 2004). The San Diego Union Tribune reveals that there has been an increase in the number of colleges and universities offering forensic science programs of study and degrees as a direct result of the interest and demand of students entering the field (Lamaine, 2007, pgs 1-3). Futhermore, "the impact of CSI is evident in other universities across the country…There are more and more programs that have forensic science now in their curriculums said Edward Robinson, an assistance professor of forensics at George Washington University, in Washington, D.C. Between 1999 and 2002, the number of graduate students studying forensics science jumped from 113 to 190 at George Washington" (Lamanie, 2007, pgs. 1-3).

As a result of the popular media attention to forensic science, jurors in criminal and civil court cases have come to expect forensic evidence to be presented. A failure on the part of plaintiff or defense to provide forensic evidence is seen by many jurors as negligent. According to an article entitled "CSI effect has juries wanting more evidence" in USA Today referencing the case of Robert Durst, "To legal analysts, his case seemed an example of how shows such as CSI are affecting the action in courthouses across the USA by, among other things, raising jurors' expectations of what prosecutors should produce at trial" (Willing, 2007). This has forced both police and attorneys to seek forensic evidence in cases just because jurors have come

to expect it (Willing). However, the popular media are not fully to blame for this increased interest in the forensic sciences. Since the case of Daubert v. Merrell Dow Pharmaceuticals and more specifically the past 15 years have demonstrated that courts are more aware of inconsistent methods and even erroneous methods of examination by some forensic scientists (Solomon & Hackett, 1996).

The standard of evidence admissibility used to be the *Frye* test. Expert testimony was admitted merely by the expert's credentials, qualifications, status, experience, skill and reputation. Any deficiencies or flaws in the expert's conclusions would be exposed through cross-examination *(Frye v. United States*, 293 F. 1013, 1014 (D.C. Cir. 1923). This provided ample room for error when the believed experts and-or scientists committed perjury in their testimony on behalf of a party.

The standards for permissibility of professional testimony were changed by the United States Supreme Court decision in *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 113 S. Ct. 2786, 125 L. Ed. 2d 469 (1993). Most states now adhere to the *Daubert* ruling. Currently under *Daubert*, the admissibility of expert testimony is to be more meticulously examined by the trial judge to conclude whether it meets the requirements of Federal Rules of Evidence No. 702, which provide:

> "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."

As a result of Daubert, the forensic community was forced to empirically prove the assumptions that had been made in the past. For example, it has always been maintained by the forensic community that no two people possess the same fingerprint. However, there has never been any empirical study to support that position. Similarly, it has always been maintained by the forensic community that no two people have identical handwriting. This too, had never been empirically supported. Forensic scientists in latent fingerprints and forensic document examination had to provide empirical research to support these claims so that the evidence would satisfy Daubert provisions and be allowed in court (Solomon & Hackett, 1996).

One area of forensic science that has not been scrutinized by the courts nor studied empirically has been in the area of firearms and ballistics. Most crime laboratories have a firearms and toolmark identification section. Forensic experts in firearms and toolmark identification normally examine spent bullets and casings to match with a suspect firearm. They may also be called upon to examine trajectories of bullets at crime scenes to establish flight paths of bullets. And, they are often called upon to determine how far a firearm was held from a subject (target) when it was discharged, known as a distance determination test.

Most crime laboratory training manuals state very simply that in order to conduct distance determination testing, the original firearm and similar ammunition must be used. Nearly all training information indicates that the examiner must use the original weapon and ammunition for this type of testing with no explanation as to why (Giroux, personal communication, June 5, 2007). However, one might assume from this rule that there are differences in gunpowder distance deposits within the same make and model of firearms.

Statement of the Problem

While a firearm distance determination test is particularly useful in establishing the distance a firearm was held from a subject or target when it was discharged, the literature suggests that the test would be invalid if the same gun in question was not used in the test. There are obvious differences in ammunition manufacturers with different powder loads and powder configuration. Therefore, using a different brand and load of ammunition for a distance determination test would not produce accurate results. However, there are no empirical data to suggest that using two identical make and model firearms in a distance determination test produce significantly different results. Again, this is an assumption made on the part of forensic firearms identification experts.

Frequently, police investigate shooting crimes where the distance the firearm was held when discharged is a significant piece of evidence. Particularly in suicide cases involving gunshots at close range and self-defense claims in shooting investigations, the distance a firearm was held to the victim when it was discharged may become the single most important piece of evidence in the finding of guilt or innocence. However, just as frequently, the suspect firearm may not be available for testing or may be missing or damaged to the point that it cannot be test fired. The defense has a legal obligation to obtain independent testing of evidence presented against them and it may be difficult to obtain the actual firearm used in the crime to make these tests. Also, the suspect firearm may be destroyed, damaged, or simply missing. If the suspect firearm can be identified as to make, model, and caliber, it may be appropriate to use an identical firearm for testing purposes. Before the scientific community and the courts recognize this, empirical testing must be done to determine if there are significant differences between same make and model firearms in distance determination tests.

Purpose of the Research

It was the purpose of this research to determine if significant differences existed between same make and model of firearms in distance determination tests. If it could be shown that no significant differences exist in these tests, the forensic community and the courts may use evidence acquired from the testing of an identical firearm when the actual firearm is not available for testing.

Hypothesis

The following null hypothesis was formulated based on the literature and purpose of the research:

Ho: There will be no significant differences between same make-model firearms in making distance determination tests.

In order to test this hypothesis, it was necessary to procure a number of same make-model firearms for testing. This was accomplished by contacting a local law enforcement agency to provide service firearms used by their officers. The police agency used in the present study issued Heckler and Koch .45 caliber semi-automatic pistols as sidearms to their officers. Ten pistols were stratified randomly selected from the police arsenal and subjected to distance determination testing at the police firing range.

Limitations

The single most limiting factor of the present study was the use of only one particular make and model firearm to conduct the study. Other firearm manufacturers may have different production standards that may or may not affect distance determination testing. Another limiting factor was no long guns (i.e., rifles or shotguns) were used in the present study. Barrel length is a contributing factor for distance determination testing and the barrel length for the firearms

under study were 4.5 inches.

Basic Assumptions

It was assumed for the purposes of this study that the 10 pistols selected for testing were representative of all same make and model pistols of this manufacturer. The police firearms instructor inspected each of the test firearms for suitability of the testing procedure.

Definition of Terms

Definitions, as they are recognized by Tennessee Administrative Office of the courts: (www.tsc.state.tn.us/geninfo/publications/forms)

Ballistics: The study of a projectile in motion. There are 3 types of ballistics: interior, within the firearm; exterior, after the projectile leaves the barrel; and terminal, the impact on a target.

Bullet: The projectile that can be shaped and-or composed differently for a variety of purposes. Some known names are round nose, hollow point, jacketed (full metal jacket or total metal jacket), wadcutter, or semi-wadcutter.

Caliber: This is the diameter of the bore measured from land to land, usually expressed in hundredths of an inch (i.e., .22 cal) or in millimeters (i.e., 9mm).

Casing: The tubular structure holding the bullet, gunpowder and primer.

Gunshot powder residue: Also known as Gunshot Residue (GSR). Unburned gunpowder (nitrates), partially burned gunpowder, and smoke from completely burned gunpowder discharging from the muzzle of a firearm.

Muzzle: The end of the barrel of a firearm where the bullet is discharged. In distance determination tests, it is the distance from the muzzle to the target that is being established.

Stippling-Tattooing: Terms used in forensic pathology to describe damage to skin due to close gunshot wounds. The burning powder strikes the skin and burns reddish marks around the

entrance hole of the bullet (www.tbi.org).

CHAPTER 2

REVIEW OF THE LITERATURE

One of the leading causes of unnatural death in the United States is from firearms. Homicide, suicide, and felonious assaults are committed using firearms more than any other type of weapon. Furthermore, accidental shootings account for nearly one fourth of all accidental deaths in the United States. Because of the frequency of deaths and injuries resulting from firearms, firearms identification, testing, and ballistics becomes an increasingly larger component of most state and federal crime laboratories.

According to the Center for Disease Control's National Vital Statistics Report of September 16, 2002, "28,663 persons died from firearm injuries in the United States" (CDC, 2002, p. 10). Furthermore it is provided that "firearms suicide and homicide, the two major component causes, accounted for 57.9 and 37.7 percent, respectively, of all firearm injury deaths in 2000. The other components—firearm accidents, firearm injuries of undetermined intent, and legal intervention involving firearms—accounted for 2.7, 0.8, and 0.9 percent, respectively" (CDC). The United States Department of Justice's Bureau of Justice Statistics state that in 1993 "4.4 million violent crimes of rape and sexual assault, robbery, and aggravated assault. Of the victims of these violent crimes, 1.3 million (29%) stated that they faced an offender with a firearm" (CDC). More recent findings according to the Bureau of Justice Statistics suggest "477, 040 victims of violent crimes stated that they faced an offender with a firearm…incidents involving a firearm represented 9 % of the 4.7 million violent crimes of rape and sexual assault, robbery, and aggravated and simple assault in 2005" (United States Department of Justice, July 1995, NCJ-148201). Although these are alarming, they are reality.

In most cases of suspected homicide and suicide committed with a firearm, police investigators need to know how far the firearm was held from the victim when it was discharged. Knowing the distance the weapon was from a victim can answer vital questions regarding self-defense issues, self-inflicted wound issues, and re-constructing the events surrounding the shooting. Determining how far a firearm was from the victim when it was discharged requires testing the same firearm and same ammunition in a methodical series of range test fires. These test fires are made from varying distances, usually from contact out to 36 inches, against a white fabric or poster board. The deposited gunpowder residues are then compared from the test firings to the actual clothing or skin on the victim. This provides an estimation of the distance that the weapon was from the victim when it was discharged.

Nearly all the literature on this subject state that the same weapon and ammunition must be used for testing. The reasoning behind this appears to be the examiner needs to know that the firearm in question is in good working order and that any alterations made to the firearm (cutting off parts of the barrel, rust build-up in the barrel, etc.) are controlled for in the testing procedure. In fact, none of the state and federal crime laboratories will accept a case to make a distance determination without the actual firearm and same ammunition. However, even when the crime laboratory does test the actual firearm in question, the results are stated in terms of estimations and bracketing rather than as a specific distance. For example, a report often reads “the gunshot residue pattern displayed on the victim’s shirt was consistent with test firings, using the same firearm and same type of ammunition, from 18-24 inches.” In addition, there have been no studies performed on whether same makes and models of firearms have any significant differences in the manner that they produce powder residues using the same type of ammunition.

Frequently, police investigators need to know the distance a firearm was held from a shooting victim when the weapon has not been located or has been destroyed. Because crime laboratories will not perform a distance test without the actual firearm, the police cannot make a determination about the distance of the shooting that can be used as evidence for or against a defendant at trial. Quite often, the police know the caliber of weapon and even the type of weapon that was used in a shooting but do not have the actual weapon or the weapon has been altered by boring out the riflings or has rusted due to being thrown in water. If the police can determine what type of firearm and ammunition was used in a shooting and determine how far that firearm was from the victim when it was discharged by using a similar firearm in distance testing, it would be a great benefit not only to the prosecution but to the defense as well.

As the criminal mind becomes more popular in the media and increasingly gains a large variety of audiences, the demand of research and continuous education within the realm of forensic science becomes a requirement. The failure to further educate within this area has shown itself evident in several cases where these advances may perhaps have been valuable. Dating all the way back to 1879, the New York Times (1879) reports that Josiah Bacon was found on the floor of his San Francisco hotel room with a pistol shot. The article states, “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. Furthermore, it is provided “There is some ground for the opinion that the tragedy was a murder and not a suicide. The clothing of the dead man was not burned where the ball entered” (New York Times, 1879). When considering the above statements, it is clear that this case, over a century old, provides confirmation that research within forensics must be provided.

Likewise, DeHaan, in his publication of the Journal of Forensic Sciences (1983), describes a young white male who was found shot to death in his home. DeHaan then provides the evidence of critical importance to reconstruct the circumstances of the crime, because the weapon itself was not recovered. To do so, DeHaan states "Weapons similar to that 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, standard distance determinations, the pathological findings, and the characteristics of the recovered projectiles, the dynamics of both victim and perpetrator could be reconstructed. Their relative positions and the sequence of the shots were also reconstructed. The comparisons conducted in this case revealed that black powder revolvers produce large amounts of unusual residues which supplement the usual range of firearm evidence to make even complex reconstructions possible" (DeHaan, 1983, p.1).

In a study that was presented at the Second Indo-Pacific Congress on Legal Medicine and Forensic Science in 1986 T. Suwanjutha explains the importance of muzzle target distance. In Suwanjutha's article entitled "Direction, Site and the Muzzle Target Distance of Bullet in the Head and Neck at Close Range as an Indication of Suicide or Homicide" it is argued that "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" (Suwanjutha, p. 1). The study emphasized the relevance of determining muzzle to target distance for reconstructing of the crime scene. A situation that would emphasize the importance of crime scene investigation was depicted within an article by Ermenc and Prijon (2005) in the Journal of Forensic Science International. A 21-year-old student was shot to death while in her home. Ermenc and Prijon stated that "The firearm, projectile and cartridge have not been found despite an intensive search. The daughter

and mother tested positive for traces of gunpowder, while the son had traces on his hands and vest" (p. 1). According to the shot patterns of the crime scene, authorities speculated whether this shooting was an accident or intent. Ermenc and Prijon provides strong emphasis on the importance of conducting firearms distance determination testing and what answers can be provided by the crime scene itself, even without the suspect firearm.

More recently was the death of the late Commerce Secretary Ron Brown. In an article by Sperry in the World Net Daily Exclusive (2001), it was stated that "a handgun carried by a body guard assigned to protect Brown, 'was lost and not recovered' from the wreckage of his plane, which crashed in Croatia in 1996". Additionally, it was revealed that "the internal security report was completed in March 1999—15 months after an Air Force forensic pathologist disclosed that an unusual wound at the top of Brown's head could have been a bullet hole". Unfortunately, an autopsy of Brown's body was not ordered and there was no attempt to recover the missing .357 Magnum from his bodyguard. According to World Net Daily (2001) there were many different speculations as to the unusual wound to Brown's head along with why the missing firearms was not recovered or investigated. The questions that arise within this sensitive case are obvious, if investigators had pursued the missing .357 Magnum, it may have aided in locating pieces to the mysterious puzzle of Brown's death. That is an answer that will never be known due to the limited forensic investigation and research within the case.

Shoebridge, a Metropolitan police officer for many years, describes how Barry George, charged with the murder of Jill Dando, attempted to appeal his conviction within his article in the Guardian Unlimited (2002). Jill Dando was a British television presenter who worked for the BBC over 15 years. At the time of her murder, police conducted a high-profile search for her killer. Although BBC's case transcript demonstrates that a thorough search of the scene was

performed, the police found no physical evidence to help identify the shooter. It was given by BBC news that the only physical evidence at the scene was a 9 millimeter bullet and cartridge. George's appeal was denied and his murder charge sustained. Shoebridge provides his opinion stating "despite the failure of George's appeal, the role of both the police and prosecution in bringing him to trail deserve scrutiny, as do the failings 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 rights to jury trial, the key question may be how best to deliver justice when a jury insists on following its instincts, rather than the evidence before it" (Shoebridge, p. 3). Once again, the obvious need for increasing awareness for forensic science is imperative, particularly ballistics. Juries are requiring more physical evidence due to their increased awareness through media; therefore, continuous research must follow to ensure proper and complete investigations are conducted, along with fair and concise trials.

According to the City News (2007) in West Toronto, Ontario Canada, Jordan Manners, a well liked 9th grade high school student, was gunned down in the hallway of her high school during May this year. Police have no gun, no suspect, and no motive regarding the case. Clearly, this becomes another piece of substantiation that should advise law enforcement personnel and the forensic community of the increasing demand for forensic knowledge, empirical research, and education. In California, June 20, 2007, Joseph Diggs is serving a 25 prison sentence along with two others related to the case on charges of conspiracy to commit murder, attempted murder, and related charges. His attorney, Marc Zilversmit, is still fighting alongside his client after 12 years, believing in his innocence. On June 18, 2007, Zilversmit filed a brief with the Ninth Circuit U.S. Court of Appeals hoping to overturn his client's conviction. The summary of Zilversmit's argument states "No substantial evidence linked him 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 any role in it" (Zilversmit, 2007, p. 5). Cases like the ones mentioned should prompt researchers, professors, and students to expand on this field. In any crime, all people are presumed innocent until proven guilty; therefore, it is the sole duty as governing officials to ensure research is ongoing on a continuous basis. Otherwise, the criminal may get away, mistrials could occur along with the possibility of false convictions and various other faulty mishaps.

Wilber (1977), in his compilation entitled, Ballistic Science for the Law Enforcement Officer, illustrates one specific method of estimating the distance from which a shot was fired. This method requires an "examination of the pattern of powder markings and smudgings left on the skin or on the clothing". When a shot is fired, the "firing a cartridge from a gun drives out the bullet from the barrel along with a mixture of gases, burnt powder, partially burnt powder, lubricant, and metal dust" (Wilber, p. 217). Furthermore, Wilber provides that "these cocentric areas vary in diameter with distance of muzzle to 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" (Wilber, p. 217). With these specific instructions, there was no alternative method of testing for those cases that lack the original weapon.

In the fourth edition of Moenssens, Starrs, Henderson, and Inbau's (1995) Scientific Evidence in Civil and Criminal Cases, it is clarified that separating crimes involving firearms as accidental or murder for example, may conceivably be a predictor on a professional determination of the distance between the gun muzzle and the first surface of the target (victim's

clothing or skin). Furthermore, for determining this range there is no specific formula or table, "in fact, what actually occurs is only an approximation" (Moenssens et al., p. 338). Moreover, many previous cases demonstrate the importance of this piece of evidence. In Williams v. State (Moenssens et al.), shot dispersal experimentation was admitted into evidence when it was shown that the test was a standard comparison of the shot dispersed in the wound with experimental patterns obtained by using cartridges and loads similar to the ones found in the defendant's shotgun which was recovered at the scene of the crime. When this evidence is clarified, it can corroborate a homicide defendant's claim as to his or her location at the time of the shooting, which could ultimately mean life or death for a defendant. It is also provided that in Guerrero v. State (Moenssens et al.), the appellate court reversed a murder conviction finding that there was a reasonable possibility that the death was caused accidentally. Testimony revealed a small powder burn on the victim's index finger and also that the gun used to kill the victim was discharged while in contact with her face. Also, in State v. Atwood (Moenssens et al.), the tests were conducted with the original weapon and similar ammunition, and consequently the sheets of blotting paper used in the tests were admitted into evidence.

According to the California Commission on Peace Officer Standards and Training's workbook for the "Forensic Technology for Law Enforcement" Telecourse presented on May 13, 1993, special instructions for testing distance of muzzle to targets are especially specific. "For gunpowder or shot pattern tests to have significance, it is essential to obtain ammunition identical in make, type, and age to that used at the crime scene. This duplicate ammunition is necessary for firing in the weapon in question to determine the distance of the muzzle of the weapon from the victim or other object at the time the questioned bullet was fired (Forensic

Technology for Law Enforcement, 1993, p. 8 of 12). The ideal question that arises is 'why' or 'what-if' when the original firearm is cannot be located.

West Virginia State Police's 8th edition Laboratory Field Manual (2007) provides some types of firearm examinations that are performed. In the section entitled, Examinations and Possible Determinations, it is stated as follows: "Distance Determinations: Determine approximate distance from impact to muzzle. (*Must have firearm used in the incident for determination)" (wvstatepolice.com, 2007, p. 1). Furthermore, it is provided that "in certain shooting cases, it may be important to know the approximate distance between the muzzle of the firearm involved and the victim" (wvstatepolice.com). No case should be weighted any less than the one before, all should receive the proper attention and manpower regardless of the circumstances to ensure that justice is served. Therefore, when crimes involving a firearm occur and that firearm cannot be located, then this form of testing needs to be re-evaluated. As criminals are becoming more educated, developing more thought out, premeditated crimes, it is imperative that law enforcement personnel do the same.

The Federal Bureau of Investigation's Handbook of Forensic Science (2003) provides that "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). A reputable website, FirearmsID.com, indicates the testing of muzzle to target creates a 'shot pattern'. Additionally, "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" (www.firearmsid.com, 2003, p.1 of 7). The limited literature on this subject

essentially instructs investigators to use the original weapon, and when stating the results of the test to use the term 'approximate'. This term refers to estimation, fairly accurate, rough, near, inexact, or, not accurate. Consequently, this demonstrates that even using the original weapon is not 100% accurate. Hence, if a crime involving a firearm occurs and the original firearm used is missing, yet the make, model, and ammunition used are known, the use of the known make, model, and ammunition should be weighted the same because this testing is not entirely accurate first and foremost.

The Orange County Sheriff Forensic Science Firearms Unit (2004) in California describes specific firearm examinations they conduct. Specifically, regarding distance determination testing, it is declared "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 firearm was from the victim. Similar examinations may also be performed 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" (Orange County Sheriff Forensic Science Firearms Unit, Brochure). Serving as the Director of the crime scene unit with the Los Angeles County Sheriff's Department and as an Adjunct Professor at California State University in their Criminal Justice Department, Fisher provides similar instruction for distance determinations. In the 7th edition of Techniques of Crime Scene Investigation, Fisher (2004) presents these same instructions. "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" (Fisher, p. 427). Additionally, Fisher illustrates the significance of this form of evidence stating 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, p. 427).

Virginia's Department of Forensic Science Firearm/Toomark Procedures Manual (2007), provides specific instructions for investigators conducting evidence testing. In section 7.6.8 entitled Test Pattern Production it is provided that "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." (Virginia Department of Forensics, Toolmarks and Prodecures Manuel, 7.6.8). Furthermore, specific aspects of this procedure are described, "it is essential that the suspect firearm and appropriate ammunition be utilized for these tests" (Virginia Department of Forensics). The Manual further states that "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" (Virginia Department of Forensics).

According to the FEI Company's (2006) publication, Tools for Forensic Science Techniques, distinguishing the shooting distance is key evidence in firearms forensics. "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" (FEI, p. 6).

Missouri's Department of Highway Patrol training manual (2006) instructs that "the suspect firearm and suspect ammunition are 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" (mshp.dps.missouri.gov, Retreived July 25, 2007).

Connecticut's Department of Safety training manual (2001) also provides specific guidelines for evidence submission by law enforcement officials. Particularly within the Distance Determination heading the instructions 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" (Connecticut Department of Safety, 2001, p. 4). Only those two instructions are given regarding this type of testing, and without reason. Usually, within any type of law enforcement training or education, the trainers inform the trainees on these subjects on why specific actions are taken and why other specific actions are not taken.

A proclaimed firearms expert, Ronald R. Scott (2006) has over 40 years of experience with firearms-ballistics all across the United States. Not only has he testified as expert over 250 times in State and Federal Courts, he also has extraordinary resume including military weapons and training. Additionally, he is a retired Commanding Officer of Massachusetts State Police Ballistics Section. He also is the founder of the reputable website, azballistics.com. Scott illustrates the importance of distance determination testing and the ability it has to strongly help investigators in their attempt to finding missing links within their cases. Scott states:

"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" (Scott, personal communication, August 24, 2006).

Furthermore, when asked about using this alternative method of determining muzzle-to-target distance Scott (2006) provides this answer:

> "The idea will be to convince the jury that by using a similarly make and model weapon that the tests are unscientific but this is not true. In a legal setting, it is always important to use or replicate evidence using the weapon. The difference will be that the expert opinion, or testimony, cannot be testified to in the degree of scientific certainty had the actual weapon been used for the tests. While there may be little or no difference in the results of gunshot distance determination, the fact still remains that it is not being conducted with the actual evidence weapon. It is they jury's decision as to how much reliability should be given to such a similar weapon test. So while there may be no difference, the defendant is still entitled to claim or ask the jury not to give it as much weight to the actual weapon. It is really more a matter of law and fairness than it is any great difference in the test results. It is the duty and responsibility of the opposing attorney to raise any doubt no matter how little it might be. My experience is that if a defense attorney raises that issue, then the prosecutor will usually rebut it with testimony that the difference would be too little" (Scott, personal communication, August 24, 2006).

Siegel (2007), in his textbook entitled Forensic Science, The Basics, describes the elements of this type of testing. "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" (Siegel, p. 235). This implication essentially states that these gaseous materials being exerted from the barrel of a firearm will travel a distance in an *approximate* narrow direction. Furthermore, Siegel adds "Depending upon the distance from the weapon to the target, some of this 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" (Siegel, p. 235)). This would support the idea that no type of testing is absolute or completely accurate. Siegel also provides that there are margins to this assessment that should be considered when muzzle-to-target measurements are made: "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 pattern 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 isn't used" (Siegel). Siegel did not provide a reference for this statement nor did he elaborate on why exact type firearms would not produce similar results in testing.

Giroux, a Physical Scientist and Forensic Examiner within the Firearms-Toolmarks Unit of the Federal Bureau of Investigation, provided information on the strict procedures one must follow in order to conduct this type of testing. Giroux states "it is required that the contributor send in the suspect firearm and some indication as to the type of ammunition that was used (cartridge, a cartridge case, and-or bullet). If the contributor is unable to provide the firearm or there isn't any indication as to they 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". (Giroux, personal communication, June 13, 2007).

In 1993, the U.S. Supreme Court set the standards on the admissibility of forensic evidence for most states in Daubert vs. Merrell Dow Pharmaceuticals (509 U.S. 579, 1993). One of the tenets required under Daubert is "…expert opinion based on a 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' technique among firearms examiners, there is no scientific basis for the accepted technique (www.findlaw.com, Retreived May 7, 2007).

The stated procedures for this specific type of testing do not explain why certain tasks have to be performed in specific manners. Testing protocols mandating that investigators use the original weapon and same or similar ammunition while conducting this test should state why this is important. There is no supporting literature or empirical research that can corroborate that this mandate is necessary. While there is ample evidence to suggest that shotgun pellet and gunshot residue dispersion varies with same make-model shotguns, there is no empirical evidence to indicate such with single bullet firearms (rifles and handguns). Additionally, none of the literature addressing distance determination testing mentioned firing the test weapon several times at the same distance to determine reliability. It would stand to reason that, if the assumption were true that same make-model firearms produce different distance gunshot residue deposits, there would be some variation with the same original firearm tested several times. The main question remains why do same make-model firearms produce different gunshot residue patterns? If the stated testing results are approximations rather than exact distances, the differences between same make-model firearms would have to be substantial to make a

difference in test results. And, with quality control standards in place at firearm manufacturing plants, it would be difficult to understand why this occurs.

The only way to determine the validity of the requirement of using the original firearm in distance determination testing is to conduct an empirical study of same make and model of firearms in distance testing to determine if significant differences occur between same make and model firearms. This would either provide support for the generally accepted practice of crime laboratories requiring the original firearm for testing purposes or open the door to allow laboratories to test same the make and model firearm if the original is destroyed or otherwise unavailable.

CHAPTER 3

RESEARCH METHODOLOY

Introduction

The purpose of this study was to determine if significant differences existed between same make and model of firearms in distance determination tests. The null hypothesis tested was: There will be no significant differences between same make-model firearms in making distance determination tests.

Procedure for Collecting Data

Permission was obtained from the Chief of the Johnson City Tennessee Police Department to use police issue sidearms and the police firing range to collect data for the present study. Ten sidearms were selected from the police arsenal. The selection of sidearms was based on how much use each firearm had in terms of number of rounds fired. The use index was: 1) unissued (less than 100 rounds fired); 2) moderate use (less than 3000 rounds fired); and, 3) heavy use (more than 3000 rounds fired). Three sidearms were stratified randomly selected from both the unissued and heavy use categories within the police arsenal. The remaining four sidearms were selected from the moderate use category. The literature suggested that barrel wear and damage might affect distance determination testing and was the main assumption for using the same firearm in any such test. The selection of sidearms based on these criteria was an effort to control for this assumption. Each of the 10 selected firearms had passed safety inspection and was in proper working order. The 10 firearms were Heckler and Koch .45 caliber semi-automatic pistols with a barrel length of 4.5 inches. The ammunition was standard issue for the Johnson City Police Department (.45 caliber Speer Lawman, 230 grain, total metal jacket).

The 10 selected sidearms were test fired at five distances: 3 inches; 6 inches; 9 inches; 12

inches; and, 24 inches from the target. Each firearm was fired five times at each distance to ensure each firearm was performing consistently. The targets were clean white cotton fabric cut in 40 by 40 inch squares and mounted onto firing range target backing material. Each firearm was fired by a certified police firearms instructor using a photographic tripod and level to insure the firearms were being held consistently. Measurements were taken from muzzle to target in inches before and after each shot using a carpenter's steel tape measure.

Each target was examined for the presence of gunpowder residue deposits. The deposits formed a circular pattern on the targets dispersing outward from the bullet hole. Each circular pattern was measured in both circumference and diameter in inches using the bullet hole as the center point of measurement. Because some powder deposits may fly outside the general pattern area, circumference was based on the deposit of at least two particles within the outermost circular area to be included in the measurement. The diameter measurements in inches for each trial of five shots were used in the analyses.

Procedure for Treating Data

Because the independent variable (firearm) was measured on a nominal level and the dependent variable (powder deposit diameter measure) was measured on an interval level, Repeated Measures Analysis of Variance (ANOVA) was used to determine significant differences between and within any of the 10 firearms distance test firings. A post-hoc test was used to determine whether any significant differences occurred with ANOVA.

CHAPTER 4

ANALYSIS OF DATA

Descriptive statistics were used first to compare differences and similarities between each firearm's five shot trials and between all firearms at the varying distances. Repeated Measures Analysis of Variance (ANOVA) was then used to test for significant differences between and within the test firings. Table 1 displays the measurements taken for all 10 sidearms with five shots at each distance. Five shots were made at each distance to insure the sidearm(s) were performing reliably. As the data in Table 1 indicate, there was some variation both within each sidearm's five shot trial as well as between all sidearms.

Table 2 shows the ANOVA results for each of the 10 sidearms five shot trials. The analysis indicates that there were no significant differences found in the five shot trial measurements with any of the 10 firearms selected. This indicated that each firearm selected for testing performed in a reliable manner, depositing gunpowder residues consistently in a similar pattern size. It was noted that, as the distance increased beyond 9 inches, the range of minimum and maximum diameter measurements increased substantially (see Table 3). While there is no mention in the literature regarding trials in the actual distance determination testing of firearms, this finding would indicate that it may be important to test a firearm using three to five trials in order to demonstrate the reliability of the firearm's performance.

Table 1
Diameter Distance Tests of Five Shots for Each Sidearm
(Diameters measured in inches)

	Sidearm									
Distance/Shot Number	1	2	3	4	5	6	7	8	9	10
3 Inches / First Shot	5.25	5.25	5.50	5.75	5.00	5.25	5.50	5.25	5.13	5.25
3 Inches / Second Shot	5.13	5.50	5.25	5.25	5.50	5.25	5.25	5.75	5.50	5.25
3 Inches/ Third Shot	5.25	5.50	5.13	5.13	5.25	5.50	5.00	5.50	5.25	5.25
3 Inches/ Fourth Shot	5.50	5.25	5.00	5.25	5.13	5.25	5.50	5.25	5.00	5.25
3 Inches/ Fifth Shot	5.25	5.25	5.50	5.25	5.25	5.75	5.25	5.50	5.25	5.25
6 Inches/ First Shot	6.75	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
6 Inches/ Second Shot	7.00	7.00	7.00	7.25	7.13	7.00	7.00	7.00	7.13	6.75
6 Inches/ Third Shot	7.00	7.00	7.00	7.25	7.00	7.13	7.00	7.00	7.00	7.00
6 Inches/ Fourth Shot	7.00	7.00	7.13	7.00	7.00	7.00	7.13	7.13	7.00	7.13
6 Inches/ Fifth Shot	7.00	7.00	7.00	7.00	7.13	7.13	7.13	7.00	7.00	7.00
9 Inches/ First Shot	7.50	7.50	7.75	7.75	7.50	7.75	8.00	8.00	7.50	7.75
9 Inches/ Second Shot	7.75	7.75	7.50	7.75	8.00	8.00	7.75	7.50	7.50	8.00
9 Inches/ Third Shot	8.00	7.50	7.75	8.00	7.75	8.00	8.00	7.50	7.75	7.50
9 Inches/ Fourth Shot	8.00	7.75	8.00	7.75	7.50	7.75	8.00	8.00	7.75	7.50
9 Inches/ Fifth Shot	7.75	7.75	7.50	7.50	7.50	8.00	8.00	7.75	7.75	7.50
12 Inches/ First Shot	8.50	9.00	9.00	8.75	8.50	9.00	10.00	9.50	9.75	9.00
12 Inches/ Second Shot	9.00	8.75	9.75	10.00	10.00	9.50	8.75	8.50	9.00	9.00
12 Inches/ Third Shot	8.50	9.00	9.00	9.50	8.00	9.00	9.75	9.00	8.75	8.50
12 Inches/ Fourth Shot	8.00	9.00	8.50	9.50	10.00	9.75	9.00	9.00	8.75	8.75
12 Inches/ Fifth Shot	8.75	9.75	9.00	9.00	10.00	9.75	9.00	9.00	8.50	8.75
24 Inches/ First Shot	11.00	12.00	13.00	12.50	11.75	12.75	13.50	11.00	11.75	12.75
24 Inches/ Second Shot	12.75	13.00	13.00	13.50	11.00	11.50	12.00	12.50	13.00	13.25
24 Inches/ Third Shot	13.25	11.00	11.50	11.75	12.00	12.75	13.50	13.25	11.75	12.50
24 Inches/ Fourth Shot	13.00	12.00	11.00	11.75	13.50	12.75	12.00	11.50	11.75	12.00
24 Inches/ Fifth Shot	13.50	11.50	11.75	12.75	13.00	12.00	12.00	11.00	12.00	11.00

Table 2
Analysis of Variance of Sidearm Distance Test Shots (N=10 sidearms)

	Shot Number				
	1	2	3	4	5
			3 Inch Distance		
Minimum	5.00	5.13	5.00	5.00	5.25
Maximum	5.75	5.75	5.50	5.50	5.75
Mean	5.31	5.36	5.28	5.24	5.35
Median	5.25	5.25	5.25	5.25	5.25
Mode	5.25	5.25	5.25	5.25	5.25
Standard Deviation	0.21	0.19	0.17	0.17	0.17
F = .744 with 4 & 36 degrees of freedom, p = .568					
			6 Inch Distance		
Minimum	6.75	6.75	7.00	7.00	7.00
Maximum	7.00	7.25	7.25	7.13	7.13
Mean	6.98	7.03	7.04	7.05	7.04
Media	7.00	7.00	7.00	7.00	7.00
Mode	7.00	7.00	7.00	7.00	7.00
Standard Deviation	0.08	0.13	0.08	0.07	0.06
F= 1.21 with 4 & 36 degrees of freedom, p = .324					

9 Inch Distance

Minimum	7.50	7.50	7.50	7.50	7.50
Maximum	8.00	8.00	8.00	8.00	8.00
Mean	7.70	7.75	7.78	7.80	7.70
Median	7.75	7.75	7.75	7.75	7.75
Mode	7.50	7.75	8.00	7.75	7.50
Standard Deviation	0.20	0.20	0.22	0.20	0.20

F = 0.545 with 4 & 36 degrees of freedom, p = .703

12 Inch Distance

Minimum	8.50	8.50	8.00	8.00	8.50
Maximum	10.00	10.00	9.75	10.00	10.00
Mean	9.10	9.23	8.90	9.03	9.15
Median	9.00	9.00	9.00	9.00	9.00
Mode	9.00	9.00	9.00	9.00	9.00
Standard Deviation	0.50	0.55	0.50	0.59	0.50

F = 0.591 with 4 & 36 degrees of freedom, p = .671

24 Inch Distance

Minimum	11.00	11.00	11.00	11.00	11.00
Maximum	13.50	13.50	13.50	13.50	13.50
Mean	12.20	12.55	12.33	12.13	12.05
Median	12.25	12.88	12.25	12.00	12.00
Mode	11.00	13.00	11.75	12.00	12.00
Standard Deviation	0.84	0.81	0.85	0.75	0.82

F = 0.529 with 4 & 36 degrees of freedom, p = .715

Table 3
Minimum and Maximum Diameter Measures of Ten Sidearms at Varying Distances

Distance	Minimum	Maximum	Difference
3 Inches	5.00	5.75	0.75
6 Inches	6.75	7.25	0.50
9 Inches	7.50	8.00	0.50
12 Inches	8.00	10.00	2.00
24 Inches	11.00	13.50	2.50

As the data in Table 4 depict, there were no significant differences between the 10 firearms at any of the five distances. At 3 inches, the mean distance measures ranged from 5.23 to 5.45 inches in diameter for each sidearm (0.22 inch difference, $F = 0.098$, $p = 0.761$). At 6 inches, the distance measures ranged from 6.95 to 7.10 inches in diameter for each sidearm (0.15 inch difference, $F = 4.210$, $p = 0.070$). At 9 inches, the distance measures ranged from 7.65 to 7.95 inches in diameter for each sidearm (0.30 inch difference, $F = 0.076$, $p = 0.790$). At 12 inches, the distance measures ranged from 8.55 to 9.40 inches in diameter for each sidearm (0.85 inch difference, $F = 0.032$, $p = 0.862$). Finally, at 24 inches, the distance measures ranged from 11.85 to 12.70 inches in diameter for each sidearm (0.85 inch difference, $F = 0.445$, $p = 0.521$). Interestingly, all of the differences in measurements for each of the 10 sidearms were less than one inch.

Surprisingly, no significant differences were found between the firearms that were unissued (less than 100 rounds fired through them) and those that had been fired over 3000 times. This would also indicate unless the barrel of a firearm was substantially damaged or altered normal wear and tear does not significantly affect distance determination testing results.

Table 4
Analysis of Variance Between Ten Sidearms Mean Diameters in Distance Determination Tests

Sidearm	3 Inches	6 Inches	9 Inches	12 Inches	24 Inches
1	5.28	6.95	7.80	8.55	12.70
2	5.35	7.00	7.65	9.10	11.90
3	5.28	7.02	7.70	9.05	12.05
4	5.33	7.10	7.75	9.35	12.45
5	5.23	7.05	7.65	9.30	12.25
6	5.40	7.05	7.90	9.40	12.35
7	5.30	7.05	7.95	9.30	12.60
8	5.45	7.03	7.75	9.00	11.85
9	5.23	7.03	7.65	8.95	12.05
10	5.25	6.98	7.65	8.80	12.30
F =	0.098	4.210	0.076	0.032	0.445
P =	0.761	0.070	0.790	0.862	0.521

CHAPTER 5

DISCUSSION

The purpose of this study sought to determine whether there were significant differences of gunshot residue patterns using same make and model of firearms in forensic distance determination tests. It was predicted that there would be no statistical difference among the same make and model of firearms and their gunshot residue dispersal patterns.

Hypothesis

Based on the literature and the policies of firearms identification examiners, the assumption has been that the same firearm used in the commission of a crime must be examined for distance determination testing. It was assumed that every firearm is different in the way it disperses gunshot powder residue, even among the same make and model firearms. However, this assumption has never been tested empirically. As a result, the null hypothesis formulated for the present study was that there would be no significant difference in gunshot powder residue deposits among same make and model of firearms.

Empirical research within this specific area of criminal justice is particularly miniscule, which made previous literature and research somewhat difficult to substantiate. By contacting reputable persons with background experience, training, and knowledge, many people of this expertise felt that continuing research within any aspect of law enforcement, including firearms, is crucial to the field entirely. Ed Moran, who is part of the Alabama Department of Forensic Services, expressed essentially what all procedural manuals instruct, “our procedures are to use the same firearms and same type of ammo (bullet style and powder) to more precisely approximate the actual muzzle to target distance” (Personal Communication, May 21, 2007).

Yet, if the subject firearm(s) is missing, Moran stated that they do not do the testing "due to the variables that can occur even with the same make, mode, and barrel length etc". This type of statement is because of the limited research there is on firearms testing, which steers laboratories to have strict guidelines because they do not know anything otherwise. Yet, Moran validated the importance of this type of testing stating that it "can be very important when either trying to corroborate the witness testimony or dispel the story told" (Moran, personal communication, May, 21, 2007). This is exactly what occurred in a more recent case in St. Augustine, Florida, when a couple's 3 year anniversary celebration ended horribly.

A trip that began as an anniversary celebration ends with death. In April, 2002, Justin and April Barber went to the beach to celebrate their 3 year wedding anniversary. Barber describes the evening "We were walking along, and I was looking down, watching the waves come in over feet and I felt April tense up. And I looked up and a man was approaching us, very quickly. And he was not too far away…the man was holding up his hand, seemed agitated and demanded cash" Furthermore he told detectives that he remembered hearing a shot and then struggling for the weapon. He then passed out briefly, then, when he "came to" he ran up and down the beach looking for April. He found her face down floating in the water and attempted to drag her about 100 yards up the beach, but something was wrong with his body, he did not realize yet he had been shot. He got April as far as the foot of the boardwalk. He said that once he put her on this rail, she then fell down and he could not pick her up. At that point he elected to leave and go get help. Police scoured the beach and scrubs for clues, using metal detectors, helicopters, and came up empty every time.

For Justin Barber to corroborate his story, he told authorities that he had been shot, a total of four times, yet could not clearly remember what happened because he passed out after the first

gunshot. Detective Howard Cole, the lead detective on this case, did not stop searching for answers to these mysterious questions. Testimony demonstrated that the gun shot wounds "all were—within a range of all the testimony…that is consistent with being self-inflicted". Based on Detective Howard's training and experience, these gunshot wounds looked peculiar; therefore, he continued to research. Dr. Tepas described the wound to the right chest as "tangential" meaning, off to the side. In order to help investigators narrow down a motive and keep the investigation moving along thoroughly, the wounds on Justin Barber demonstrate a key piece of this puzzle. (Murphy, MSNBC Dateline Correspondent, 2006).

Sergeant Jay Lawing of the Saint John's Sherriff's Office, who assisted in the Barber case, provides his expertise on the subject matter. Sgt. Lawing feels that distance determination testing is important when determining if a gunshot wound is self inflicted or not, but the information is combined with other factors. However, this type of testing does not solve a case, it does give investigators an idea of what happened at one moment in time and hopefully that information coincides with the rest of the investigation. Sgt. Lawing is not an expert of the specifics done within the lab and speculates that conducting testing without the original weapon "would not be used in court, since there would be so many variables unanswered because you don't have the original weapon". Furthermore, Sgt. Lawing states that when these tests are conducted "the reports are only estimates of approximate range, i.e. three to five feet. The only definitive distance that can be scientifically proven is a contact wound". As demonstrated, this area of testing is so limited, that most do not trust the possibility of it being an option to the criminal justice system. Along with many others, and despite the possible variables, Sgt. Lawing believes that any testing that can be done that would help an investigation is worth while. (Lawing, personal communication, June 13, 2007).

Findings

Based on Analysis of Variance (ANOVA) testing of 10 sidearms, there were no significant differences found between any of the 10 sidearms at any of the distances measured (3, 6, 9, 12, and 24 inches). Based on these findings, the null hypothesis was not rejected.

There were no significant differences noted for a single firearm being test fired five times at the same distance (known as a trial). Although there were some variations, ANOVA testing indicated similar size patterns of gunshot residue deposits occurred in each trial.

Implications

The results of this study indicate that forensic distance determination testing may be performed when the original firearm is not available. Even when the original firearm is provided for such testing, the opinions provided by the firearms examiners are approximations rather than specific measurements. And, while no significant differences were found with trials of five shots for each sidearm in this study, it might be important for the examiner to test fire a firearm three to five times at each distance to verify the reliability of the firearm in producing the same patterns, even if the original firearm is used for testing. Apparently, from the present study's findings, there were no pattern differences found between new (unfired) firearms and older firearms that had been fired over 3000 times. Therefore, if a test firing is to be made with another firearm of the same make and model as the original used in commission of a crime, the fact that the test firearm is new or used is of no consequence assuming the original firearm's barrel has not been substantially altered or damaged.

Crime laboratories and forensic firearm examiners should not be too quick to change their current policies based on the findings of this study. However, they should be cognizant that the same make and model firearms may produce no significant differences in the manner they

deposit gunpowder residues with the same or similar ammunition. More research is needed in this area, specifically with different types of firearms. The present study focused on a particular make and model semi-automatic pistol. Future studies should include revolvers, rifles, shotguns, and black powder firearms to determine if they, too, produce similar findings. In addition, future studies should also examine the differences in ammunition used in the same make and model of firearms to determine if the same ammunition must be used in order to produce the same distance determination results.

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