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Practical Evidence Processing: Does Cyanoacrylate Fuming Hinder Firearms Analysis?

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Practical Evidence Processing: Does Cyanoacrylate Fuming Hinder Firearms Analysis?

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ABSRACT

Keywords: Cartridge Cases, Cyanoacrylate Fuming, Firearms Analysis, Forensic Ballistics

Cyanoacrylate fuming is a successful and efficient chemical process of revealing latent prints on non-porous objects found at crime scenes. In a crime laboratory setting, firearms are often processed for latent prints. While firearms are fumed using the cyanoacrylate fuming method, little research has been conducted to determine if this process hinders firearm analysis. The question of whether latent print examiners should protect the barrel or openings during the process has not been thoroughly researched. The lack of research on this subject may lead to potential misinterpretations as to what precautions should be taken prior to the latent print examination, and may lead to the loss of potentially vital evidence.

The purpose of this study is to discover whether cyanoacrylate fuming masks critical areas within a firearm that may provide individual characteristics for identification. Fired cartridge cases were examined and intra-compared before and after fuming. Results indicate significant differences in the mean number of matching striations for the gun and taping combination of pistols and revolvers, taped and not taped, respectively. This indicates that not taping the barrel of a firearm has an effect on the number of striations produced after the fuming process.

Acknowledgments

I would like to thank my committee members, Dr. Lord and Mr. Stokes, for their support and guidance during my project. They were able to give me great suggestions when formulating this project, not only scientifically, but also when applying it in an actual laboratory setting.

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Chapter 1

Introduction

Purpose and Significance of Study

Comparing firearm components before and after the fuming process can provide information that may prove useful when processing fingerprint evidence on firearms. This study is beneficial for labs conducting both firearm and fingerprint analyses. While fuming firearms for latent prints is common, there is not a specific protocol indicating if/when examiners should protect the barrel or breech opening before fuming. This study was important in determining the value of protecting the barrel of a firearm during fuming. If examiners knew how the fuming process affects firearm information, appropriate corrective measures could be used to ensure the maximum amount of evidence is discovered.

Research Hypotheses

This study sought to determine whether it is necessary to protect critical areas, such as the breechface and primer areas on a firearm during the fuming process. Focusing on the individual characteristics exhibited on fired cartridge cases before and after the cyanoacrylate fuming process, the following hypotheses were developed:

H_0: There is no difference in individual characteristics seen on cartridge cases between semi-automatics that are fumed closed versus semi-automatics that are fumed closed with tape over the barrel.

H_1: There is a difference in individual characteristics seen on cartridge cases between semi-automatics that are fumed closed versus semi-automatics that are fumed closed with tape over the barrel.

H_0: There is no difference in individual characteristics seen on cartridge cases between revolvers that are fumed closed versus revolvers that are fumed closed with tape over the barrel.

H_1: There is a difference in individual characteristics seen on cartridge cases between revolvers that are fumed closed versus revolvers that are fumed closed with tape over the barrel.

Limitations of the Study

The methodology and procedure for collecting data, while objective in its collection, was done solely by the researcher and later checked by a certified examiner. Tabulations were calculated by the researcher in an attempt to create a quantitative approach to these hypotheses. Limitations such as the firearm type, sample size, and number of variables created various constrictions on the statistical testing that could be performed. Future research will be necessary to validate the current study's methodology and approach.

Chapter 2

Review of the Literature

There has been minimal literature illustrating the relationship between the cyanoacrylate fuming method and its possible impacts on the firearm analysis process. The cyanoacrylate fuming method is an important process for latent fingerprint recovery. This procedure helps to uncover latent prints that are not clearly seen on non-porous objects; specifically objects found at crime scenes. There are laboratories, such as the Oklahoma State Bureau of Investigation (OSBI) Laboratory, that utilize this method yet there is no set procedure or guideline on how to specifically fume firearms. This project resulted from a research question posed by the OSBI to determine proper practicing guidelines for this specific procedure.

The first section of the literature review will describe the cyanoacrylate fuming method, its various methods, and its chemical interaction with fingerprints. The next section describes the field of firearm identification, illustrating the varying metals involved in firearm construction, the different coatings applied to firearms, and the class and individual characteristics firearm analysts use to conduct examinations. The final section reviews literature that involves the cyanoacrylate fuming method and its previous applications with firearms.

Cyanoacrylate Fuming Method

The cyanoacrylate fuming method is a chemical process that is used on nonporous surfaces, such as plastic, glass, metal and glossy paint, to develop latent fingerprints (Lennard, 2007, Lewis, 2012). The method was accidentally discovered in 1942 by Dr. Harry Coover while working with cyanoacrylate monomers to find an efficient material for clear plastic firearm sights (Ramotowski, 2012). It wasn’t recorded as being useful in latent print identifications until

1977 when Fuseo Matsumura and Masato Soba, both trace and fingerprint examiners from Japan, found that cyanoacrylates could be used for detecting fingerprints on nonporous surfaces (Lewis, 2012, Ramotowski, 2012). A demonstration of this technique was given in front of two U.S. Army latent print examiners, and was later brought back to their base in Georgia (Lewis, 2012, Ramotowski, 2012). The process was patented in the United States in 1981 and became popular in laboratories shortly thereafter (Lewis, 2012, Ramotowski, 2012).

In general, cyanoacrylate esters (usually methyl or ethyl cyanoacrylates) are without color and are sold as high-strength adhesives such as super glue (Lennard, 2007). The mechanism of the polymerization process between the fingerprint residue and the cyanoacrylate vapor is not completely understood by researchers (Wargacki, Lewis, & Dadmun, 2007). Polymerization occurs when the cyanoacrylate monomer comes into contact with the fingerprint residue, creating a white polymer on the ridges of the latent print. The cyanoacrylate vapor will polymerize selectively on the moisture left by the latent fingerprint but will not accumulate in between the friction ridges (Wargacki, et al., 2007, Lennard, 2007). While this is an excellent procedure for revealing latent prints, scientists aren't certain as to why the polymers attach exclusively to the moisture left by the fingerprint and not in between the print ridges (Wargacki et al, 2007). The esters are able to polymerize quickly when set at an ambient temperature (Lennard, 2007). Literature indicates that a cyanoacrylate vapor will form when the super glue is evaporated at a heated temperature usually between 80°-400° C, depending on method and equipment (Lennard, 2007, Lewis, 2012).

Currently there are two established methods when fuming for fingerprints. The first is an alternative method known as vacuum deposition. This is a fuming process without a heat source. The liquid cyanoacrylate ester is placed inside a vacuum chamber along with the nonporous item being fumed. A vacuum pump then creates pressure inside the closed system. Once the ideal pressure has been reached, the container will be sealed to allow the cyanoacrylate to vaporize at room temperature (Lewis, 2012). These types of prints will usually need to be treated to a secondary process, such as powdering, since the prints come out translucent (Lewis, 2012).

The second method is called the microburst method. This process requires a specific amount of cyanoacrylate ester, in liquid form, to be placed in an aluminum container. The aluminum helps with the polymerization process by acting as a retardant during the heating process (Lewis, 2012). Heating the chamber to about 400° C will quickly vaporize the high concentration of super glue, forming a white substance on the latent print (Lewis, 2012). The microburst method is currently the most popular method of fuming since a lower amount of time is required. The processing time will vary from lab to lab depending on their specific protocols, equipment, and size of the object being fumed.

The cyanoacrylate fuming method has been shown to be a capable means of revealing latent prints on nonporous objects. While firearms are nonporous, their construction, metallurgy, grips and frames can all complicate the efficiency of the fuming process. Based on construction and design, firearm components are normally not conducive for retaining the moisture of latent fingerprints.

Firearm Analysis

The metallurgic composition of firearms can vary. Wallace (2008) states the basic material used in the firearms industry is chromium-molybdenum steel; however a single firearm may contain a variety of different steels and metals. The steel used in firearms construction is exceptional in that it is efficient in resisting wear, has good tensile strength, and has high-quality machining components (Wallace, 2008). Chromium, copper, manganese, molybdenum, nickel, phosphorus, silicon, tungsten, and vanadium may be combined in varying ways and amounts to create an acceptable metallic property for the construction of the firearm, although this may vary from manufacturer to manufacturer (Wallace, 2008). Stainless steel and aluminum alloys are also becoming increasingly popular in the production of firearms (Wallace, 2008). In an effort to create lighter firearms, polymers are also being used. This plastic-like substance is becoming more popular in grips, stocks, frames, and also magazines (Wallace, 2008). Unconventional materials such as nylon, polyurethane, fiberglass and Kevlar have also been experimented with for their lighter weight and cost effectiveness (Wallace, 2008). Whether these materials will yield a fingerprint is a not widely researched topic.

The various metal surfaces and finishes on firearms can make it difficult to process fingerprints when utilizing the cyanoacrylate fuming method (Barnum et al., 1997). Additional chemical aspects, such as blueing and Parkerizing, should also be taken into consideration. Blueing is a passivation process that will protect a firearm to make it more resistant to rust. The passivation procedure will use a coating of various solutions and chemicals to further protect the firearm. Blueing solutions usually contain copper and selenium compounds in an acidic solution (Ramotowski, 2012). The use of firearm blueing reagents has led assistance in the recovery of latent fingerprints off of cartridge cases in some research that has been done (Ramotowski, 2012). Another chemical passivation process used is Parkerizing. This process is used mostly on military grade weapons, to help prevent rust development (Barnum & Klasey, 1997). Because both processes help deter moisture, they are not ideal for retaining latent prints. These factors should be taken into consideration when fuming firearms.

Firearm examiners analyze both class and individual characteristics firearms and ammunition components. In principle, analyses will determine class and individual characteristics that set one firearm apart from all others. The five class characteristics firearm examiners routinely seek out when analyzing ammunition are: caliber, chambering or cartridge type, number of lands and grooves, direction of twist, and land and groove dimensions (LeMay, 2010). These are useful for examiners when narrowing the search for a specific firearm. Individual characteristics found on firearms and/or corresponding ammunition are particularly important during a firearms examination. Individual characteristics are essentially imperfections that are replicated during the firing process and can be seen on areas such as the cartridge case breech markings, bolt markings, striations from lands and grooves, and fired ammunition. No two barrels are alike and will create different imperfections in their ballistic capabilities (DiMaio, 1999). These individual flaws enable an examiner to make identifications. If these characteristics are masked by the fuming process, important individual characteristics, such as striations, used to draw conclusions may be hidden.

Fuming and Firearms

In a general laboratory setting, it is unclear as to whether or not fuming should occur before or after the firearms information is collected. Firearms are unique in that they have the potential to contain varying forms of evidence and information. In theory, conducting a firearms examination before fuming may erase possible latent print evidence, while conducting the latent examination before may impair or mask the firearms information. Currently, the FBI latent print lab division states “the accumulation of cyanoacrylate glue fumes on some parts of a firearm *could* have an unfavorable effect during a subsequent firearms examination” (FBI, 2000). To combat this, the FBI suggests taping over vulnerable parts of the firearm, such as the chamber opening and over the end of the barrel (2000). Currently, there are no studies that indicate whether the fuming process hinders a firearm examiners ability to analyze key characteristics exhibited from the weapon or ammunition components.

Although few in number, there have been case work applications exploring certain aspects of performing the cyanoacrylate fuming method on firearms. In 1988, the United States patent for the cyanoacrylate fingerprint development method was being published. In its publication, the researchers stated numerous case examples of how the method was used to help process evidence from actual crime scenes, two of which involved the fuming of firearms. In the first case, the researchers examined a firearm that was possibly involved in a drive-by shooting. At that time, fuming a firearm was a standard operating procedure. The firearm was processed twice, which resulted in an identifiable latent print that linked the firearm back to a suspect (Thompson, Hinkle, & Carroll, 1988). In another case, researchers fumed a .357 Magnum revolver that was supposedly used in a shooting. Along with other physical evidence, the researchers were able to link this firearm, through a latent print revealed after fuming, to the suspect who had fired the weapon (Thompson et al., 1988).

A research study conducted by Engler was another experiment related to this project. Its aim was to see if cyanoacrylate fuming had an effect on the trigger pull of a firearm. The researchers took twelve firearms and processed them using the fuming method, subjecting six weapons to one gram of superglue, and the other six to five grams (Engler, 2005). All of the firearms were fumed without the use of barrel plugs or taping and the actions of all firearms were open (2005). The firearms were then fired first with the hanging weight and then fired again with the TriggerScan. The TriggerScan is a “computer controlled device that can display trigger pull to the one thousandth of a pound, compared to the nearest quarter pound measurements obtained with hanging weights" (Engler, 2005). The goal of this research was to determine if the hanging weight or TriggerScan methodologies were better at the analysis of the trigger pull after fuming. The results of the experiment showed that no significant variations between the pre- and post-fuming trigger pull measurements were found (2005). While this experiment contributes to understanding firearms and their operation after fuming, it did not question the possible internal damage the cyanoacrylate was causing.

The most relevant research experiment that influenced the current study was done in 1985 by Arnold and Gallant. The researchers tested whether the cyanoacrylate fuming method impaired firearms identification. They acquired nine firearms with nine types of corresponding ammunition, all varying calibers and models (1985). The researchers took the test fired bullets and cartridge cases and fumed them in a fuming chamber for thirty minutes. These were then re-submitted and fumed for another thirty minutes. Noting the white coating over the casings, a cotton swab with acetone was used to remove the substance before examination (1985). After a subsequent microscopic examination of the fumed ammunition, all of the corresponding ammunition was linked back to their original firearms without difficulty (1985). It was concluded that the cyanoacrylate fuming method did not hinder the microscopic examination analysis after fuming as each ammunition component was matched back to its original firearm. While the researcher appreciates the experiment, it is clear that they performed a different type of analysis. The current study sought to understand if the cyanoacrylate was masking critical areas needed for identification, without any type of chemical treatment being applied to the cartridge cases. There was also no re-fuming of the cartridge cases once they had been fired from the firearms nor were there multiple types of firearms. The current experiment is trying to uncover whether protecting the barrel is an appropriate pre-fuming necessity.

Chapter 3

Article Submission #1

Prepared for the AFTE Journal

Practical Evidence Processing: Does Cyanoacrylate Fuming Hinder Firearms Analysis?

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Keywords: Cartridge Cases, Cyanoacrylate Fuming Method, Firearms Analysis, Forensic Ballistics

Abstract

The purpose of this study was to analyze whether cyanoacrylate fuming masks critical areas on firearm components that may hinder an examiner’s ability to make an identification. This study is beneficial for labs conducting both firearm and fingerprint analyses by demonstrating that protecting critical areas on a firearm is or is not necessary. Using a frequency occurring tabulation, the researcher was able to examine the effects of the cyanoacrylate fuming method before and after firing by counting the reoccurring matching striae found on the breechface of cartridge cases. The results of this experiment indicate that the striations on the cartridge cases, before and after fuming, do not decrease as the firearms were fired. However, taping or not taping a firearm had significant results between the number of mean matching striations for the various combinations of firearm type and taped or not taped. Validation of this

procedure will be necessary for future studies. This research was part of a larger academic thesis.

Introduction

At this time, the Federal Bureau of Investigation latent print laboratory guidelines state that “the accumulation of cyanoacrylate glue fumes on some parts of a firearm *could* have an unfavorable effect during a subsequent firearms examination” [2]. The FBI suggests taping over vulnerable areas of the firearm, such as the barrel end and chamber opening [2]. Presently, there is limited literature describing the cyanoacrylate fuming method and its effects on firearms analysis. Currently, there is no set protocol for how a lab must fume firearms. For example, the Oklahoma State Bureau of Investigation (OSBI) will fume firearms however they are submitted as evidence and do not tape any part of the firearm.

Cyanoacrylate fuming is a successful and efficient chemical process of revealing latent prints on non-porous objects [1]. This method has been used on objects found at crime scenes that have the potential to hold hidden prints on their surfaces. While firearms are fumed in laboratories, there is little research to determine how often this is done and whether or not this affects subsequent firearm analyses. The lack of information on this subject could lead to the loss of vital evidence. If examiners knew how the fuming process affects the ballistics information it could provide, appropriate measures could be taken to ensure the maximum amount of evidence is being obtained.

Literature Review

The current literature on the cyanoacrylate fuming method and its use on firearms is limited. A study conducted by Arnold and Gallant in 1985 was used as a foundation for the current study. This experiment aimed to test whether cyanoacrylate fuming impairs firearms identification. The researchers used a total of nine firearms with nine types of corresponding ammunition, all varying calibers and models [3]. The researchers took the test fired bullets and cartridge cases and fumed them in a cyanoacrylate chamber for thirty minutes. The bullets and casings were then re-submitted and fumed for another thirty minutes [3]. They then removed the cyanoacrylate with acetone before any examinations were done. After the firearm analysis was done, they were able to match back all ammunition to their original firearms. The researchers concluded that the cyanoacrylate fuming method did not hinder the following microscopic examination [3].

This study left out key information such as fuming time, sample size, and they also re-fumed the cases. This is not a normal procedure when processing this type of evidence in a laboratory. The current study sought to discover the effects of cyanoacrylate by processing the evidence the way one would in a laboratory setting.

Other real life cases and studies have been conducted [4,5] however none make implications on how the cyanoacrylate aftereffects may or may not cover critical areas that would hinder a firearms analyst to make an identification from ammunition components such as cartridge cases.

Materials

Firearms

Two firearm types were utilized in this study. Two HiPoint C9 9mm semi-automatic firearms were used and labeled 1a and 1b. Two Smith & Wesson .38 Specials were used and labeled 2a and 2b. These firearms were designated for destruction at the OSBI, but were tested for operability prior to the study.

Ammunition

Federal Ammunition 9mm Luger 115 grain, Full Metal Jacket ammunition was used for both semi-automatics and Winchester 38 Special 130 grain, Full Metal Jacket ammunition was used for both revolvers.

Equipment

Cleaning materials, such as Hoppes no.9 and lubricant Rem. Oil were used in this study. Both were chosen based on popularity, availability, and were used to clean each firearm before they were test fired.

Materials utilized for the cyanoacrylate fuming method included the fuming chamber and heater, an aluminum dish, Omega-Print forensic liquid cyanoacrylate, and a timer. Various lab areas and equipment were also utilized for this research experiment. The University of Central Oklahoma’s Leeds Comparison Macroscope LCF 1600 was used for the cartridge case intra-comparisons. The macroscope has a total visual magnification range of 6x-102x and a zoom ratio of 16:1. The OSBI firing range and a cyanoacrylate microburst chamber in their latent print laboratory were used for this experiment.

Methods

Procedure for Collecting Data

Based on the nature of comparative analyses as seen in both fingerprints and firearms examination and addressing the concern of the National Academy of Sciences report (NAS) in regards to adding an objective component to this discipline [6], it was decided that tabulating the frequency of the average number of matching striae seen on a particular region of interest would be an objective and quantitative approach to answer the questions in this study. Each of the aforementioned firearms were thoroughly cleaned prior to firing samples. The semi-automatic firearms were designated as 1a and 1b while the revolvers were designated as 2a and 2b. Ten test fires were fired from each firearm to retain as known controls.

The test fires were fired at 10 second intervals to allow the firearm to rest between shots. These test fires were to be intra-compared to one another paying close attention to the selected region of interest (breechface and primer areas) on the cartridge cases. For example, for firearm 1a, 10 test fires were intra-compared to one another. This amounts to 45 intra-comparisons per firearm. The intra-comparisons were to be averaged across all samples for each firearm to get an average number of matching striae seen on the controls prior to fuming. An orientation process and traditional methods of microscopy were utilized when conducting comparisons.

All firearms were fumed together to ensure that they were all treated with the same amount of cyanoacrylate for the same amount of time. Firearms labeled 1a and 2a were fumed with the slide or cylinder closed. Firearms labeled 1b and 2b were fumed the slide or cylinder closed in addition to the barrel being taped. The firearms were all then exposed to the cyanoacrylate fuming process for a maximum time limit of 15 minutes. A specific amount (1.05 g) of Omega-Print forensic liquid cyanoacrylate was used to fume the firearms. After they had been in the fuming chamber for 15 minutes they were removed from the chamber and taken back to the OSBI firearms laboratory. The firearms were test fired an additional 10 times, in 10 second intervals, using the same caliber and ammunition brand as the control samples.

Procedure for Assessing Data

Tabulations were calculated for each intra-comparison, another 45 per fumed firearm. The tabulation was averaged again across all 10 fumed samples to get an average number of consecutive striae seen on the fumed samples. For example, the total average number of matching striae from control group 1a was compared to the total average number of matching striae from the fumed group of 1a. Because every firearm marks differently, each fumed firearm set was compared back to its original control set. All comparisons were conducted on the Leeds Macroscope at a magnification of x22, with the exception of firearm 2a, which needed a higher magnification of x56 because of the smaller region of interest it presented. While all other firearms yielded 45 comparisons, firearm 2a only yielded 28 comparisons as test fires 1 and 3 were uncountable in each the control and fumed groups. A total of 326 comparisons were completed for the study.

Results

Two hypotheses were assessed for this experiment. To determine statistical significance, a three factor (firearm, taping, fuming) analysis of variance with nesting was performed seen in Table 1. Specifically, the fuming factor was nested within firearm*taping. *p*-values less than 0.05 were considered significant. All analysis was performed using SAS v. 9.1.

Table 1.

ANOVA Table

Source	**df**	**SS**	**MS**	***F***	***p*-value**
Gun	1	18882.2	18882.2	1230.35	<0.0001
Taped	1	1507.7	1507.7	98.24	<0.0001
Gun*Taped	1	83.4	83.4	5.44	0.0227
Fumed(Gun*Taped)	4	1527.2	381.8	24.88	<0.0001
Error	68	1043.6	15.3		
Total	75	22402.1			

1. H_0: There is no difference in individual characteristics seen on cartridge cases between semi-automatics that are fumed closed versus semi-automatics that are fumed closed with tape over the barrel.

The results indicated that there was a significant difference in the mean number of matching striations between the semi-automatic that was taped and the semi-automatic that was not taped ($p<0.0001$).

2. H_0: There is no difference in individual characteristics seen on cartridge cases between revolvers that are fumed closed versus revolvers that are fumed closed with tape over the barrel.

The results also indicated that there was a significant difference in the mean number of matching striations between the revolver that was taped and the revolver that was not taped ($p<0.0001$).

In each case, the mean number of matching striations is higher for the firearm that was taped. The summary statistics for all combinations are seen in Table 2 and are graphically displayed in Figure 1.

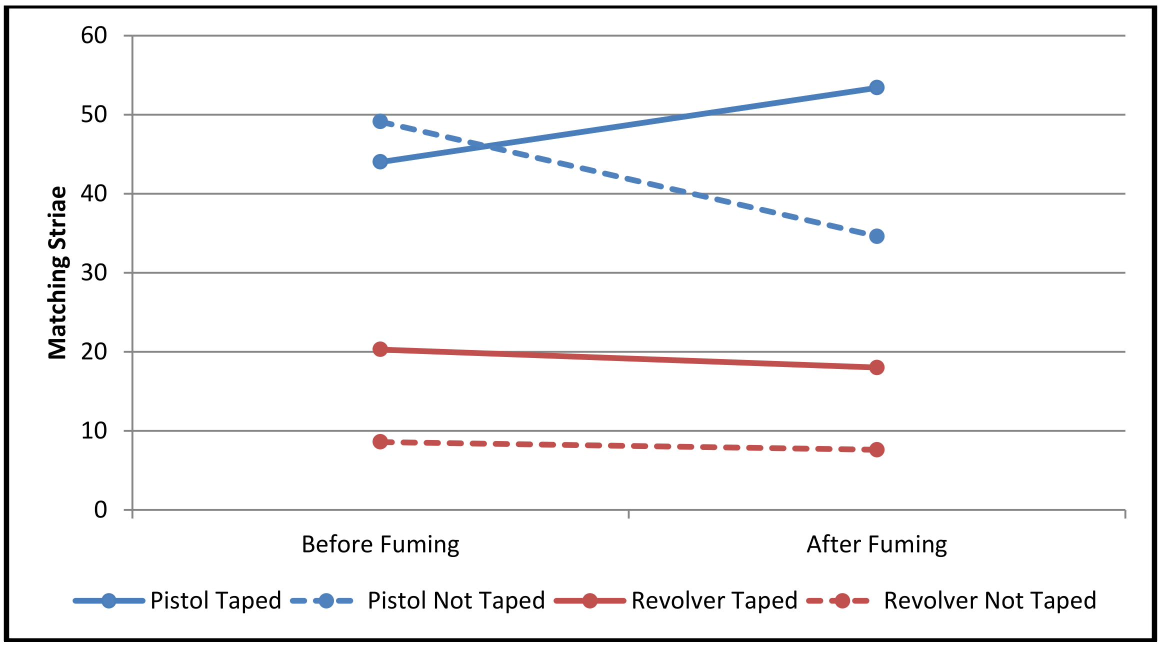
Table 2.

Means (std. dev.) of the average number of matching striations by cartridge number.

	Semi-Automatic		Revolver	
	Taped *n*=10	Not Taped *n*=10	Taped *n*=10	Not Taped *n*=8
Before	44.0 (2.6)	49.1 (8.8)	20.3 (2.1)	8.6 (1.5)
After	53.4 (3.5)	34.6 (2.8)	18.0 (2.0)	7.6 (1.3)

Figure 1.

Means of the average number of matching striations by cartridge number.



There was also a significant difference in the mean number of matching striations before and after fuming (*p*<0.0001). Specifically, there is a significant difference in the mean number of matching striations for the semi-automatics (p<0.0001 for both), but not for the revolvers (p=0.2045 for the taped revolver and p=0.5987 for the revolver that was not taped). This can also be seen in Figure 1. Notice that the lines for the revolvers are approximately horizontal, whereas the lines for the semi-automatics have non-zero slope. It is also interesting to note that the lines for the two semi-automatics are sloped in opposite directions.

Conclusion

The results indicate an increase in the mean number of striations in the semi-automatic when the barrel was protected. This indicates that taping the barrel of a semi-automatic can be helpful in protecting the individual characteristics that firearm could provide on a cartridge case. The same result was indicated by the revolvers, however, it is unclear if this was the result of the taping factor or from revolver 2a yielding a different set of data because of an internal flaw during the firing process.

Limitations

Revolver 2a was an anomaly that could not follow the original methodology of the experiment. After research had begun, it was discovered that revolver 2a fired differently than the other firearms. This is likely due to an internal flaw within the interior of the firearm. Adjustments, such as the region of interest and magnification range, were forced to be made because of the way the firearm discharged. This may have potentially affected the results. The firearms were also fumed together to ensure they were being treated to the same amount of cyanoacrylate which was used to control the fuming session. Because of this, replacement firearms could not be used or added to the experiment. Future research needs to account for the addition of more firearms, as well as firearms that don’t fire correctly.

There also needs to be the addition of a gun in each combination of firearms type and taped or not taped. This would help with certain statistical tests and use more of the data efficiently.

Future Research

Future research needs to be conducted to fully assess how cyanoacrylate affects subsequent firearm analyses. Because this was a preliminary study, it needs to be tested for reproducibility and validity. Other experiments could be accomplished with this study as a foundation. Certain aspects and variables such as firearm type, number of firearms, fuming time, taping locations, and ammunition types are all different ways in which this experiment could be changed or expanded. Since the results showed statistically significant results, more research needs to be done to ascertain whether or not the cyanoacrylate is masking critical areas on the breechface of cartridge cases and other ballistics components.

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Chapter 4

Article Submission #2

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Cyanoacrylate fuming and its effects on ballistics information: A statistical approach

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Abstract

The subject of whether or not cyanoacrylate fuming hinders subsequent firearms analyses has not been widely researched. A strict methodology and statistical tests were needed to create an objective approach to these research hypotheses. Using a frequency occurrence tabulation, objective and quantitative results were achieved. The results indicated that there was a significant difference in both firearm types that were taped and not taped. There was also some interaction with the semi-automatics when comparing their before and after fuming means. This was a preliminary research experiment that needs future research to reproduce results and validate the methodology. This research was part of a larger academic thesis.

Keywords: Cartridge Cases, Cyanoacrylate Fuming Method, Firearms Analysis, Forensic Ballistics

1. Introduction

The cyanoacrylate fuming method is an efficient means of identifying latent prints on non-porous items [1]. Firearms go through this process in laboratories across the country. Currently, there is no strict laboratory protocol that defines how to fume the firearm or whether or not the barrel of said firearm should be protected. The Federal Bureau of Investigation suggests protecting the firearm, covering essential firearm components, as the cyanoacrylate *could* have an adverse effect on the subsequent firearms analysis [2].

Few real life applications or research studies have been conducted to assess how cyanoacrylate fuming affects firearm components [3], [4] and [5]. None of the studies have assessed if the cyanoacrylate fuming method masks critical areas on the breechface of a cartridge case. For evidence processing purposes, this is a practical question that needs to be addressed. The current study sought to create a numerical and objective approach to answering whether or not cyanoacrylate has an effect on firing and ammunition components. To accomplish this, the researcher counted the striations that matched in the same relative position, in a designated region of interest, on the breechface of two cartridge cases.

The National Academies of Science stated in their national report on forensic science, that "the extent of agreement in marks made by different tools, and the extent of variation in marks made by the same tool, is a challenging task. AFTE [Association of Firearm and Toolmark Examiners] standards acknowledge that these decisions involve subjective qualitative judgments by examiners and that the accuracy of examiners' assessments is highly dependent on their skill and training" [6]. This experiment seeks to combine the subjective ability of the examiner during the microscopic phase of analysis with the objective component of statistical analysis.

2. Materials and methods

2.1 Firearms

Two firearm types were utilized in this study. Two HiPoint C9 9mm semi-automatic firearms labeled 1a and 1b and two Smith & Wesson .38 Specials labeled 2a and 2b. These firearms were designated for destruction at the Oklahoma State Bureau of Investigation (OSBI), but were tested for operability prior to the study.

2.2 Ammunition

Federal Ammunition 9mm Luger 115 grain, Full Metal Jacket ammunition was used for both semi-automatics and Winchester 38 Special 130 grain, Full Metal Jacket ammunition was used for both revolvers.

2.3 Equipment

2.3.1 Cleaning materials

Hoppes no.9 and lubricant Rem. Oil were used in this study to clean all firearms before use. Both were chosen based on popularity and availability.

2.3.2 Cyanoacrylate Fuming Method

A microburst fuming chamber and heater, an aluminum dish, Omega-Print forensic liquid cyanoacrylate, and a timer were materials utilized during the cyanoacrylate fuming period.

2.3.3 Laboratories

Various lab areas and equipment were also utilized for this research experiment. The University of Central Oklahoma's Leeds Comparison Macroscope LCF 1600 was used for the cartridge case comparisons. The macroscope has a total visual magnification range of 6x-102x and a zoom ratio of 16:1. The OSBI firing range and a cyanoacrylate microburst chamber in their latent print laboratory were used for this experiment.

2.4 Methodology

2.4.1 Procedure for collecting data

Based on the subjective nature of comparative analyses as seen in both fingerprints and firearms examination, it was decided that tabulating the frequency of the average number of matching striae seen on a particular region of interest would be an objective approach to answer the questions in this study. Each of the aforementioned firearms were thoroughly cleaned. The semi-automatic firearms were designated as 1a and 1b while the revolvers were designated as 2a and 2b. Ten test fires were fired from each firearm to retain as known controls.

The test fires were fired at 10 second intervals to allow the firearm to rest between shots. These test fires were to be intra-compared to one another paying close attention to the selected region of interest (breechface and primer areas) on the cartridge cases. For example, for firearm 1a, 10 test fires were intra-compared to one another. This amounts to 45 intra-comparisons per firearm. The intra-comparisons were averaged across all samples for each firearm to gain an average number of matching striae seen on the controls prior to fuming. An orientation process and traditional methods of microscopy were utilized when conducting comparisons.

All firearms were fumed together to ensure that they were all treated with the same amount of cyanoacrylate for the same amount of time. Firearms labeled 1a and 2a were fumed with the slide or cylinder closed. Firearms labeled 1b and 2b were fumed the slide or cylinder closed in addition to the barrel being taped. The firearms were all then exposed to the cyanoacrylate fuming process for a maximum time limit of 15 minutes. A specific amount (1.05 g) of Omega-Print forensic liquid cyanoacrylate was used to fume the firearms. After they had been in the fuming chamber for 15 minutes they were removed from the chamber and taken back to the OSBI firearms laboratory. The firearms were test fired an additional 10 times, in 10 second intervals, using the same caliber and ammunition brand as the control samples.

2.4.2 Procedure for assessing data

Tabulations were calculated for each intra-comparison, another 45 per fumed firearm. The tabulation was averaged again across all 10 fumed samples to get an average number of consecutive striae seen on the fumed samples. For example, the total average number of matching striae from control group 1a was compared to the total average number of matching striae from the fumed group of 1a. Because every firearm marks differently, each fumed firearm set was compared back to its original control set. All comparisons were conducted on the Leeds Macroscope at a magnification of x22, with the exception of firearm 2a, which needed a higher magnification of x56 because of the smaller region of interest it presented. While all other firearms yielded 45 comparisons, firearm 2a only yielded 28 comparisons as test fires 1 and 3 were uncountable. A total of 326 comparisons were completed for the study.

3. Results

3.1 Statistical Methods

Ten shots were fired from each gun, before and after fuming. The cartridges were numbered in sequential order, and every possible pair of cartridges was then examined. The number of matching striations was recorded. For each cartridge, the number of matching striations with the other cartridges was averaged. These averages are displayed in Figures 1 and 2. It was theorized that the number of striations would decrease as the gun was fired. There was no evidence of this, either before or after fuming, as indicated by the horizontal patterns in Figures 1 and 2.

Figure 1.

Mean number of matching striae by casing number, before fuming.

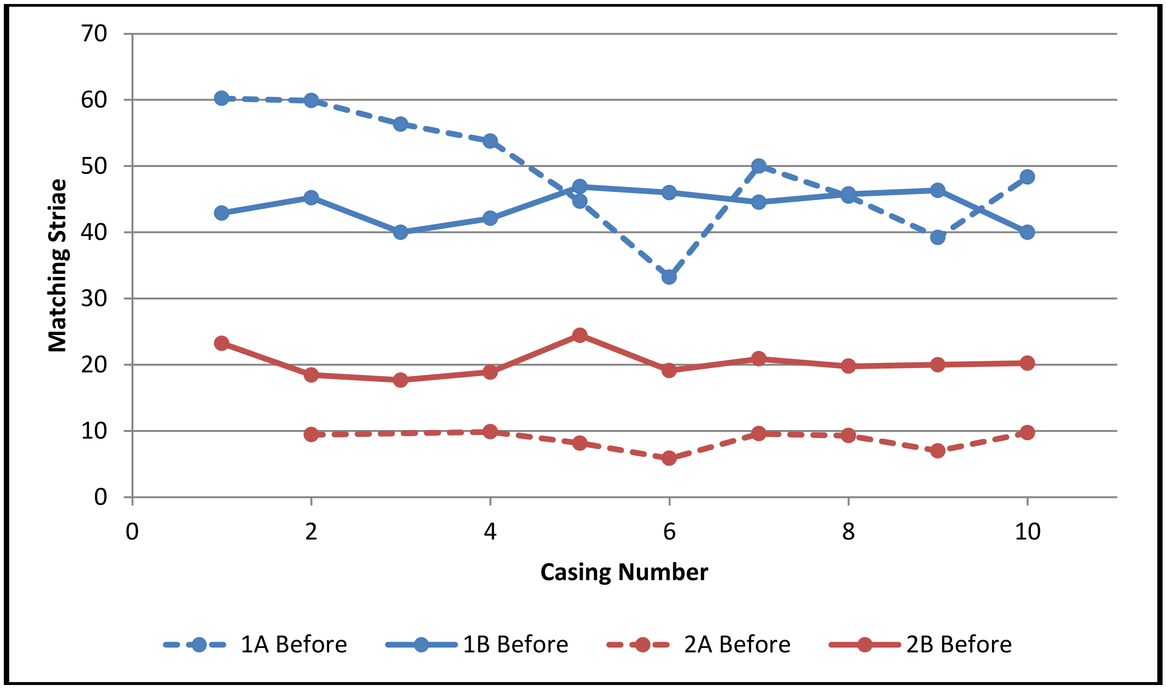
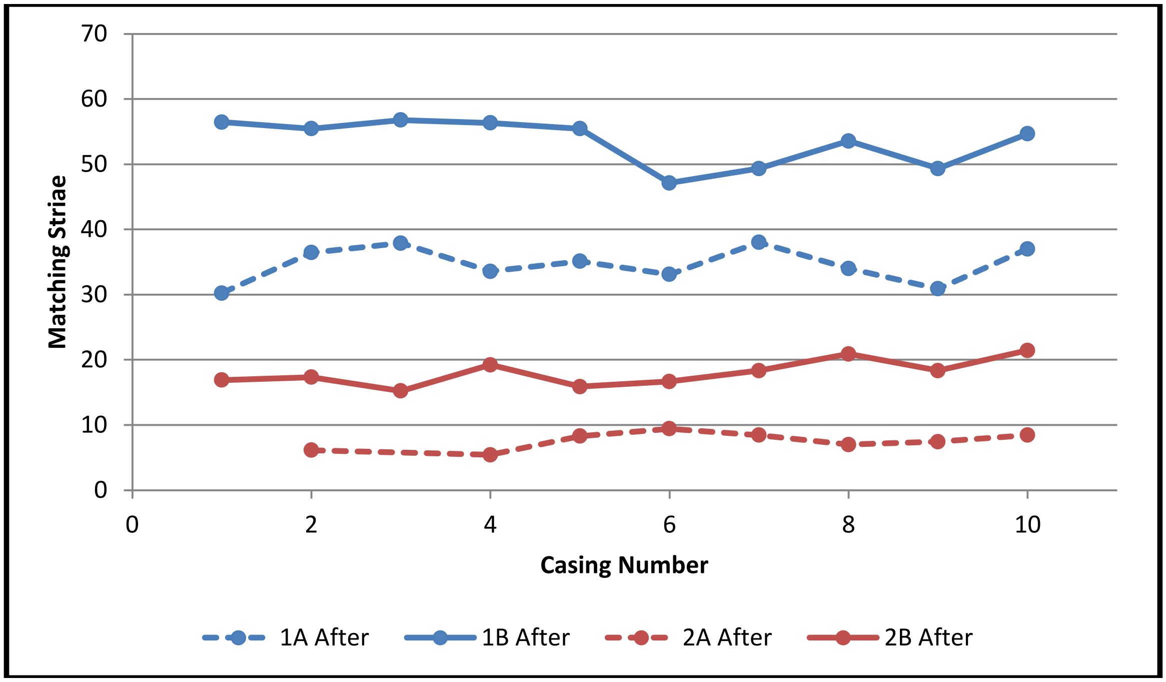


Figure 2.

Mean number of matching striae by casing number, after fuming



The summary statistics for each combination of firearm (semi-automatic or revolver), taping (taped or not taped), and fuming (before or after) are presented in Table 1. The means are also displayed graphically in Figure 3.

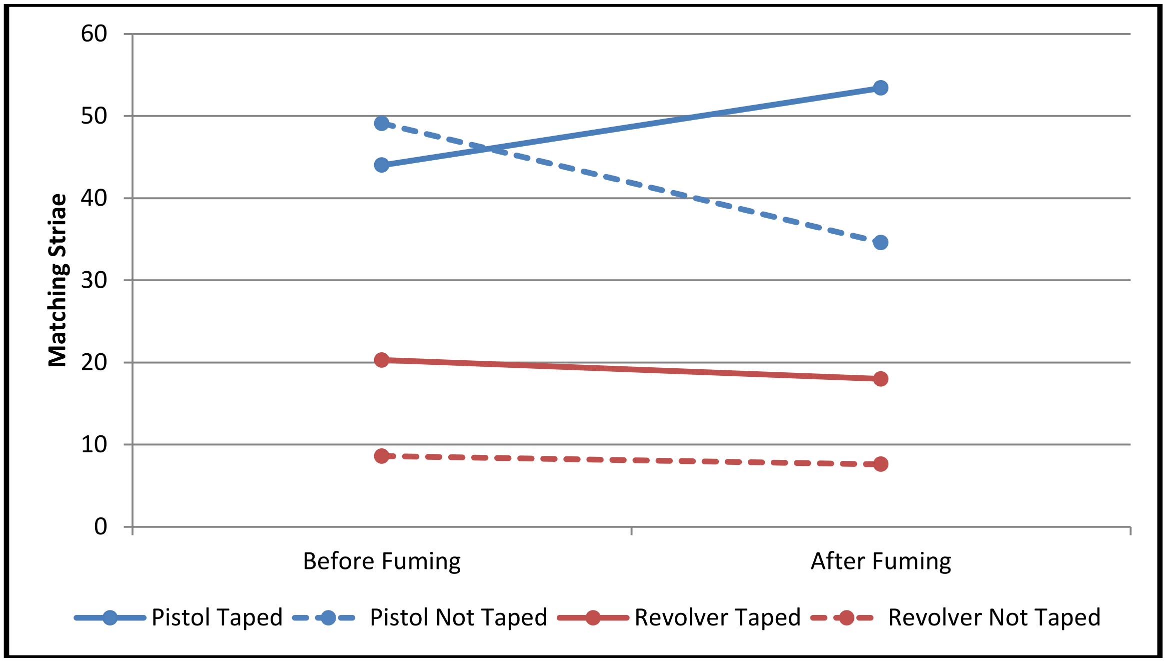
Table 1.

Means (std. dev.) of the average number of matching striations by cartridge number

	Pistol		Revolver	
	Taped *n*=10	Not Taped *n*=10	Taped *n*=10	Not Taped *n*=8
Before	44.0 (2.6)	49.1 (8.8)	20.3 (2.1)	8.6 (1.5)
After	53.4 (3.5)	34.6 (2.8)	18.0 (2.0)	7.6 (1.3)

Figure 3.

Means of the average number of matching striations by cartridge number



To determine statistical significance, a three factor (gun, taping, fuming) analysis of variance with nesting was performed seen in Table 2. Specifically, the fuming factor was nested within gun*taping. *p*-values less than 0.05 were considered significant. All analysis was performed using SAS v. 9.1.

Table 2.

ANOVA table

Source	**df**	**SS**	**MS**	***F***	***p*-value**
Gun	1	18882.2	18882.2	1230.35	<0.0001
Taped	1	1507.7	1507.7	98.24	<0.0001
Gun*Taped	1	83.4	83.4	5.44	0.0227
Fumed(Gun*Taped)	4	1527.2	381.8	24.88	<0.0001
Error	68	1043.6	15.3		
Total	75	22402.1			

3.2 Results

The gun*taping interaction was found to be significant ($F_{1,68}$=5.44, p=0.0227). Consequently, the gun and taping main effects should not be analyzed. Rather, the differences in the mean matching striations for the pistols and revolvers should be analyzed separately for the guns that were taped and not taped. There is a significant difference in the mean number of matching striations between the semi-automatic that was taped and the semi-automatic that was not taped ($p<0.0001$). There is also a significant difference in the mean number of matching striations between the revolver that was taped and the revolver that was not taped ($p<0.0001$). In each case, the mean number of matching striations is higher for the gun that was taped.

There is also a significant difference in the mean number of matching striations before and after fuming ($F_{4,68}$=24.88, $p<0.0001$). Specifically, there is a significant difference in the mean number of matching striations for the semi-automatics ($p<0.0001$ for both), but not for the revolvers ($p=0.2045$ for the taped revolver and $p=0.5987$ for the revolver that was not taped). This can be seen in Figure 3. Notice that the lines for the revolvers are approximately horizontal, whereas the lines for the pistols have non-zero slope. It is also interesting to note that the lines for the two pistols are sloped in opposite directions.

4. Discussion

The results indicate that taping or protecting the barrel of a semi-automatic can increase the number of matching striae that appear on said firearms ammunition components. This was also the case for the revolvers and their taping/non-taping interaction, although this is not concrete because of the data assessed from revolver 2a.

This study proves that cyanoacrylate has the potential to mask individual characteristics on cartridge cases from semi-automatics that are not protected. This can further hinder a subsequent firearms analyst from potentially making an identification. The revolver showed potential for this as well, however more research will need to be conducted to determine if they are also susceptible to the cyanoacrylate. Future research and variations of this study will be necessary in the future to discover the extent of the problem. Experiments set in a working laboratory will need to be implemented to see if this is a wide spread problem in the processing of firearms evidence.

5. Conclusion

This study indicates that fingerprint analysts using the cyanoacrylate fuming method on firearms need to protect the barrel of firearms as the vapor has the potential to mask individual characteristics that would assist a firearms examiner in his or her analysis. This was seen in semi-automatics however more research will be needed to analyze revolvers and how they react to the cyanoacrylate fumes.

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Chapter 5

Discussion

Introduction

The cyanoacrylate fuming method is a successful means of uncovering latent prints on non-porous objects, particularly from crime scenes. While they are fumed for prints, firearms can offer other evidence through a subsequent firearms examination. What is not widely understood is whether the fuming method can have adverse affects on the internal mechanisms of the firearm. This study wanted to see the difference between protecting the barrel of a firearm versus not protecting it from the fuming process. This was analyzed by counting the number of matching striae from intra-comparisons done of the fired cartridge cases from each test group. By taping the barrel of the firearm, it was hypothesized that there would be more striations on the fired cartridge cases that the firearm examiner could utilize for identification purposes.

The current literature on the subject is limited. There have been studies that have involved the fuming process and firearms (Arnold & Gallant, 1985, Engler, 2005, & Thompson, et al., 1988), but nothing as in depth as the current study. There is also limited literature on the current guidelines and protocols for fuming firearms in a laboratory setting. It is suggested that labs conduct the fuming process in whatever way they see is necessary, per object. In terms of firearms, labs are fuming them differently across the nation, per their own laboratory's procedure.

In the following discussion, the implications of this study will be discussed. The statistical results will be evident through the following tables, figures, and statistical tests. Hypothesis 1 will describe the results between the semi-automatics that were taped and not taped after the fuming process. Hypothesis 2 will describe the results between the revolvers that were taped and not taped after the fuming process. Limitations will also be discussed as well as future recommendations for research.

Hypotheses

To determine statistical significance, a three factor (firearm, taping, fuming) analysis of variance with nesting was performed. Specifically, the fuming factor was nested within firearm*taping. *p*-values less than 0.05 were considered significant. All analysis was performed using SAS v. 9.1 (Morris, 2014). Two hypotheses were assessed for this experiment.

Hypotheses 1: H_0: There is no difference in individual characteristics seen on cartridge cases between semi-automatics that are fumed closed versus semi-automatics that are fumed closed with tape over the barrel.

The results indicated that there was a significant difference in the mean number of matching striations between the semi-automatic that was taped and the semi-automatic that was not taped ($p<0.0001$) seen in Table 1 and graphically in Figure 1(Morris, 2014).

Hypotheses 2: H_0: There is no difference in individual characteristics seen on cartridge cases between revolvers that are fumed closed versus revolvers that are fumed closed with tape over the barrel.

The results also indicated that there was a significant difference in the mean number of matching striations between the revolver that was taped and the revolver that was not taped ($p<0.0001$) seen in Table 1 and graphically in Figure 1 (Morris, 2014). In each case, the mean number of matching striations is higher for the firearm that was taped (Morris, 2014).

Table 1.

Means (std. dev.) of the average number of matching striations by cartridge number

	Pistol		Revolver	
	Taped *n*=10	Not Taped *n*=10	Taped *n*=10	Not Taped *n*=8
Before	44.0 (2.6)	49.1 (8.8)	20.3 (2.1)	8.6 (1.5)
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Figure 1.

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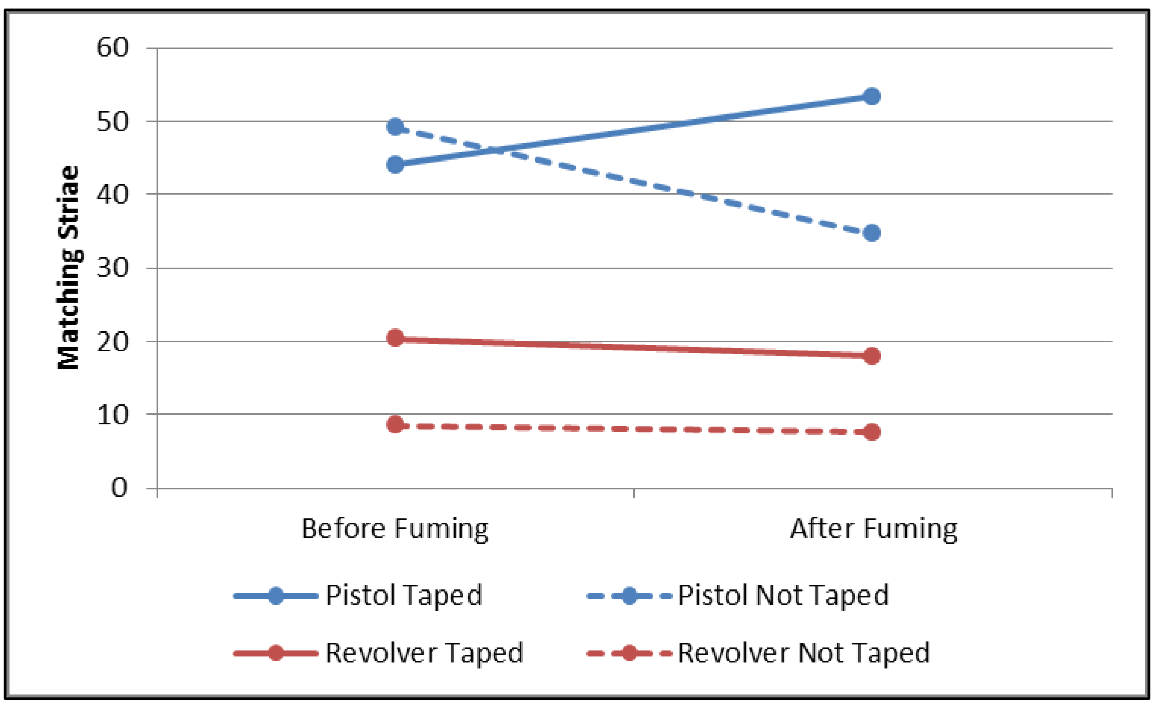


Two additional research questions became apparent within the study. While studying the effects of the fuming, the statistical results indicated that there was a significant difference in the mean number of matching striations before and after fuming. Specifically, there was a significant difference in the number of matching striations for the semi-automatic ($p<0.0001$ for both), but not for the revolvers ($p=0.2045$ for the taped revolver and $p=0.5987$ for the revolver that was not taped) (Morris, 2014). This indicates that the semi-automatics are more vulnerable to the fuming process than revolvers.

Another interesting point was that it was thought that the number of striations would decrease as the firearm was fired. There was no evidence of this, either before or after fuming, as indicated by the horizontal patterns in Figures 2 and 3. In future studies, additional rounds could be test fired to see if this same trend continues or changes throughout the fuming process (Morris, 2014).

Figure 2.

Mean number of matching striae by casing number, before fuming.

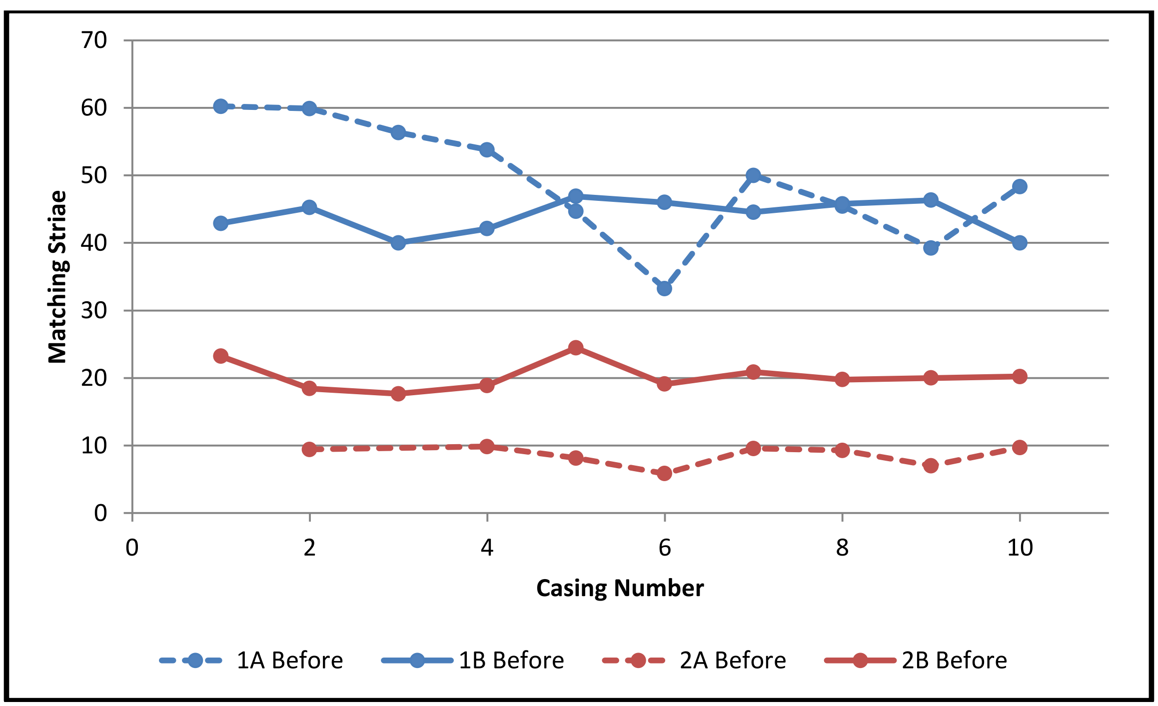
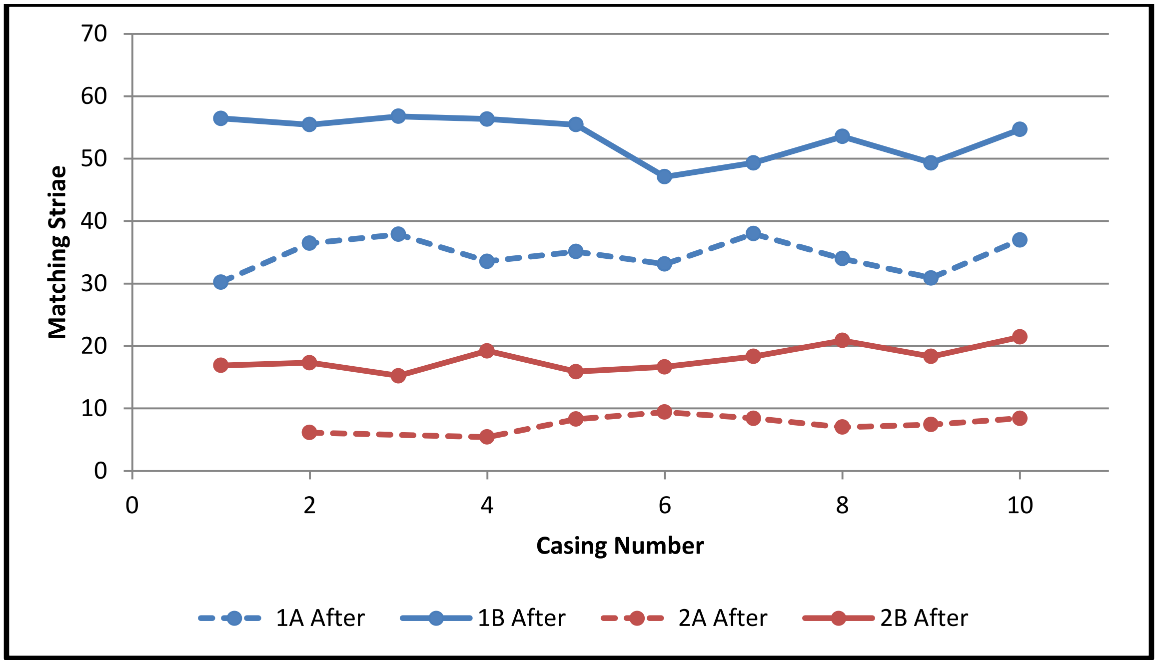


Figure 3.

Mean number of matching striae by casing number, after fuming.



Importance of the Study

This experiment studied the effects cyanoacrylate may have on a subsequent firearms analysis. Particularly, there is no set rule that the barrel of the firearm should be protected or covered during the fuming process. These results permit laboratory personnel to take whatever action they can to prevent this hindrance from occurring. As there are no specific protocols on how to fume firearms for the cyanoacrylate fuming process, there is the potential for new guidelines to be implemented in a laboratory setting. Simply adding a piece of tape of the barrel of a weapon prior to fuming is a quick, cost-effective, and efficient means of protecting the barrel from the unwanted affects of the cyanoacrylate vapor. This study has created a foundation for more research to be conducted. There are multiple variables that should be tested, especially after this study has illustrated significant results.

Limitations of the Study

While there are other studies illustrating the cyanoacrylate fuming method and its effects on firearms, this study was novel. Through the methodology, we were able to create a quantitative method of tabulating the reoccurring frequency of the matching striae. With this new methodology comes the need for future validation studies.

Fuming the firearms together was efficient in ensuring that each firearm received the same amount of treatment, however the researcher was unable to add more guns or switch out anomalies that could skew data. For example, revolver 2a had various challenges associated with it so that couldn’t be treated with the same methodology while collecting its intra-comparisons on the comparison macroscope. It also had less test fire comparisons because test fires 1 and 3 were uncountable and therefore could not be compared back to the other casings. If the firearms had been separately fumed, there could have been the chance to add additional firearms to the experiment. These were some limitations that occurred after the experiment had begun. The firearms had been tested before and had marked sufficiently, however the ammunition had changed once the experiment began. It is unclear if other ammunition could have marked better or if there was something inside the firearm that caused it to mark inconsistently. It is also unclear whether the change in 2a was a result of the not taping it or if it was because of the way the firearm discharged.

This experiment utilized one type of firearm for each combination, thus limiting the type of statistical tests that would accurately demonstrate an interaction between the separate main effects of firearm type, taping, and fuming. Adding an additional firearm to each of the combinations would have assisted in cushioning the data so that more statistical tests could have been performed. Other experiments should keep these factors in mind when recreating or expanding this project to achieve more statistical results.

Recommendations for Future Research

Future research should explore additional variables and combinations introduced in this experiment. Firearm type, number of firearms, fuming time, taping locations, ammunition types and components are all different ways in which this experiment could be changed or expanded. Since the results showed statistically significant results, additional research needs to be conducted to ascertain whether or not the cyanoacrylate is masking critical areas on the breechface of cartridge cases and other ballistics components.

Conclusion

Overall, this experiment sought to understand the interaction between the cyanoacrylate fuming method and firearms analysis. This study wanted to determine if latent print lab personnel should protect the barrel of a firearm prior to the fuming process. Specifically, the study looked to determine if taping the barrel of a firearm helped prevent cyanoacrylate vapors from masking critical areas on a cartridge case. This was achieved by examining semi-automatics and revolvers individually, before and after fuming. Counting the number of matching striae was a quantitative way of analyzing if the cyanoacrylate was affecting the number of striations made on the fired cartridge cases.

The first hypothesis looked at before and after fuming effects of semi-automatics that were taped and not taped. A statistically significant result was found between the mean number of matching striae of the taped semi-automatic and the un-taped semi-automatic. This indicated that taping the barrel helped to increase the number of matching striae when compared to the un-taped firearm. A significant difference was also seen before and after fuming of both semi-automatics.

The second hypothesis looked at before and after fuming effects of revolvers that were taped and not taped. A statistically significant result was found between the revolver that was taped and the revolver that was un-taped. However, it is unclear whether this difference is a factor of taping or because revolver 2a had an internal flaw. In comparing before and after fuming, there was no significant difference found in revolvers. The limitation of revolver 2a hindered the publication of all revolver data however it holds no bearing on the results gained from the semi-automatics.

This study was a practical evidence processing experiment meant for possible laboratory implementation. Because it involves fingerprint and firearms analysis, laboratories that utilize both of these fields could benefit from this study. By placing a piece of tape over the barrel of a firearm prior to fuming, examiners could increase the potential for individual characteristics that a firearms analyst could utilize to determine an identification. The OSBI proposed this question for use in their own lab. This study has laid the foundation for others to validate the process and implementation into a crime laboratory setting.

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