The Scientific Foundations of Firearms and Tool Mark Identification – A Response to Recent Challenges

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Introduction

Recently, an article was published in The Columbia Science and Technology Law Review entitled "A Systemic Challenge to the Reliability and Admissibility of Firearms and Toolmark Identification."[2] The author, Dr. Adina Schwartz, is an Associate Professor with the John Jay College of Criminal Justice and the Graduate Center, City University of New York. Dr. Schwartz uses the framework of an *amicus* brief written on behalf of the defense in the case *United States v. Kain*[3] to expound on her arguments as to why "all firearms and toolmark identifications should be excluded until the development of firm statistical empirical foundations for identification and a rigorous regime of blind proficiency testing."[4]

Outlining her treatise, Schwartz first discusses the scientific issues related to firearms and tool mark identification. These scientific issues include:

- The types of tool marks
  - Class
  - Subclass
  - Individual
- Three major sources of misidentification
  - Individual characteristics are comprised of non-unique marks
  - Subclass characteristics may be confused with individual characteristics
  - Individual marks of a particular tool change over time
- A call for statistical treatment using DNA as an analogy
- The lack of adequate proficiency testing
- Fundamental problems not cured by development of "computerized firearms database"

Subsequent to her discussion of the scientific issues, Schwartz discusses some of the case law related to firearms and tool mark identification. She does this to illustrate, in her opinion, that, "no state or federal court – either before or after *Daubert* – has understood the scientific problems with firearms and toolmark identification."[5]

The purpose of this article is to review and assess the arguments made by Schwartz and to evaluate the basis of support cited to support those arguments. It will be demonstrated throughout this article that the challenge offered by Schwartz is not as substantiated as an uncritical review of her article would suggest. There are numerous instances in which studies and articles are inappropriately quoted or inaccurately paraphrased. During the discussion of some of the scientific issues, there is an apparent lack of understanding of the relative significance as applied to the science of firearm and tool mark identification. While the author was apparently aware of the large number of articles available that can be used to address many of these issues, there was no mention of them made in her argument.[6] Furthermore, there were instances in which research into some of these primary resources, rather than reliance on some secondary resources, would have been much more enlightening.

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[2] Schwartz, Dr. Adina. "A Systemic Challenge to the Reliability and Admissibility of Firearms and Toolmark Identification." The Columbia Science and Technology Law Review, Volume VI, 1-42.

[3] *United States v. Kain*, Crim. No. 03-573-1 (E.D. Pa. 2004). Subsequently published as "A Challenge to the Admissibility of Firearm and Toolmark Identifications: *Amicus* Brief prepared on Behalf of the Defendant in United States v. Kain, Crim. No. 03-573-1 (E.D. Pa. 2004)." The Journal of Philosophy, Science, &Law, Vol. 4, December 7, 2004.

[4] *Supra* note 2, at 42.

[5] *Supra* note 2, at 3.

[6] Personal communication with Bruce Moran, Criminalist with the Sacramento County District Attorney's Forensic Science Laboratory via e-mail on April 16, 2005. Moran provided Dr. Schwartz with personal notes citing in excess of 100 different citations dealing with firearm and tool mark identification.

It would also appear that when the case law is examined in a fuller context than that offered through the brief quotes and paraphrases by Schwartz, there is evidence to believe that the courts are more aware of the relevant scientific issues than for which she gives them credit. In addition, the lack of context for some of the quotes and paraphrases does a significant disservice to the reader of Dr. Schwartz's work.

I. Firearms and Tool Mark Identification Is Rooted In Sound Scientific Foundations

A careful and thorough review of the literature will demonstrate that the discipline of firearms and tool mark identification is firmly rooted in the application of the scientific method culminating in the definition of a theory of identification by the relevant scientific community associated with the discipline. The great majority of the study in the discipline follows the premise of the scientific method of defining a problem, formulating a hypothesis or tentative explanation, designing and performing an experiment to test the hypothesis, making observations, and interpreting the results to determine the reasonableness of the tentative explanation. At this point it would be appropriate to test the hypothesis further, adjusting some newly defined variables or, forming a new hypothesis all together and performing more experiments. This cycle is repeated as many times as necessary. A hypothesis that has successfully stood the test of many experiments with different variables can be established as a theory.

The scientific basis of the discipline is criticized in Part II of Schwartz's article. Yet, she does do without once either referring to or citing the AFTE Theory of Identification. The Theory of Identification is the work of the relevant scientific community, a careful reading of which would help answer some of the claims made by Schwartz. It reads:

> [a] The theory of identification as it pertains to the comparison of tool marks enables opinions of common origin to be made when the unique surface contours of two tool marks are in "sufficient agreement".
> [b] This "sufficient agreement" is related to the significant duplication of random tool marks as evidenced by the correspondence of a pattern or combination of patterns of surface contours. Significance is determined by the comparative examination of two or more sets of surface contour patterns comprised of individual peaks, ridges and furrows. Specifically, the relative height or depth, width, curvature and spatial relationship of the individual peaks, ridges and furrows within one set of surface contours are defined and compared to the corresponding features in the second set of surface contours. Agreement is significant when it exceeds the best agreement demonstrated between tool marks known to have been produced by different tools and is consistent with the agreement demonstrated by tool marks known to have been produced by the same tool. The statement that "sufficient agreement" exists between two tool marks means that the agreement is of a quantity and quality that the likelihood another tool could have made the mark is so remote as to be considered a practical impossibility.
> [c] Currently the interpretation of individualization/identification is subjective in nature, founded on scientific principles and based on the examiner's training and experience.[7]

Schwartz identifies three central concerns dealing with the issue of firearms and tool mark identification, characterizing them as "central pitfalls."[8] Rather than "pitfalls" it will be shown that they would be better addressed as critical issues of which conscientious examiners will be aware.

A. Critical Identification Issues Do Not Undermine Its Evidentiary Value in Court

The literature has identified three central identification issues that do not undermine the evidentiary value of firearms and tool marks identification evidence in court because it has been demonstrated that they can be readily identified and addressed in the regular course of a conscientious

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[7] AFTE Criteria for Identification Committee. "Theory of Identification, Range of Striae Comparison Reports and Modified Glossary Definitions – an AFTE Criteria for Identification Committee Report." AFTE Journal, Vol. 24, No. 2, April 1992, 336-340.
[8] *Supra* note 2, at 5.

evidence examination. These issues are the establishment of a criterion for identification, the potential for subclass characteristics, and the change a tool surface undergoes over time.

1. The Criterion for Identification Is Defined In the AFTE Theory of Identification

The AFTE Theory of Identification coupled with the comparative analysis and examination method upon which it is based, along with extensive studies in the literature and the individual training, experience, and expertise of examiners adequately addresses the primary question of the court – was this tool mark produced by this tool? This can routinely be accomplished despite the recognized and established fact that tool marks produced by different tools may display some level of similarity.

Schwartz cites this fact as a pitfall to the issue of identifying two tool marks as produced by the same tool. In doing so, she cites several references but does so in an incomplete manner such that the reader is left with the impression that it is an issue that the discipline has either ignored or produced little answer for. Considering that the criterion for identification is an issue of central concern for the discipline, it would do well to discuss it in its fuller and more complete context.

Schwartz says,

> As a result of the overlapping individual characteristics of toolmarks made by different tools, examiners who assume that a certain amount of resemblance proves that the same tool produced both test and evidence toolmarks may be wrong because the same amount of resemblance may exist in toolmarks produced by different tools of that type.[9]

When making this statement she ignores that this represents only a part of the criterion for identification as specified in the AFTE Theory of Identification. Prior to rendering a call of same source, the examiner must also observe agreement that "is consistent with the agreement demonstrated by tool marks known to have been produced by the same tool."[10]

That trained examiners can distinguish between tool marks made by different tools has been established through controlled studies pursuant to the tenants of the scientific method. These have been summarized elsewhere.[11,12] What the reader should note is that many of these studies were performed using consecutively manufactured tools which by their very nature are expected to contain more similarity than tools manufactured otherwise. These studies do demonstrate that the Theory of Identification is sound and has a scientific basis.

Schwartz highlights several articles to demonstrate the severity of the issue. In doing so, she takes many out of context and relies on secondary resources instead of going to the original. When addressing that there are some identifications that may be missed due to a small sample size, such as a fragment, Schwartz cites a list of questions developed by Murdock as a source. Specifically, she writes,

> *See e.g.*, John E. Murdock…(stating that a "considerable amount of agreement" among striated toolmarks made by different tools is especially likely to be found "if the width of the mark being compared is quite small [say, two millimeters or less]")…[13]

The implication here is clear. If the tool marks are small, on the order of 2mm or less, then one can expect considerable agreement likely leading to false identifications. However, Murdock was a secondary source with regard to this issue of 2mm, not the primary source which he cited as a reference. The primary source of Butcher and Pugh simply set this 2mm size as a standard point for the study that was to be

[9] *Supra* note 2, at 6.
[10] *Supra* note 7.
[11] Nichols, R. "Firearm and Toolmark Identification Criteria: A Review of the Literature." Journal of Forensic Sciences. Vol. 42, No. 3, May, 1997, 466-474.
[12] Nichols, R. "Firearm and Toolmark Identification Criteria: A Review of the Literature – Part 2." Journal of Forensic Sciences. Vol. 48, No. 2, March, 2003, 318-327.
[13] *Supra* note 2, at 6-7, n. 13.

undertaken. At no point did they suggest that there would be a higher likelihood of considerable agreement in marks less than 2mm wide.[14]

Schwartz continues to emphasize the "significance of these problems" by citing statistics from some well known studies in the discipline. She writes,

> The significance of these problems is illustrated by findings that up to 25% of the striae in toolmarks made by different screwdrivers of the same brand matched, while the percentage increased to 28% when comparing toolmarks made by different bolt cutters of the same brand. Similarly, in a classic, statistical empirical study in 1955, Alfred A. Biasotti found that 15 to 20% of the striae on bullets fired from different .38 Special Smith & Wesson revolvers matched. [15]

The review of the primary sources produces a different perspective than that offered by Schwartz. The 25% correspondence was in a single KNM comparison[16], the 28% was the highest of 880 KNM comparisons in which only three approached the figure of 28%[17], and Biasotti found that the percentage of matching lines should not be used as an indicator of same source[18]. If not already aware, the reader should know that because of these issues with the potential for an unusually high percentage of matching lines in a known, non-match situation, the straight percentage of matching lines is not the commonly accepted practice in the relevant scientific field.

Schwartz concludes her argument by citing a "study"[19] by Joseph Masson[20], who happened to be the tool mark expert involved in the aforementioned *United States. v. Kain*. In this discussion the author displays a lack of fuller understanding of the purpose of the IBIS system and how it works. She also highlights the Masson "study" making it look like a treatise on the subject when it is nothing more than a

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[14] *See, e.g.*, Butcher, S. and Pugh, D., "A Study of Marks Made By Bolt Cutters," Journal of the Forensic Science Society, Vol. 15, No. 2, April, 1975, 120 (stating "We set a minimum of 2mm as the extent of the matching area. This limit was chosen mainly as a result of experience. In case work it is occasionally necessary to examine marks less than 2mm wide, but such marks can introduce special problems associated with the number of lines in the pattern. In our experience a mark 2mm wide will normally contain sufficient lines to allow for an accurate assessment of whether test and suspect mark correspond.).

[15] *Supra* note 2, at 7.

[16] *See, e.g.*, Burd, D. and Kirk, P., "Tool Marks: Factors Involved in Their Comparison and Use as Evidence," Journal of Police Science, Vol. 32, No. 6, 1942, 465 (stating "Figure 4 illustrates how greatly two seemingly smooth edges on two tools of standardized manufacture will differ with respect to the marks they produce. Although in a comparison of two marks made by the same edge more than 80% of the lines matched, in *this case* [emphasis added] the percentage of matches is from 20-25%. It becomes immediately obvious that the number of matching lines in itself has no significance since in marks made with different tools one can find a considerable number of chance matches if the total number of lines is high. (A concept extensively detailed in a mathematically modeled study performed by Brackett. *See, e.g.*, Brackett, J. "A Study of Idealized Striated Marks and Their Comparison Using Models." Journal of the Forensic Science Society, Vol. 10, No. 1, Jan. 1970, pp. 27-56. This study, which is vital to a comprehensive understanding of identification criteria, is not cited by Schwartz.) The proportion of matching lines, on the other hand, will never be high unless the contour is very similar which in turn will not happen except when the same tool has been used.")

[17] *Supra* note 14.

[18] *See, e.g.*, Biasotti, A., "A Statistical Study of the Individual Characteristics of Fired Bullets." Journal of Forensic Science, Vol. 4, No. 1, Jan. 1959, 37-39 (stating "it will be seen that the average percent match for bullets fired from the same gun ranged from 36 to 38% for lead bullets and from 21 to 24% for metal-cased bullets. For bullets fired from different guns (not tabulated) 15 to 20% matching lines per land or groove mark was frequently found. Relatively speaking this data indicates that even under such ideal conditions the average percent match for bullets from the same gun is low and the percent match for bullets from different guns is high, which should illustrate the limited value of percent matching lines without regard to consecutiveness.").

[19] *Supra* note 2, at 7.

[20] Masson, J. "Confidence Level Variations in Firearms Identifications Through Computerized Technology." AFTE Journal, Vol. 29, No. 1, Winter 1997, 42-44.

one-page technical note once two photographs and the abstract is removed. In no way is there an attempt to belittle the offering made by Mr. Masson to the scientific community, but to characterize his contribution as a "study," offers it far more credibility than it deserves.

If one were to read Masson's article one will quickly observe that the entire point of the article was to encourage firearms examiners to use IBIS as a tool to gain even more familiarity with known non-match comparisons. As already stressed, such comparisons are vital because it is through these comparisons that firearm and tool mark examiners establish their baseline for their own criterion for identification.

Schwartz mischaracterizes what little was offered. She writes,

> …finding that as the IBIS data base grew for guns of a particular caliber, increasing similarities were discovered in the individual characteristics of tool marks on ammunition components known to have been fired by different guns of that caliber. The similarities between known non-matching tool marks were sometimes *so great* [emphasis added] that even under a comparison microscope, it *was difficult to tell the tool marks apart and not erroneously attribute them to the same gun* [emphasis added].[21]

This statement has great implications. However, it would have been much more accurate to quote Masson in lieu of offering an inaccurate paraphrase. Here is what Masson offered.

> As the database grew within a particular caliber, 9mm for instance, there were a number of known non-matched test fires from different firearms that were coming up near the top of the candidate list. When retrieving these known non-matches on the comparison screen, there were numerous two dimensional similarities. When using a comparison microscope, these similarities are still present and it is difficult to eliminate comparisons even though we know they are from different firearms.[22]

The use of the words, "*so great"* is not supported by Masson's statement. In addition, the author's characterization of Masson's conclusion is not quite what the author said.

As a final statement with regard to this particular issue of IBIS, the system has never been offered as a means of "computerized firearms identification"[23] or as implied by Masson in the title of his article. IBIS is a tool, similar to the AFIS system used by the fingerprint community. This tool is designed to search a database of information and offer the examiner an opportunity to compare two items that may share a common source.

The author uses this opportunity to open discussion about the databases that do and do not exist. She writes that,

> Masson's study implies that, due to the absence of non-firearms toolmark databases and the incomplete databases for firearms toolmarks, misidentifications *are likely to* [emphasis added] result because examiners underestimate the possible similarities between the individual characteristics of toolmarks made by different tools.[24]

A full read of the article will quickly show that Masson never implied any of this statement. Furthermore, only the last part of the statement can be considered true by removing "are likely to" with "can." This paraphrase is the opinion of the author, not supported to any extent by Masson's study. Furthermore, if there is a study showing a direct link between the absence, or incompleteness, of databases and the likelihood of an examiner to underestimate the possible similarities between tools, I have yet to see one.

The issue of identification criteria is a central one for any identification discipline including firearms and tool mark identification. It is expected that tool marks having different origins will have coincident similarity. A multitude of studies in combination with training, education and experience

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[21] *Supra* note 2, at 7-8.
[22] *Supra* note 20, at 42.
[23] *Supra* note 2, at 1.
[24] *Supra* note 2, at 8.

demonstrates that this is not an insurmountable obstacle. Furthermore, the relevant scientific community has developed a theory of identification that deals with this issue in a concise and testable format.

2. The Potential for Subclass Characteristics is Discernible

Knowledge and study of manufacturing processes of tools in combination with the many studies addressing the issue of subclass characteristics assist a trained and qualified examiner to easily discern their potential for interference in comparative casework. Schwartz sums up the potential difficulty very well in the very first sentence in her discussion with regard to the issue of subclass characteristics. She writes, "A tool may also be wrongly identified as the source of a toolmark it did not produce if an examiner confuses subclass characteristics shared by more than one tool with individual characteristics unique to one and only one tool."[25] She continues with an analogy of fingerprints and DNA. However, since neither deals with subclass characteristics in a manner even approaching that of tool mark identification; their inclusion is irrelevant and only muddies the waters.

In her discussion, Schwartz acknowledges that, "…wear and tear on some tools may cause the subclass characteristics on their toolmarks to be completely replaced by individual characteristics…" while warning that "…subclass characteristics may persist alongside individual characteristics."[26] In support of this statement Miller's article[27] is referenced with Schwartz paraphrasing, "…finding both subclass and individual characteristics on the striated toolmarks on both land and groove impressions of bullets fired by used guns."[28] Not offered was Miller's contention that a correct identification of the bullets would not be affected by the presence of subclass characteristics and that it was difficult to find areas where subclass characteristics were even an issue.[29]

Schwartz then goes on to criticize firearm and tool mark examiners for seemingly ignoring this very evident problem.

> Despite their knowledge of this variation, firearms and toolmark examiners have not formulated any generalizations or statistics about which types of tools can be expected to produce toolmarks with subclass or individual characteristics when they are newly manufactured. Nor have they developed statistics or generalizations about the rate(s) at which subclass characteristics on toolmarks produced by various types of tools can be expected to be replaced and/or joined by individual characteristics.
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> Firearms and toolmark examiners have also failed to develop any rules for distinguishing between subclass and individual characteristics. To avoid confusing subclass characteristics shared by more than one tool with individual characteristics unique to one and only one tool, examiners can only rely on their personal familiarity with types of forming and finishing processes and their reflections in toolmarks.[30]

Four charges are leveled against the discipline in the above passage. The first is that no generalizations exist with regard to which types of tools might produce subclass characteristics when newly manufactured. The second is that no statistics or generalizations have been made regarding when subclass characteristics might be replaced or joined by individual characteristics. The third is that rules for

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[25] *Ibid*.
[26] *Supra* note 2, at 9.
[27] Miller, J. "An Examination of the Application of the Conservative Criteria for Identification of Striated Tool Marks Using Bullets Fired From Ten Consecutively Rifled Barrels." AFTE Journal, Vol. 33, No. 2, Spring 2001, 125-132. Schwartz is inaccurate in her reference with regards to volume number for this particular article.
[28] *Supra* note 2, at 9, n. 24.
[29] *See, e.g.*, Miller, J., n. 27, 128 (stating "Although some striae present in the land and groove impressions of the bullets fired from consecutively rifled barrels could be the result of subclass influence, none of these features affected the correct identification of the bullets. None of the areas examined between different bullets were of sufficient quality to lead to a misidentification. In fact, it was difficult to find areas that could be considered as having been produced by a subclass source.").
[30] *Supra* note 2, at 9.

distinguishing between subclass and individual characteristics do not exist. The fourth is that a limitation exists because examiners can only rely on their personal familiarity with finishing processes and how they impact the tool surface. These will be handled in turn.

a. Generalizations Do Exist With Regard to the Potential for Subclass Characteristics on Newly Manufactured Tools

Beginning as early as 1949, there has been recognition of potential subclass issues when comparing tool marks produced by different tools which has resulted in well defined generalizations and applications in comparative casework. Schwartz makes the assertion that we have not, "formulated *any generalizations* [emphasis added] or statistics about which types of tools can be expected to produce toolmarks with subclass or individual characteristics when they are newly manufactured."[31] Miller's article that previously cited by Schwartz contradicts that very statement.[32]

Miller's is not the only article in which subclass issues were identified and connected with the tool working process from which they emanated. In a recent study published in 2004, 19 different references were cited that were of import to the definition, recognition and interpretation of subclass characteristics.[33]

In 1949, Churchman observed subclass characteristics on bullets that had been fired from consecutively made, broach-cut rifled, rifle barrels.[34] In 1975, Skolrood made similar observations when examining three similar barrels though now being manufactured by a company different than when Churchman did his study.[35] Although not designated as subclass characteristics. Lomoro observed "family characteristics" on bullets fired from different guns. This carryover was only on the groove impressions and attributed to a worn or very poor rifling tool used to cut the grooves.[36]

These three studies alone demonstrate how one can move from generalizations to specific application. These three studies linked subclass characteristics on groove impressions with broach or otherwise cut rifling. In cut rifling, the metal of the barrel (grooves only) is cut away by a sharp bladed tool. If the surface of this tool responsible for the cutting has an imperfection it can be transferred to the cut surface. This imperfection can be transferred to the surface of the next barrel in sequence to be cut if the imperfection is durable and does not change. If one were to examine a cast of the bore of a firearm, such characteristics would have to exist for the entire length of the cut surface. If a certain characteristic appeared after the cut surface had already started, then it would be an imperfection caused by the current process. If it disappeared before the end of the cut surface, then it is gone and by definition of its absence cannot be passed onto the next cut surface. Therefore, the only characteristics capable of being defined as subclass would be those that persist for the entire length of the cut surface. In this case we have moved from a generalization to a specific application and understanding of distinguishing between subclass and individual characteristics.[37]

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[31] *Ibid.*

[32] *See, e.g.*, Miller, J., n. 27, 126 (stating, "Many articles and reported studies have shown that subclass characteristics will occur on the groove impressions rather than the land impressions. This is due to the manufacturing process, type of rifling method used, and the steps followed within the manufacturing process after rifling.).

[33] Nichols, R. "Firearm and Tool Mark Identification: The Scientific Reliability and Validity of the AFTE Theory of Identification Discussed Within the Framework of a Study of Ten Consecutively Manufactured Extractors." AFTE Journal, Vol. 36, No. 1, Winter 2004, 67-88.

[34] Churchman, J. "The Reproduction of Characteristics in Signatures of Cooey Rifles." R.C.M.P. Gazette, Vol. 11, No. 5, May 1949, 133-140.

[35] Skolrood, R. "Comparison of Bullets Fired From Consecutively Rifled Cooey .22 Calibre Barrels." Canadian Society of Forensic Science Journal, Vol. 8, No. 2, 1975, 49-52.

[36] Lomoro, V. "Class Characteristics of 32 SWL, F.I.E. Titanic Revolvers." AFTE Journal, Vol. 6, No. 2, April 1974, 18-21.

[37] This is in direct contradiction to the charge made in the third charge to be discussed. In addition, such reasoning extends to all surfaces cut by tools. Whether it is a breech face that was cut with a broach, rifling that was cut with a broach, or the teeth of pliers that were cut by a broach, the principles of metal cutting extend to many different types of tools.

Murdock recognized a significant issue in that some barrels were not formed with a cutting process but a swaging process.[38] In such a process, the barrel is drilled (leaving tool marks perpendicular to the axis of bullet travel) and a button is passed down the barrel. Having a negative impression of the rifling, the button actually pushes metal out of the way, forming the rifling instead of cutting it. Such a process is significantly different than the cutting approach because in a swaging method no metal is removed.

Qualified and trained examiners consider the process. When a button is passed down a barrel, it does so under a tremendous amount of pressure. As such it tends to polish tool marks that are already present (from the drilling process) and not impart any other markings except those that appear as imperfections on the portion of the button itself that comes into actual contact with the bore. This particular issue was observed to be taking place when Matty examined bullets from barrels produced from one button-rifled blank (one long button rifled barrel sectioned into three smaller barrels).[39]

Biasotti addresses both of these general types of rifling methods (cut and swage). He offers reasoning as to why subclass characteristics are not necessarily common and offers some appropriate words of caution to an examiner.[40] In a study of the same broach-cut rifled barrels used by Biasotti in his CMS study[41], Tulleners and Hamiel examined both lead and jacketed bullets specifically for subclass characteristics and found them present on only some barrels and none on land impressions.[42]

In addition to barrels, those parts of the firearm that can come into contact with the cartridge case have also been studied and can be used to aid in our discussion of subclass characteristics. One of the first was a study performed on consecutively manufactured Smith & Wesson firing pins.[43] It was observed that the circumferential tool marks on the surface of the firing pins, caused by their being turned in a lathe, displayed remarkable similarity among the firing pins. As a result, firearm and tool mark examiners are aware that such marks are not wholly reliable for identification to a specific firearm.

Breech face marks can be cut, milled or stamped. In each instance, subclass characteristics may be produced.[44,45,46,47] As a result of such studies, firearm and tool mark examiners are alerted to the

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[38] Murdock, J. "A General Discussion of Gun Barrel Individuality and an Empirical Assessment of the Individuality of Consecutively Button Rifled .22 Caliber Rifle Barrels." AFTE Journal, Vol. 13, No. 3, July 1981, 84-111.

[39] Matty, W. "A Comparison of Three Individual Barrels Produced From One Button Rifled Barrel Blank." AFTE Journal, Vol. 17, No. 3, July 1985, 64-69.

[40] *See, e.g.*, Biasotti, A. "Rifling Methods – A Review and Assessment of the Individual Characteristics Produced." AFTE Journal, Vol. 13, No. 3, July 1981, 34-61 (stating, "Two factors virtually assure that a unique set of individual characteristics will be reproduced in barrels rifled consecutively by the current rifling methods evaluated [hook cutter, scrape cutter, broach cutter, button swage, and hammer swage (forge)]. The first is the random nature and rapidity with which the toolmarks produced by "cut" type rifling methods change within a single barrel, or consecutively rifled barrels. Secondly, the toolmarks remaining in "swage" type rifling are predominately perpendicular to the axis of bullet travel. A possible exception to this generalization is the rare case where barrel blanks, are cut into multiple barrels; or where a swage or broach rifling tool with gross defects is capable of producing axial toolmarks that can be seen to extend the entire length of the bore. This latter case should present a problem to the examiner only where the questioned barrel is not available for examination. In those cases where the barrel is not available for examination, the examiner should use the toolmarks made by the lands or forcing cone to confirm an identification."). This article is accompanied by photographic documentation of various tool marks to be found in rifled barrels.

[41] *Supra* note 18.

[42] Tulleners, F. and Hamiel, J. "Sub Class Characteristics of Sequentially Rifled .38 Special S&W Revolver Barrels." AFTE Journal, Vol. 31, No. 2, Spring 1999, 117 (stating "These subclass characteristics were present on some, but not all of the ten sequential barrels and in some but not all of the groove impressions…These subclass characteristics were not found on the land impressions of the fired lead bullets or on the land or groove impressions of the copper-jacketed bullets.").

[43] Matty, W. and Johnson, T. "A Comparison of Manufacturing Marks on Smith & Wesson Firing Pins." AFTE Journal, Vol. 16, No. 3, July 1984, 51-56.

[44] Lardizabal, P. "Cartridge Case Study of the Heckler and Koch USP." AFTE Journal, Vol. 27, No. 1, Jan. 1995, 49-51.

[45] Thompson, E. "False Breech Face Id's." AFTE Journal, Vol. 28, No. 2, Apr. 1996, 95-96.

generalization that such processes can result in subclass characteristics. Marks, apart from those produced by the manufacturer, are commonly used for identifications for this very reason. In addition, when suspicion of subclass is high and cannot be resolved, examiners will routinely look to other marks, such as chamber marks, that are not as susceptible to subclass influence.

Advances in technology have included the use of computer numerical controlled (CNC) machining for more efficient tooling of various tools, including parts of firearms.[48] Despite observing subclass characteristics on bolt faces that were broach cut through the use of CNC machining, each of the bolt faces was unique enough to permit individualization.[49] In a similar study involving anvil marks on .22 caliber cartridge case rims, the author observed significant subclass characteristics to exist on the breech end (not the bore but the actual rear face of the barrel) on consecutively machined barrels.[50]

Ten consecutively made extractors were recently studied for potential for subclass characteristics.[51] In this study it was observed that there was significant persistence of subclass characteristics on two of the machined surfaces of the extractor. Detailed with photographs, the study demonstrated the importance of not only the presence of subclass characteristics but, also, the importance of understanding how tools and surfaces interact to determine if the subclass characteristics, while present, are even relevant. Specifically,

> Two of the extractor surfaces exhibited significant subclass carryover among all ten extractors. One of the surfaces was on the beveled surface on the forward edge of the extractor hook…. The other surface was on the underside of the hook, limited to the area adjacent to the beveled surface at the base of the channel of the extractor hook…. Yet, results demonstrate that the presence of such subclass characteristics did not have any impact on the ability to distinguish between marks produced by each of the ten extractors. One likely reason is the ridge that is formed on the corners to which these surfaces are adjacent. … they [ridges] protrude away from the flat and beveled surfaces of the hook and are the common result of tooling different surfaces that share a common corner. It is apparent that these ridges are having a significant impact on the tool marks produced by the extractor, *so much so that the issue of significant subclass characteristics is negated* [emphasis added].[52]

Tools other than firearms have also been studied. In 1968, Burd and Kirk demonstrated that if the tips of screwdrivers are not subsequently finished, such as by grinding, then the stamping or die process used to manufacture them could be a source of subclass characteristics.[53] While subclass characteristics

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[46] Matty, W. "Lorcin L9MM and L380 Pistol Breechface Tool Mark Patterns. AFTE Journal, Vol. 31, No. 2, Spring 1999, 134-137.

[47] Lopez, L. and Grew, S. "Consecutively Machined Ruger Bolt Faces." AFTE Journal, Vol. 32, No. 1, Winter 2000, 19-24.

[48] *Supra* note 33, at 74 (stating, [Such machining has] allowed many different tooling operations that might be performed on a single piece by multiple operators to be performed by a single machine equipped with a wide range of various tools operated by a single individual. The concepts of the tooling are the same with the added variable of more precise tool placement from object to object.").

[49] Coffman, B. "Computer Numerical Control (CNC) Production Tooling and Repeatable Characteristics on Ten Remington Model 870 Production Run Breech Bolts." Presented at the 33rd AFTE Annual Training Seminar, San Antonio, TX, May 2002. Also published in AFTE Journal, Vol. 35, No. 1, Winter 2003, 49-54.

[50] Nies, R. "Anvil Marks of the Ruger MKII Target Pistol – An Example of Subclass Characteristics." Presented at the California Association of Criminalists Northern Section Firearm Examiners' Study Group Meeting, Sacramento, CA, Oct. 2001. Also published in AFTE Journal, Vol. 35, No. 1, Winter 2003, 75-78.

[51] *Supra* note 33.

[52] *Supra* note 33, at 74-75.

[53] *Supra* note 16.

were not observed on the teeth of consecutively broach cut pliers, Cassidy observes that in the normal use of the tool at present concern, they would not have been relevant anyway.[54]

In some instances molds are used to produce items of comparative value. In such instances it is important to understand the molding process and how such marks may persist across many items from a single mold[55] or across several molds produced from a single master mold.[56]

It cannot be stressed enough that it is important to not only understand the potential of a tool surface to have subclass characteristics, but, also, the action of the tool on an object. Such sentiments were evident in studies performed by Thompson when dealing with stamped and painted breech faces of Lorcin pistols[57] and Moran when dealing with lips on an ammunition magazine.[58] In this latter article there is detail concerning manufacture, potential for subclass, and potential for transference of such marks to a cartridge case.

In summary, nineteen studies have been offered detailing issues of subclass characteristics from which well-trained and competent firearm and tool mark examiners may draw generalizations regarding the potential for subclass influence on the specific evidence with which he or she is concerned. None of these found reference in Schwartz's article.[59]

b. Rate of Change Regarding When Subclass Characteristics Might be Replaced or Joined by Individual Characteristics is Not Relevant in Practice

Statistics or generalizations about the rate of change regarding when subclass characteristics might be replaced or joined by individual characteristics have not been offered because in conscientious practice, it is not relevant. It has already been demonstrated that there is sufficient literature upon which an examiner can base generalizations about tool working surfaces for their potential for subclass. Then, the potential for transference is assessed based on tool action. If the individual examiner finds that there is potential for the presence and transference of subclass characteristics such features simply should not be exclusively used for individualization to a particular tool. A conscientious examiner should concede the point made by Schwartz, being as conservative as possible, and not consider the possibility that subclass characteristics may have changed. Instead, individualizations to a particular tool will be made on other features that the examiner is confident do not include subclass characteristics.

c. Rules for Distinguishing Between Subclass and Individual Characteristics Do Exist

There exists a tremendous amount of background and literature upon which examiners routinely rely to assess surfaces for the purpose of distinguishing between subclass and individual characteristics. One need only examine many of the aforementioned articles detailing the issue of subclass characteristics to discover this. Therefore, the third charge leveled at the discipline, "Firearms and toolmark examiners have also failed to develop any rules for distinguishing between subclass and class characteristics"[60] is simply not true.

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[54] Cassidy, F. "Examination of Tool Marks from Sequentially Manufactured Tongue and Groove Pliers." Journal of Forensic Science, Vol. 25, No. 4, Oct. 1980, 796-809.
[55] Kreiser, J. "Identification of Cast Bullets and Their Molds." AFTE Journal, Vol. 17, No. 3, July 1985, 88-90.
[56] Miller, J. "An Introduction to the Forensic Examination of Tool Marks." AFTE Journal, Vol. 33, No. 3, Summer 2001, 233-248. See also Nichols, R. *supra* note 33, at 74 (characterizing this article by Miller as, "…one of the best general articles written in this regard, Miller discusses metallurgy, various tool manufacturing processes, basic tool types and their specific means of manufacture, and the tool marks typical of such tools. With respect to subclass characteristics, Miller emphasizes that they can exist over generations of tools. He suggests that a mold with an imperfection that is reproduced on multiple tools could have been the result of an imperfection on a master mold that was reproduced on multiple molds.").
[57] Thompson, E. "Individual Characteristics Criteria." AFTE Journal, Vol. 30, No. 2, April 1998, 276-279.
[58] Moran, B. "The Application of Numerical Criteria for Identification in Casework Involving Magazine Marks and Land Impressions." AFTE Journal, Vol. 33, No. 1, Winter 2001, 41-46.
[59] That she was aware of at least some is evident. *Supra* note 6. Also, many of the primary sources were identified in the various secondary resources upon which Schwartz relied for the defense of her thesis.
[60] *Supra* note 2, at 9.

Most specifically, Tulleners and Hamiel provided such direction in their article, citing a letter from Biasotti who wrote,

> That the occurrence of subclass characteristics in rifled firearm barrels is a rare event that can be easily determined by direct inspection of the rifling or a barrel cast; and where the barrel or barrel cast is not available, by applying a more conservative criteria in determining common origin.[61]

d. Examiners Must be Knowledgeable with Tool Finishing Processes and Their Effects

Examiners must be knowledgeable with regard to tool finishing processes and their effects on the resultant tool surfaces and the wealth of published information and studies helps to fulfill this requirement. Therefore, the fourth charge is that "examiners can only rely on their personal familiarity with types of forming and finishing processes and their reflections in toolmarks"[62] is only partially true. As has just been demonstrated through the extensive reliance on resources and other references in the literature, there is much for the examiner to reply upon.

Furthermore, there is not one conscientious firearms and tool mark examiner who would suggest that personal familiarity with tool finishing processes and their effects on tool surfaces is anything but vital to the proper understanding of subclass characteristics. Without such knowledge and appreciation of manufacturing techniques examiners would have no way of ascertaining if subclass characteristics could exist. With such knowledge, examiners can articulate that they do (if they do), how they are formed, and the relevance of them for this particular case at hand.

A review of the remainder of Schwartz's argument with regard to subclass characteristics finds references that were inaccurately paraphrased. This includes discussion of why the AFTE formed the Criteria for Identification Committee[63], proficiency testing results published by Collaborative Testing Services (CTS)[64], and a review article by Eckerman[65]. Schwartz also cites Biasotti and Murdock in which

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[61] *Supra* note 42, at 121.

[62] *Supra* note 2, at 9.

[63] Citing Bruce Moran's work in footnote 29 on page 10 (Moran, B. "A Report on the AFTE Theory of Identification and Range of Conclusions for Tool Mark Identification and Resulting Approaches to Casework." AFTE Journal Vol. 34, No. 2, pp. 227-235.) Schwartz writes, "The danger is that misidentifications will result from confusing subclass with individual characteristics is real, not theoretical. In the 1980's this type of confusion was discovered to have produced misidentifications of striated toolmarks. In response, members of the Association of Firearms and Toolmark Examiners ("AFTE") formed the Criteria for Identification Committee." (*Supra* note 2, at 10.) A review of Moran's work demonstrates that the paraphrase was inaccurate. Reading Moran's review of the history, the reason for the formation of the committee was given as well as the recognition that misidentifications were the reason. Whether those misidentifications were due to subclass is not known based on Moran's work. Specifically, Moran writes, "In the 1980's some striated toolmark mis-identifications resulting from a poor understanding of toolmark criteria for identification were experienced. An increasing need to address problems of applying subjective criteria became apparent. As a result of this need, a group of AFTE members formed the Criteria for Identification Committee (CFID Committee) in 1985 to investigate the problems and find solutions" (Moran, at 227).

[64] *Supra* note 2, at 10. Specifically, "Invoking laboratory policy that identifications cannot be reached unless the suspect firearm is examined to eliminate the possibility of subclass characteristics, test takers have refused to make identifications in the absence of a gun." Reviewing the tests cited by Schwartz (CTS Test Reports for Test Numbers 03-526 and 03-527), nowhere in the additional comments does it state that an individual invoked laboratory policy. The closest to this is when CTS made this assumption in their own summary of conclusions, "Many of the latter responses [concluding inconclusive results when the actual evidence was fired in different weapons] may be due to laboratory policy requiring the actual firearm and some history before reporting an elimination." (CTS, Inc. "Firearms Examination Test No. 03-526 Summary Report," 3 at http://www.collaborativetesting.com/reports/2326_web.pdf last visited June 21, 2005). Again, this was an assumption by CTS. Not only that, it dealt with the issue of eliminations, not

they discuss that the goals and concerns of tool manufacturers are not necessarily always in line with our desire to see individual marks.[66] Not offered was the cautionary conclusion that Biasotti and Murdock drew from this observation when they wrote, "[As a result] The firearms and toolmark examiner must be alert to the possibility that evidence toolmarks may have been produced by a tool working surface having subclass characteristics."[67]

The author discusses a very legitimate concern of the firearms and tool mark identification discipline, that of subclass characteristics. However, unlike the impression with which Schwartz leaves the reader, there is a vast amount of literature dealing with this very issue. Furthermore, firearm and tool mark examiners are very aware of the issue and are in a position to evaluate submitted evidence for the potential of subclass characteristics. Finally, they are also in a position to evaluate the specific action of the tool on the substrate to determine the relevance of any subclass characteristics that *may* be present.

3. Changes of Characteristics on Tool Surfaces Does Not Render Firearms and Tool Mark Identification Impotent

It is important to understand that it has never been asserted that characteristics on tool working surfaces would not change and that this change does not necessarily negate the potential for a qualified examiner to examine two tool marks and determine that they were produced by the same source. Schwartz asserts otherwise, citing this fact as a "barrier in the way of firearms and toolmark identification's goal of individualization."[68] Others have expressed similar concerns.[69]

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subclass characteristics. In a review of the published comments made by laboratories in that specific test, the issue of subclass characteristics was mentioned. Comments included, "A cast of the firearm's breech face would have been taken to rule out any sub-class characteristics from the similar ammunition used for tests in this comparison." In addition, another reported "I would want to examine the tool working surfaces of the firearms in order to eliminate the possibility of subclass carryover." Comments made in the second of the tests offered by Schwartz included this mention of subclass characteristics, "Subclass characteristics in the GEA's are ruled out." (CTS, Inc. "Firearms Examination Test No. 03-527 Summary Report," 35 at http://www.collaborativetesting.com/reports/2327_web.pdf last visited June 21, 2005). The final results of these proficiency tests might also be of interest to the reader. In CTS Test 03-526 there were no misidentifications out of a total of 246 responses that associated a cartridge case as having been fired from a firearm from which it was not fired. In CTS Test 03-527 there were 4 misidentifications, wrongly identifying a bullet as having been fired from a particular firearm when in fact it was not. This was from a response base of 116 where the general feedback regarding the test as being very difficult and that the actual firearm was strongly desired.

[65] *Supra* note 2, at 11. Schwartz writes, "Changes in manufacturing processes *are likely* [emphasis added] to increase the risk of misidentifications resulting from the confusion of subclass with individual characteristics." As support for this statement she references and quotes Eckerman's article, quoting directly that, "[a]s tool manufacturers minimize the steps necessary to produce tools in an effort to become more efficient and economical, the possibility for tools produced with similar characteristics increases." (Eckerman, S. "A Study of Consecutively Manufactured Chisels." AFTE Journal, Vol. 34, No. 4, Fall 2002, 379.) A review of Eckerman's article clearly demonstrates that this statement was made in the introduction part of her report, in the context of developing a hypothesis to be tested. Eckerman also said (on the very same page that this statement can be found) that, "Results showed that each ground chisel produced individual and identifying characteristics, and that there was no carry-over of features due to the finishing process between consecutively finished tools. Consecutively forged and trimmed tools did possess similar features *prior* [emphasis added because in casework we are dealing with finished tools] to a grinding step." (Eckerman, 379)

[66] Supra note 2, at 11, n. 33.

[67] Biasotti, A.A., Murdock, J. "Firearms and Tool Mark Identification." In: Faigman, D.L., Kaye, D.K., Saks, M.J., Sanders, J., editors. Modern Scientific Evidence: The Law and Science of Expert Testimony, Volume 3. St. Paul: West, 2002, 501.

[68] *Supra* note 2, at 11.

[69] Griffin, J. and LaMagna, D, "*Daubert* Challenges to Forensic Evidence: Ballistics Next on the Firing Line," The Champion, September/October 2002, 20 (stating "Unlike DNA or fingerprints, markings left by an individual gun on ammunition fired through it are neither unique nor permanent.").

The surface of a tool will change over time but, it is important to understand that this does not make identification unreliable. This is true for two reasons. The first is that it is through use that a tool will continue to acquire individual characteristics that are vital to the comparative identification process. It has been established that under most circumstances even consecutively made tool marks will not produce identical marks. Yet, there will be sufficient similarity such that the similarity would not be confused with that expected in a known non-match situation. That is why the conscientious examiner will examine a multitude of tool marks, made by different and the same tools, to develop a criterion for identification as specified in the aforementioned AFTE Theory of Identification. This theory accounts for these differences as do the many studies that affirm the scientific reliability of firearm and tool mark identification.

The second is that were the change of a tool surface so rapid as to change from mark to mark (or bullet to bullet) then attempts at identification would be pointless. However, aside from possibly the first series of bullets fired from a newly manufactured barrel, published studies have shown otherwise.

Hamby test fired 501 bullets in a 5.56 NATO caliber, M16A1 military rifle. [70] Approximately 40,000 other rounds had been previously fired through this barrel. Every effort to make the conditions as deleterious as possible including test firing as rapidly as possible. The first bullet and every hundredth after that was collected for comparison. Although some differences were observed there was sufficient similarity of individual markings to permit a conclusion that the first and last bullets were fired in the same firearm.

Biasotti performed a limited study that examined the effects of lead build-up in a .22 caliber barrel.[71] He demonstrated that lead buildup in a barrel from successive fires of lead bullets can cause markings to change such that cleaning of the barrel with a solvent and brush may be necessary to remove the deleterious effect of the leading. He concluded that the best reproducibility was between bullets fired with similar bore conditions.

Shem and Striupaitis performed a study of 501 test fires from a Raven, .25 Auto caliber, semi-automatic pistol.[72] The first and every tenth set of test fires were recovered with comparison between the first and every fiftieth set of test fires. A gradual change of the individual characteristics on the bullets was observed. However, it was still possible to conclude that the first and last bullets were fired from the same firearm. With regard to the cartridge cases, the individual markings within the breech face markings were sufficient to permit a conclusion that the first and last test fired cartridge cases were fired in the same firearm.

In a study similar to Biasotti's, Kirby examined the effect of firing 900 cartridges from a .455 caliber Smith & Wesson revolver on individual markings produced on cartridge cases and bullets.[73] Lead bullets were fired through the barrel and the firearm was not cleaned during the test. With regard to the cartridge cases, firing pin impressions and breech face markings on the first and last test fired cartridge cases showed no significant difference, such that it could be concluded that each was fired in the same firearm. The bullets revealed a different situation. The author found no difficulty in determining that the first and twenty-fifth bullets were fired in the same firearm. Indeed, some differences were being noted by the fiftieth test fired bullet but the coarser individual striations showed little to no change. Twenty-five bullets later it could not be concluded that the first and 75th bullets fired were fired from the same gun. There was some similarity, but it was insufficient for an unequivocal identification. Further testing showed that test fired bullets #125 and #150 showed sufficient similarity to conclude that they were fired in the same firearm. It is apparent that the continual firing of lead bullets without cleaning has a deleterious effect on the bore condition. This has been well established in the literature prior to this study. However, like Biasotti's study, those bullets fired with similar bore conditions could be compared and a conclusion reached that they were fired from the same firearm.

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[70] Hamby, J. "Identification of Projectiles." AFTE Journal, Vol. 6, No. 5/6, Oct. and Dec. 1974, 22.

[71] Biasotti, A. "Bullet Bearing Surface Composition and Rifling (Bore) Conditions as Variables in the Reproduction of Individual Characteristics on Fired Bullets." AFTE Journal, Vol. 13, No. 2, April 1981, 94-102.

[72] Shem, R. and Striupaitis, P. "Comparison of 501 Consecutively Fired Bullets and Cartridge Cases From a .25 Caliber Raven Pistol." AFTE Journal, Vol. 15, No. 3, July 1983, 109-112.

[73] Kirby, S. "Comparison of 900 Consecutively Fired Bullets and Cartridge Cases From a .455 Caliber S&W Revolver." AFTE Journal, Vol. 15, No. 3, July 1983, 113-126.

In 1983, several authors collaborated on a study of 5,000 full metal jacketed, .45 ACP caliber bullets fired from a M1911A1 semi-automatic pistol.[74] Every tenth test fired bullet and cartridge case was recovered for comparison. With regard to the test fired cartridge cases, the breech face marks showed no significant change with slight form variations of the firing pin and extractor. They observed that the ejector marks changed at a relatively rapid rate. With regard to bullets, it was observed that while some land impressions showed a faster relative change of some individual markings than others, a conclusion that the two bullets were fired from the same firearm was possible through all 5,000 test fired bullets.

Interested in ejector marks, Schecter and colleagues performed a study in which they fired 7,100 cartridges in a 5.56x45mm Galil rifle.[75] They observed change within the first several test fires, but once the ejector had seemingly stabilized, the ejector marks on test fired cartridge cases 9 and 7060 showed sufficient individual similarity to permit a conclusion that the same ejector was responsible for producing the mark.

Most recently, Doelling reported on the persistence of individual markings over the course of 4000 test-fired bullets.[76] He was able to determine that the first and last test-fired bullets could be identified as having been fired from the same firearm.

Hall also addressed this issue when he desired to determine the persistence of tool marks produced by bolt cutters.[77] When the marks were produced in lead, Hall saw no difference in marks produced by any of the bolt cutters to a maximum of 25 cuts. This was the maximum number of cuts produced. He did notice a difference in markings when the bolt cutters were used to cut lock shackles, but he indicated that this appeared to be more of an issue of the shackle hardness creating reproducibility problems.

In summarizing her concern with regard to the permanence of tool marks, Schwartz writes,

> As a consequence of the impermanence of toolmarks, differences between evidence and test toolmarks will sometimes be correctly attributed to changes in the surfaces of the suspect tool between the time the evidence and test toolmarks were made. At other times, such an attribution will be wrong; the evidence and test toolmarks differ because the source of the evidence mark was a tool similar, but not identical to the suspect tool.[78]

It would have bee more accurate to state that, "as a consequence of the impermanence of tool marks, differences between evidence and test tool marks *will exist*" and end the sentence at that point. The rest of the concern is dealt with in the AFTE Theory of Identification where the examiner is exhorted to be mindful of the significance of the combination of differences *and* similarities.

It is recognized that a tool surface will change over time. However, the suggestion that individualization to a specific tool is therefore invalid is not an appropriate extension of the concern. The issue has been recognized and studied within the discipline. There will be differences in individual detail from mark to mark produced by the same tool. But, the change is neither rapid enough to devalue firearms and tool marks as an identification science, nor is it necessarily significant enough such that an identification criteria based on similarities cannot be established. Furthermore, the worst possible scenario is that a particular mark will not be able to be associated with the tool from which it was made because the working surface of the tool has changed thereby not permitting identification.[79]

This concludes a review of three very critical issues specifically dealing with the value of firearms and tool mark identification as an identification science. Schwartz refers to these issues as "central pitfalls

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[74] Ogihara, Y., Kubota, M., Sanada, M., Fukuda, K., Uchiyama, T., and Hamby, J. "Comparison of 5000 Consecutively Fired Bullets and Cartridge Cases From a .45 Caliber M1911A1 Pistol." AFTE Journal, Vol. 15, No. 3, July 1983, 127-140.

[75] Schecter, B., Silverwater, H., and Etzion, M. "Extended Firing of a Galil Assault Rifle." AFTE Journal, Vol. 24, No. 1, Jan. 1992, 37-45.

[76] Dolleing, B. "Comparison of 4000 Consecutively Fired, Steel-Jacketed Bullets." Presented at the 53rd Annual AAFS Seminar, Seattle, WA, February 2001.

[77] Hall, J. "Consecutive Cuts by Bolt Cutters and Their Effect on Identification." AFTE Journal, Vol. 24, No. 3, July 1992, 260-272.

[78] *Supra* note 2, at 12.

[79] *Supra* note 33, at 77.

in firearms and toolmark identification."[80] Her argument is unrepresentative of the available literature published by the relevant scientific community. Furthermore, based on a review of that literature her claims are found to lack general support. While some legitimate questions were posed with respect to uniqueness of tool marks, her answers to those questions were not credible.

B. The Scientific Basis for Firearms and Tool Mark Identification Has Been Validated

As the preceding discussion has highlighted the primary question of firearms and tool mark examiners of whether it possible to distinguish between tool marks produced by different tools has been empirically tested and validated. It is possible. There are some difficulties discussed. Rather than being insurmountable obstacles discipline wide, they have been shown to limit a conscientious examiner's ability in some instances to make a determination whether two marks were or were not produced by the same tool. An example is subclass characteristics. At times they may be a very significant issue. Most times, they are not. The studies have demonstrated that.

Schwartz claims that it is necessary to have empirical statistical foundations, drawing once again on the DNA analogy. Her claim is lack of an adequate database in part disqualifies all firearm and tool mark evidence from being held admissible. If she is relying on her analogy as a basis for support then it rapidly disintegrates when one understands irreconcilable differences between the two disciplines.

The first is that firearms and tool mark identification relies on individual marks to render the final conclusion. However, "DNA identification as practiced worldwide relies entirely on subclass characteristics – a small number of discrete marks at a small number of fixed locations."[81] Statistics are inherently necessary for DNA identification because there has to be some way of determining the frequency with which a combination of subclass characteristics will exists within the population. Not so for firearms and tool mark identification.

In addition, her argument throughout this section lacks coherency. It draws heavily on a discussion of consecutive matching striations (CMS) as an alternative comparative method to a traditional pattern matching method when such a dichotomy does not even exist. It will be important to discuss many of Schwartz's points because in making them she errs critically in a fuller understanding of the issues at hand, severely mischaracterizes the available literature, and neglects a good portion of available published literature.

That being said, it is important not to be neglectful of a very good question. That question is whether statistics have a potential role in the discipline and if so, in what form should those take. Such a question is healthy for the discipline to consider and a discussion of such consideration will be offered.

1. The AFTE Theory of Identification Does Not Support Claims of Absolute Individualization

Despite claims by prominent practitioners that individualization is not an unreasonable extension of the discipline the AFTE Theory of Identification does not make claims of absolute individualization. Schwartz claims otherwise. In the introduction of her article she writes,

> The expert testimony in the case, *United States v. Kain*, was *typical* [emphasis added] of that offered by firearms and toolmark examiners. The goal of the forensic science discipline of firearms and toolmark identifications is to identify particular tools, such as a

[80] Supra note 2, at 5.

[81] Gutkowski, S. "A Response to: A Systematic Challenge to the Reliability and Admissibility of Firearms and Toolmark Identification, a recently published article by Adina Schwartz." *The Forensic* Bulletin, Winter, 2005, 23. Gutkowski goes on to say that "Schwartz uses DNA as an example of the right way to establish the empirical statistical base. As mentioned above this demonstrates a lack of understanding of DNA typing as being the analysis of ethnically biased assortment of a limited number of sub-class characteristics in which individuality is not a property of the characteristics being typed…On the other hand FATM [firearm and tool mark] identification is based on random individual characteristics superimposed on sub-class and class characteristics so individualisation [sic] is to be expected. The DNA experience is irrelevant to pattern matching using individual characteristics in areas such as fingerprints, FATM, documents and hair morphology."

> bolt cutter or the barrel of a particular gun, as the unique source of marks on crime scene evidence, such as a fence or a fired bullet.[82]

The AFTE Theory of Identification, a statement of the relevant scientific community, does not make a claim of absoluteness. As mentioned, at no point did Schwartz quote or even paraphrase this critically important statement. The AFTE Theory of Identification states, "The statement that "sufficient agreement" exists between the two toolmarks means that the likelihood another tool could have made the mark is so remote as to be considered a practical impossibility."[83] This is not a statement of absoluteness.

She also mischaracterizes the role of the AFTE and current practice within the discipline. She states that,

> The denial of the need to determine the statistical significance of "matches" is implicit in the restrictions that the Association of Firearms and Toolmark Examiners has set on examiners' conclusions. In accordance with the AFTE Range of Conclusions, examiners in the United States may only (1) identify a particular tool as *the* source of the toolmark(s) found on an object; (2) eliminate a particular tool as *the* source; (3) conclude that the comparison of test and evidence toolmarks is inconclusive, or (4) conclude that the evidence toolmark is unsuitable for comparison. [Emphasis is the author's][84]

AFTE does offer a Range of Conclusions based on the AFTE Theory of Identification.[85] However, unlike what Schwartz implied to the reader this range is "encouraged" and not "required." The actual statement of conclusions is based in individual laboratory policy which may or may not choose to accept the AFTE model. To suggest that examiners in the United States are under these restrictions implies that there is a distinct difference in what other nations offer. Quite the contrary as AFTE is an international organization in which there are members from various countries in Europe, Africa, The Middle East, Asia, Australia, New Zealand, Northern America, and Southern America. This encouragement is expressed to all examiners, worldwide. Finally, the language of how identifications are defined is in line with the AFTE Theory of Identification in which there is no claim of absoluteness. Therefore, the implication that the range of conclusions has examiners identifying "the" tool is a mischaracterization.

Despite the official published position of the AFTE, Schwartz's point that testimony of firearm and tool mark examiners is *typical* in that claims of absolute identity are made cannot be denied. For purposes of clarity, examiners should communicate that conclusions of identity are reached because the chances of another tool producing the same mark are so remote that for practical purposes it can be ignored.[86]

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[82] *Supra* note 2, at 2.

[83] AFTE Glossary. "Theory of Identification as it Relates to Toolmarks." AFTE Journal, Vol. 30, No. 1, Winter 1998, 86.

[84] *Supra* note 2, at 13.

[85] *Supra* note 83 (stating "The examiner is encouraged to report the objective observations that support the findings of toolmark examinations. The examiner should be conservative when reporting the significance of these observations. 1. IDENTIFICATION – Agreement of a combination of individual characteristics and all discernible class characteristics where the extent of agreement exceeds that which can occur in the comparison of toolmarks made by different tools and is consistent with the agreement demonstrated by toolmarks known to have been produced by the same tool. 2. INCONCLUSIVE – A. Some agreement of individual characteristics and all discernible class characteristics, but insufficient for an identification. B. Agreement of all discernible class characteristics without agreement or disagreement of individual characteristics due to an absence, insufficiency, or lack of reproducibility. C. Agreement of all discernible class characteristics and disagreement of individual characteristics, but insufficient for elimination. 3. ELIMINATION – Significant disagreement of all discernible class characteristics and/or individual characteristics. 4.UNSUITABLE – Unsuitable for microscopic comparison."

[86] Schwartz writes, "Firearms and toolmark examiners' absolute identity conclusions cannot be excused on the ground they are convenient shorthand for well-grounded probabilistic conclusions." (*Supra* note 1, at 13.) This author would agree in that language that does not offer the full meaning and intent of the AFTE Theory of Identification is not appropriate.

The issue at the root of this is not a new one. Kirk recognized this question of absolute identity versus practical identity as a source of much "quibbling of attorneys with expert witnesses."[87] Emphasizing this distinction and the importance of clear articulation, Kirk writes,

> In all matters involved in the examination and interpretation of physical evidence, the term *identity must be understood to signify practical and determinable identity only.* If necessary, the witness must be very willing to admit that he has not and cannot ever establish absolute identity, and in fact there is no such thing when applied to tangible objects.[88]

Furthermore, Kirk cautions that "accurate identification must rest on a proper basis of training, experience, technical knowledge and skill and an understanding of the fundamental nature of identity itself. It should not be attempted without this kind of background, either by the police officer or the amateur."[89]

In 1991, David Stoney discussed this concept as being analogous to a "leap of faith"[90] when addressing statistics in the framework of fingerprints and (at the time) newly emergent DNA analysis. Despite her repetitive analogies and contrasts with fingerprints and DNA and her concern in this section with statistics and absolute identifications, Schwartz makes no reference of Stoney's work, which focuses on this very issue.

Stoney's claim was that we move from a subjective interpretation of the observed characteristics (in Stoney's example, it was fingerprints) and declare an absolute identity. Stoney writes,

> The conclusions [of a fingerprint examiner] are accepted and supported as subjective; very convincing, undoubtedly valid, but subjective. In fingerprint comparisons, the examiner notes the details in the patterns of the ridges. Beginning with a reference point in one pattern, a corresponding point in a second pattern is sought. From this initial point the examiner then seeks neighboring details that correspond in their form, position, and orientation. These features have an extreme variability that is readily appreciated intuitively, and which becomes objectively obvious upon detailed study. When more and more corresponding features are found between two patterns, scientist and lay person alike become subjectively certain that the patterns could not be possibly duplicated by chance. What has happened here is somewhat analogous to a leap of faith. It is a jump, an extrapolation, based on the observation of highly variable traits among a few characteristics, and then considering the case of many characteristics. Duplication is inconceivable to the rational mind and we conclude that there is an absolute identity.[91]

Stoney moves on to suggest that trying to "prove uniqueness" is a "ridiculous notion."[92] Using the discipline of fingerprints he comments, "We hold fingerprint specificity and individuality up as our ideal, yet this is achieved only through a subjective process. In fingerprint work, we become subjectively convinced of identity; we do not prove it. And this works just fine. For fingerprints [contrasted with DNA]."[93] He then concludes by saying, "Even without theoretical models and statistics, we can, and do,

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[87] Kirk, P. *Crime Investigation*. New York: Interscience Publishers, 1953, 14. He goes on to say that, "Any attorney can state that two objects are not identical and be correct in the absolute sense, even though the identity is overwhelmingly positive from the practical standpoint of origin. The expert witness will be well advised to admit without argument that no two objects are ever completely identical, but he should at the same time be very certain of his ground as to what constitutes a sufficient identity for practical use."
[88] *Supra* note 87, at 16.
[89] *Supra* note 87, at 17.
[90] Stoney, D. "What Made Us Think We Could Individualize Using Statistics?" Journal of the Forensic Science Society. Vol. 31, No. 2, April/June, 1991, 198.
[91] *Supra* note 90, at 197-198.
[92] *Supra* note 90, at 198.
[93] *Ibid.*

make absolute identifications. We can apply scientific, critical judgment, expert and informed, to make the subjective determination of identity (or less absolutely, of 'very very rare').[94]

Schwartz claims that in *typical* testimony of firearm and tool mark examiners, claims of absolute identity are made. Inherent in this is a recognition (on the part of a *typically* trained firearm and tool mark examiner) that should be readily admitted, that not every tool in the world has ever been examined by a particular examiner nor would there ever be an opportunity to do so. However, the examiner is confident that such a claim could be made based on his or her training, experience, and the wealth of literature that is available.

2. Consecutive Matching Striations is a Means to Articulate Observed Striated Pattern Agreement

Recent literature has helped to clear up an early misconception within the discipline that consecutive matching striations (CMS) and the traditional pattern matching approaches were different methods of comparative examination – they are not. CMS is simply a convenient way to communicate with other examiners the extent of agreement being observed in a striated tool mark comparison.[95] Schwartz, however, does not recognize this in her argument.

Schwartz has linked the traditional approach of firearm and tool mark examiners as being "subjective" and the CMS approach as being more "objective."[96] Dealing with the issue of objectivity and subjectivity within the firearms and tool mark discipline, it is important to understand the basic process of comparison. A comparative examination is a process in which a firearm and tool mark examiner compares two items, makes observations regarding similarities and differences, and then draws an interpretation (conclusion) based on observations.

Webster's dictionary defines objective as, "publicly or intersubjectively observable or verifiable esp. by scientific methods…of such nature that rational minds agree in holding it real or true or valid…perceptible to the senses or derived from sense perception."[97] In a situation where two patterns are being compared, as in a firearm and tool mark situation, the examiner assesses the relative position, placement, and size of certain characteristics. For example, an examiner may declare two striations to correspond when they are present in the same relative location from the leading edge, have the same relative width, and the same relative height.[98] All of these are objective observations as another equally well-trained examiner could look at the same two marks and make similar observations.[99]

The fact that, aside from using numbers, it may not be easy to communicate does not make the observations any less objective. For example, if two individuals were to go outside on a cloudless day and observe that the sky is blue, that is an objective observation. Just because it is not particularly easy to describe the color blue does not make the observation any less objective.

This is where the concept of consecutive matching striations is helpful. It is a means of describing the pattern that one is observing. That's it. The issue of subjectivity enters the discussion because it is the actual interpretation of the significance of the culmination of objective observations that is subjective. The individual examiner then compares this collection of objective observations with past training, knowledge

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[94] *Supra* note 90, at 199.

[95] In a necessarily simplified explanation, a striated tool mark can be thought of as a series of horizontal lines having different widths and spacing (in a two dimension environment). When comparing two such marks some examiners find it convenient to say that they observe agreement of some of the pattern. Examiners who utilize CMS find it convenient to articulate the agreement in terms of the number of lines that match consecutively, without interruption. CMS is therefore a means of describing what one is observing. There are other ways in which this can be accomplished such as through a well articulated written description or more simply through photography.

[96] *Supra* note 2, at 14-15.

[97] Gove, P.B., Editor-in-Chief. *Webster's Third New International Dictionary of the English Language Unabridged.* Springfield: Merriam-Webster, 1993.

[98] *Supra* note 7, at 337 (where the AFTE Theory of Identification specifies these quite clearly stating "Specifically, the relative height or depth, width, curvature and spatial relationship of the individual peaks, ridges and furrows within one set of surface contours are defined and compared to the corresponding features in the second set of surface contours.").

[99] That they are, 1) "publicly or intersubjectively observable or verifiable," 2) "of such nature that rational [equally trained] minds agree in holding it real or true or valid," and 3) "perceptible to the human senses…"

(including available literature[100]), and experience to determine whether it meets the criteria as set forth in the AFTE Theory of Identification.

In 1997, Biasotti and Murdock first presented their conservative minimum quantitative criteria for identification in CMS language, which reads as follows

> In three dimensional tool marks when at least two different groups of at least three consecutive matching striae appear in the same relative position, or one group of six consecutive matching striae are in agreement in an evidence tool mark compared to a test tool mark. In two dimensional tool marks when at least two groups of at least five consecutive matching striae appear in the same relative position, or one group of eight consecutive matching striae are in agreement in an evidence tool mark compared to a test tool mark. For these criteria to apply, however, the possibility of subclass characteristics must be ruled out.[101]

Based on the previous discussion it can be readily discerned that their language simply communicates the correspondence necessary to exceed the best known non-match as specified in the AFTE Theory of Identification. Several studies have examined the appropriateness of these quantitative criteria and with a combined population total of over 6,000 known non-match comparisons (including both two dimensional and three dimensional tool marks), not one time would there have been a false inclusion based on the criteria offered by Biasotti and Murdock.[102]

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[100] See, e.g., Nichols, R. "Consecutive Matching Striations (CMS): Its Definition, Study and Application in the Discipline of Firearms and Tool Mark Identification." AFTE Journal, Vol. 35, No. 3, Summer 2003, pp. 298-306 (stating "Unlike the impression some may have given with regards to CMS, this author has not contended that CMS is either a more objective or a more scientific process than the traditional pattern matching approach. However, it must be remembered that two things need to be defended. The first is the validity of firearms and tool mark identification as a science. This is easily supported using the plethora of articles that have been published through the history of the discipline whether they deal directly with CMS or not. The second issue that needs to be defended is the validity of the individual examiner's criterion for identification. In support of this, a traditional pattern matcher is unable to rely on those non-CMS studies performed by others because those studies do not communicate a criterion for identification in a manner that can be visualized by others unless the work is repeated. Therefore, when asked what one's identification criterion is, the answer has to be based in one's own training and experience. Whether one cares to admit it or not, this sounds extremely subjective to a lay juror or judge because they do not see any sort of standard except one's own personal training and experience. However, an examiner who utilizes the CMS regime can rely on numerous studies that have been performed to show that the criterion for identification is supported by the work of others and is not based solely in his or her own training and experience. Whether one cares to admit it or not, this does have a more "objective" implication to the lay juror or judge."). Schwartz made reference to this article, though not in this context (*supra* note 1, at 15, n. 52). Addressing similar concerns, Schwartz cites an earlier work (*supra* note 11) as support for her statement, "emphasizing that articles that do not explain why an examiner concluded that a particular tool was the unique source of a questioned toolmark, but instead include only subjective comparisons of toolmarks, are 'very difficult for other examiners to utilize.'" (*Supra* note 2, at 15, n. 50.) That very same reference Schwartz used to support her contention also reported, "Not all [34 summarized studies] have generated quantifiable numbers which those in the legal field inextricably link to scientific progress. However, as was discussed in the early part of this article, all of these appear to be based at least in part on the scientific method which tests hypotheses by experimenting and making observations. ..Certainly though, part of the problem stems from the way this material is presented (or not presented) in courts of law. It is incumbent upon qualified examiners to know their field and know it well. Bad and ill-prepared examiners do not mean the science is bad, it just means they are bad and ill-prepared examiners." (*Supra* note 11, at 473.)

[101] Biasotti, A.A., Murdock, J. "Firearms and Tool Mark Identification." In: Faigman, D.L., Kaye, D.K., Saks, M.J., Sanders, J., editors. Modern Scientific Evidence: The Law and Science of Expert Testimony, Volume 3. St. Paul: West, 2002.

[102] *Supra* note 33, at 84-85.

Schwartz highlights three concerns regarding the actual practice of using CMS. The first is concerned with impression evidence, the second with differing counts of CMS runs, and the third with examination protocol when utilizing CMS. Given an appropriate understanding of CMS, which was not evident in Schwartz's discussion, it is easily seen that such concerns are primarily applicable in discussing the suitability for using CMS as a means of communicating the pattern one is observing. As such they are not relevant to the issue of scientific basis for firearms and tool mark identification. Therefore, the logical flow of discussion will not be interrupted to address these matters.[103]

3. Extensive Statistical Databases are Not Necessary for Substantiating Scientific Basis

Much confusion in the area of statistical databases for firearms and tool mark identification exists because of the uneducated and uninformed comparisons with DNA identification, so different from firearms and tool mark identification that any analogies are intellectually inappropriate. Furthermore, an examination of the typical arguments proposing such databases demonstrate a lack of fuller understanding of the real relevant issue at hand – it is not necessarily the tool itself, but, rather, the manufacturing process for the working surface of the tool that is the critical feature in the scientific basis of firearm and tool mark identification.

In her argument Schwartz emphasizes the actual tool as opposed to the tooling action that was used to form the working surface of the tool. For example, she states that, "To date, the only other statistical empirical support for the claimed absence of any realistic chance that CMS criteria will produce misidentifications consists of published studies of bullet striae and unpublished studies of chisel and knife toolmarks."[104]

By concentrating on discrete populations of tools that share common methods of tool manufacture, the focus of the criticism is misdirected. Striated tool marks are formed by the movement of the working surface of the tool against an object. Yet, the striations are actually influenced not by the actual object, but, rather, the manner in which the working surface of the tool was finished. The rifling process of a barrel results in metal being cut or swaged. Tools such as screwdrivers might be stamped or stamped with final grinding. The cutting tips of knives are typically ground. There are only so many ways to finish a tool surface. And, as it has been already demonstrated, many of them result in random tool marks.[105]

Schwartz is correct in her contention that CMS may vary because of the size and quality of the working surface of a particular tool.[106] However, it is not relevant. She cited Miller as a source for this information who does indicate that the number of striations and groups of CMS will be affected by the size of the tool. However, not in one of those instances, and he did a variety of studies with tool marks of varying widths (different bullet diameters, different rifling impression widths, etc.) did he find that using the conservative criteria for identification would result in a false inclusion.[107] As another example, in personal studies of consecutively manufactured knives, the tool size was quite large and there were

[103] The reader should note however, that Schwartz's discussion of these three concerns was replete with gross and flagrant mischaracterization of the cited literature, an ignorance of other available literature, and an unsupported digression into the ethics of practitioners and researchers.

[104] *Supra* note 2, at 21. Later Schwartz states with regard to Miller's study (Miller, J. "An Examination of Two Consecutively Rifled Barrels and a Review of the Literature." AFTE Journal, Vol. 32, No. 3, Summer 2000, 259-270) that "an observation of bullets worked through *two guns* of *one type* cannot eliminate the possibility that misidentifications could result from applying CMS criteria to all the land impressions of bullets fired from, or otherwise worked through, *all types* of guns." (*Supra* note 2, at 23, n. 93) While Miller was dealing in that article with two guns of one type, Schwartz's statement appears to ignore the other data of which she has already admitted having knowledge. Therefore, her statement is unsubstantiated by any of the published CMS literature. Furthermore, it deals more with the issue of CMS and thus confuses the argument.

[105] Therefore, the analogy with DNA identification is wholly inappropriate because, as it is currently practiced, DNA identification is based on a combination of subclass characteristics for which a statistical treatment is inherently necessary.

[106] Supra note 2, at 21.

[107] *Supra* note 33, at 84.

hundreds of striations present. Yet, in no case of known non-match comparisons would the criteria have permitted a false inclusion.[108]

Many studies have demonstrated that tool marks produced by different tools can be readily distinguished. Furthermore, significant work has focused on defining more discretely the identification criteria by which this is done. The implied need for representative statistical databases for each and every tool one might encounter is not founded because the science of firearm and tool mark identification is based on manufacturing methods and an ability to assess and distinguish among the class, subclass and individual characteristics produced by the tool manufacturing process.

However, that being said it is important not to ignore a pertinent and very relative question. That question is, "Is there a role for statistics in the discipline of firearms and tool mark identification?" This attempts to address Schwartz's concern from a broader perspective. The next section will be devoted to examining that very question.

4. The Role of Statistics in Firearms and Tool Mark Identification Has Received Extensive Continuing Attention by the Community

If statistics has a role in the firearms and tool mark identification discipline, it is most appropriately directed at the logical question that would emanate from the statement in the AFTE Theory of Identification that specifies the criteria needed to make an identification and how that identification is defined. Restating the relevant portion of the AFTE Theory of Identification, it states "The statement that 'sufficient agreement' exists between two tool marks means that the agreement is of a quantity and quality that the likelihood another tool could have made the mark is so remote as to be considered a practical impossibility."[109] The logical questions to which statistics could be directed is, "How remote is that practical impossibility?"

Schwartz claims that "Firearms and toolmark examiners do *not* even attempt to answer this question."[110] While that may be true in the context of testimony she has personally observed, within the scope of the published literature it is not. Biasotti made that attempt in his article published in 1959.[111] In 1970, Brackett examined the use of various models to study "idealized" striated marks.[112] These "idealized" marks consisted of individual elements within a set of striations defined by position only, without the additional defining characteristics of width, contour or height. The purpose of these models was to examine statistical and probabilistic application to striated tool marks.

Blackwell and Framan ran simulated studies based on Brackett's formulae and models resulting in numbers similar to those produced by Biasotti in 1959.[113] Uchiyama was responsible for another computer simulation granting greater than practical tolerances for striation correspondence and produced numbers similar to those of Biasotti.[114] In his article he developed a probability equation and a significance level based on actual, test-fired bullets. Deinet published a study[115] the purpose of which was to "calculate the probability of random occurrence of matches using actual striated tool marks."[116]

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[108] *Ibid*. Though, the actual amount of striations on each was not cited in that summary nor in any other format.
[109] *Supra* note 7.
[110] Supra note 2, at 13.
[111] *Supra* note 18.
[112] Brackett, J. "A Study of Idealized Striated Marks and Their Comparison Using Models." Journal of the Forensic Science Society, Vol. 10, No. 1, Jan. 1970, 27-56.
[113] Blackwell, R. and Framan, E., "Automated Firearms Identification Systems AFIDS: Phase I." AFTE Journal, Vol. 12, No. 4, Oct. 1980, 11-37.
[114] Uchiyama, T., "A Criterion for Land Mark Identification." AFTE Journal, Vol. 20, No. 3, July 1988, 236-251.
[115] Deinet, W. Studies of Models of Striated Marks Generated by Random Processes. Journal of the Forensic Science Society, Vol. 26, No. 1, Jan. 1981, 35-50.
[116] *Supra* note 11, at 472. It should be noted that the previous four citations were all reviewed in this article written in 1997. Dr. Schwartz relies extensively on this review article but no where in her discussion are any of the references cited in notes 112-115 found.

There have also been more recent attempts to answer a statistical question. Miller and Neel evaluated the statistical significance of various runs of consecutive matching striations (CMS) for 1000 comparisons.[117] Rocky Stone ventured into a mathematical model to describe the probabilities of impressed tool marks on a theoretical hammer face.[118] Just recently, Collins has offered a follow-up to Stone's model by empirically assessing such marks on 20 actual hammer faces.[119]

The literature indicates that firearm and tool mark examiners have found some usefulness in the area of statistics. It very well could be that it is because there was early recognition that an examiner, at best, could individually examine no more than a small fraction of the firearms that actually exist. Yet, using probabilities, an examiner would still be in a position to discuss the uniqueness of an identification.[120]

However, there have been dissenters. Deschênes *et al* would argue no.[121] In support of their contention they cite two objections. The first is that, "statistics never permit to draw conclusions concerning a particular situation."[122] In support of this they use a weather analogy. "It is not going to rain just because there are 97% chances that it is going to rain. Statistics do not yield a "cause to effect" relationship."[123] The second is that a firearms and tool mark examiner is in a better position to interpret the meaning of what is being observed.[124]

This article received some relatively rapid criticism.[125] The criticism focused on the fact that statistics does have a role to play and that is in the area of uncertainty. They argue that because the examiner does not have a complete set of circumstances regarding a particular tool, "…the tool mark examiner is never in a position to identify a tool. But when considering the whole population of the world, the expert estimates that the probability of another match is very close to zero, then it is common sense to declare an identification."[126]

Bunch's article supports a similar view.[127] He states that firearm and tool mark examiner have the goal of determining the likelihood ratio, a Bayesian reference, that a tool mark was made by a particular tool.[128]

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[117] Miller, J. and Neel, M. "Criteria for Identification of Toolmarks Part III Supporting the Conclusion." AFTE Journal, Vol. 36, No. 1 Winter 2004, 7-38. Also presented at the AFTE 34th Annual Training Seminar, May 2003, Philadelphia, PA. These statistics were not among the previously discussed 6,000 known non-match comparisons that have not violated the CMS criteria.

[118] Stone, R. "How Unique are Impressed Toolmarks?" AFTE Journal, Vol. 35, No. 4, Fall 2003, 376-383.

[119] Collins, E. "How 'Unique' are Impressed Toolmarks? An Empirical Study of 20 Worn Hammer Faces." Presented at the CAC Semi-Annual Seminar, May 2005, Oakland, CA. Also presented at the AFTE 36th Annual Training Seminar, June 2005, Indianapolis, IN.

[120] Hatcher, J.S., *Textbook of Firearms Investigation, Identification and Evidence*. Marines, NC: Small Arms Technical Publishing Company, 1935.

[121] Deschênes, M., Chaltchi, A., Desjardins, G., Desrochers, C., Dion, J., Gaulin, R. "Statistics and Toolmarks Comparisons." AFTE Journal, Vol. 27, No. 2, April 1995, 140-141.

[122] *Supra* note 121, at 140.

[123] *Ibid.*

[124] *Supra* note 121, at 140-141 (stating "The specialist in statistics uses his knowledge, experience and judgment to form a statistical model which represents reality, and to apply that model to a particular situation. He then uses his judgment to conclude, according to the statistical results he obtains, if this tool mark was or was not made by that particular tool. In the same way, the specialist in tool marks uses his knowledge, experience and judgment to conclude, from what he observes under the comparison microscope, if the tool mark was or was not made by that particular tool. In theory, the human judgment of the specialist in statistics is as valid as the human judgment of the specialist in tool marks. But for real tool mark comparison, the specialist in tool marks has the advantage of working directly with the exhibits, without intermediaries…Thus, in the event of an expert's testimony concerning tool marks, the opinion of the specialist in tool marks should have more weight than the opinion of a specialist in statistics, although the second one might more easily impress the jury…Numbers always look so scientific!").

[125] Taroni, F., Champod, C., Margot, P. "Statistics: A Future in Tool Marks Comparison?" AFTE Journal, Vol. 28, No. 4, Oct. 1996, 222-229.

[126] *Supra* note 125, at 126.

[127] Bunch, S., "Consecutive Matching Striation Criteria: A General Critique." Journal of Forensic Science, Vol. 45, No. 5, September 2000, 955-962.

Use of the word "likelihood" or phrase "likelihood ratio" implies reference to Bayesian inference because it specifically deals with measuring likelihood. This is one manner in which the question can be approached. Indeed, some favor it because it allows for an assessment of more than just the questions of the comparative results.[129] However, a review of some work in which there has been discussion of applicability to firearms and tool mark identification shows that it does not answer the question as discretely as the judicial system may like. It is true that numbers representing a likelihood ratio are generated but, the explanation for what those numbers mean in a real sense leaves the judicial system no closer to real answer that has much more meaning than what is being offered now.[130]

A different approach is a more routine probabilistic approach such as that most oft-cited in the literature. In essence, this latter approach deals with the question, "What are the chances that another tool made these marks?" Those favoring Bayesian inference would suggest that a more complete answer is given by the likelihood ratio because prior odds favoring a particular conclusion are factored into a likelihood ratio. Therefore, they would argue that the discrete "chances that another tool made the mark," offers an incomplete picture.

The question of Bayesian versus straight probabilistic statistics has been debated but really not seen resolution. Two primary articles in support of Bayesian inference used it as a framework to critique the concept of CMS.[131] Strong responses to those articles suggested that the connections being drawn were not truly legitimate, but, rather, based in a misunderstanding of the concept of CMS and the practice of those utilizing it.[132] Similar misunderstanding is apparent in Schwartz's argument as she pursued this issue of statistics.

The potential role for statistics in the firearms and tool mark discipline has been and continues to be studied unlike the assertion made by Schwartz. While it may have some utility in its current form, the debate among the relevant scientific community is not completely resolved. However, it is getting a significant amount of attention.

Given the incomplete picture currently offered by statistics and their potential role in the discipline, it is recommended that the reader explore the applicability of proficiency testing and error rates to assist the judicial system in evaluating the validity of the scientific basis for the firearm and tool mark discipline.

C. The Role of Proficiency Tests and Error Rates in Practical Determination of Validity of Firearms and Tool Mark Identification

While less than ideal, proficiency tests can be of value in providing a general indicator of error rates in firearms and tool mark identification.[133] As recognized, individuality cannot be proven because it is impossible for an examiner to examiner every tool in the world to a tool mark of question. Furthermore, because of the difficulty in assessing the non-quantitative aspects of firearms and tool mark identification, statistics cannot wholly answer the question.[134] Therefore, proficiency tests can offer to the court a reliable

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[128] There is criticism of Bunch's work with respect to the treatment offered CMS, as CMS was criticized in the framework of Bayesian inference. *Supra* note 12.

[129] *Supra* note 127.

[130] *Supra* note 127. *See also*, Champod, C.; Baldwin, D.; Taroni, F.; and Buckleton, J.S. "Firearms and Tool Marks Identification: The Bayesian Approach." AFTE Journal, Vol. 35, No. 3, Summer 2003, 310 (offering that a range of likelihood ratios of 1 to 10,000+ would represent conclusions of "limited evidence to support" an identification to "very strong evidence to support" an identification. However, the assignments appear arbitrary without a definable, quantifiable basis for support.

[131] *Supra* notes 127 and 130.

[132] *Supra* note 12. *See also*, Nichols, R. "Letter to the Editor, Re: 'Firearm and Tool Marks Identification: The Bayesian Approach,' Champod, C.; *et al*. AFTE Journal, Vol. 35, No. 4, Fall 2003, 354-355.

[133] Grzybowski, R.; Miller, J.; Moran, B.; Murdock, J.; Nichols, R.; Thompson, R. "Firearm/Toolmark Identification: Passing the Reliability Test Under Federal and State Evidentiary Standards." AFTE Journal, Vol. 35, No. 2, Spring 2003, 209-241.

[134] *See e.g.*, Gutowski, S., "Error Rates in the Identification Sciences," *The Forensic Bulletin*, Summer 2005, p. 23 (stating "An estimate of the actual or potential error rate is crucial to the probative value of all evidence. This is certainly true of the field and identifications sciences where hard statistics on the

practical indicator of how often the profession, using accepted procedures, practices and controls, makes a false identification.[135]

Grzybowski *et al* recognize that even with their limitations, "Collaborative Testing Service (CTS) is currently the only source of international proficiency testing results in the firearm and toolmark identification discipline from which a source of potential error rate may be inferred."[136] Given that, the authors provide a review of the Peterson and Markham data[137] in addition to CTS data subsequent to that examined by Peterson and Markham with the specification that inconclusive conclusions are not necessarily incorrect or correct.[138] Therefore, such inconclusive conclusions will not be deemed as incorrect responses as was done by Peterson and Markham.

Given this structure of examination Robert Thompson assessed the CTS data for two time periods, the first 1978 through 1997 (the same as Peterson and Markham) and 1998-2002. The percentage of false identifications for firearms was 0.9% and 1.0%, respectively. The percentage of false identifications for tool marks was 1.0% and 1.5%, respectively.[139] Based on this evaluation the authors offer the following.

> So, what does this mean for the individual examiner? The examiner must first acknowledge that errors can be made. The examiner must then be prepared to discuss the CTS tests and their limitations, and recognize that, despite their limitations, they may offer the court some indication of error. It does not mean, for example, in the instance of a 1.5% CTS error rate, that every toolmark identification case report is subject to being right only 98.5% of the time, but rather that for all those respondents, 1.5% made an incorrect association. Secondly, assuming that the work <u>has</u> been done thoroughly and the conclusions fully supported by clear and complete notes, it is suggested that examiners advocate that it's his/her opinion that he/she has made no error in the case at hand. It is easier to convince others of this if: 1) he or she has graphically demonstrated the basis for the opinion with the use of photographs; 2) comprehensive notes have been taken that fully support the conclusions in the lab report and; 3) the examiner's work has been technically peer reviewed and administratively reviewed per ASCLD/LAB requirements (whether or not the individual's laboratory participates in this program). Such actions would serve to further minimize any reasonable chance of error in reaching a correct conclusion and will be persuasive to those in court responsible for determining the weight to be accorded the examiner's testimony.[140]

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frequency of occurrence of a particular pattern are impossible to come by and individuality is assumed but cannot be proven.").

[135] *See e.g., supra* note 133, at 216 (stating "The statement that the science of firearm and toolmark identification has a '0%' error rate is clearly not responsive to the court when questions of error rate are brought forward. The court is not interested in "theoretical error rate", which assumes everything has been done correctly and the correct answer obtained, but is interested in the real life potential error rate that is reflective of all human endeavors….To proffer that firearm and toolmark identification is "infallible" is simply not true and will be met with immediate suspicion. The court is interested in "known or potential error rate" as a means by which to assign weight to the examiners testimony. The examiner will be more credible by readily discussing the reported error rates in the process of firearm and toolmark identification (*i.e.*, the first half of the *Daubert* element) and then be prepared to discuss what steps have been taken as an individual and through laboratory peer and administrative review processes to eliminate the possibility of error in the work currently being presented in court (i.e., the second half of the element).").

[136] *Supra* note 133, at 216.

[137] Peterson, J. and Markham, P. "Crime Laboratory Testing Results, 1978 – 1991, II: Resolving Questions of Common Origin." Journal of Forensic Sciences, Vol. 40, No. 6, November 1995, pp. 1009-1029.

[138] *See e.g.*, Grzybowski, R. and Murdock, J, "Firearm and Toolmark Identification – Meeting the *Daubert* Challenge," AFTE Journal, Vol. 30, No. 1, Winter, 1998, pp. 3-14 (stating [the belief that] "this is the error rate the judicial system is interested in.").

[139] *Supra* note 133, at 218.

[140] *Supra* note 133, at 219-220.

Recent validation studies might also assist in this venue. In 1992, Brundage reported on a study of ten consecutively step-broached 9mm Luger caliber barrels.[141] He provided thirty different laboratories across the country with pairs of test fires from each of the ten barrels along with fifteen unknowns, with at least one from each of the ten barrels. In each and every instance the unknowns were properly associated to the barrel from which they were fired. At the 2003 AFTE Training Seminar Hamby reported that 294 different examiners from 15 countries had examined and compared the bullets without a single instance of a misidentification.[142]

A study that involved the ten consecutively manufactured knives was reported in 2003.[143] The authors obtained 10 consecutively manufactured knives and produced a series of test marks and questioned marks. The final sharpening was accomplished with a 24" diameter grinding wheel. 103 examiners provided a total of 1030 results (ten questioned marks per examiner). Of the 1030 results, there were 8 errors for a calculated false identification rate of 0.77%.

A third study involved cartridge cases fired using ten Glock pistols.[144] The total number of comparisons conducted was 360 with no errors reported.

A fourth study was directed at assessing the validity of the CMS criteria for two dimensional tool marks.[145] If one considers CMS to be a validate representation of a comparative examination of a striated tool mark comparison, then it may be of interest to note that of 1000 known non-match comparisons, not one violated the CMS criteria for two dimensional tool marks.

While valuable, the validation studies provide only a part of the picture. Proficiency tests offer an assessment of laboratory practice, quality assurance and quality control procedures. In addition, the wide range of proficiency tests offered involve tools and firearms from a variety of manufacturing methods. In combination, the material offered provides a good picture of how often the profession will make an incorrect association.[146]

D. Computerized Firearms Identification is a Misnomer

The Integrated Ballistics Identification System (IBIS) is not a means of computerized firearms identification by a strict usage of the language. In fact, no such system exists as all comparisons are conducted for final determination not by computers but trained and qualified firearms and tool mark examiners. Therefore, Schwartz's assessment of the system and conclusions drawn as a result are both inaccurate and irrelevant to the issue of validation of firearms and tool mark identification and its admissibility.

In the introduction to her argument, Schwartz writes, "As will be seen, however, computerization has not eliminated the risks of misidentifications and missed identifications by firearms as well as toolmark examiners."[147] The current technology was never intended to even address this issue. The point of the Integrated Ballistics Identification System (IBIS) is to serve as a computerized database of data and images from bullets and cartridge cases for rapid searching of these images in an attempt to link cases that might have otherwise not been linked. As such it is an investigative aid only.[148]

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[141] Brundage, D. "The Identification of Consecutively Rifled Gun Barrels." Presented at the 25th Annual AFTE Training Seminar, Indianapolis, IN, June 1994.

[142] Hamby, J. "An Update on the Identification of Bullets Fired From Consecutively Rifled 9mm Ruger Pistol Barrels." Presented at the 34th Annual AFTE Training Seminar, Philadelphia, PA, May 2003.

[143] Thompson, E. and Wyant, R. "KIP (Knife Identification Project)." Presented at the 34th Annual AFTE Training Seminar, Philadelphia, PA, May 2003.

[144] Bunch, S. and Murphy, D. "A Comprehensive Validity Study for the Forensic Examination of Cartridge Cases." *AFTE Journal*, Vol. 35, No. 2, Spring 2003, 201-203.

[145] Miller, J. and Neel, M. "Criteria for Identification of Toolmarks Part III Supporting the Conclusion." AFTE Journal, Vol. 36, No. 1, Winter 2004, 7-38.

[146] An alternative is offered by Gutowski who writes, "A better estimation of error rate in casework would be most rigorously achieved by the re-examination of several thousand cases where each case was examined by a panel of experts to achieve consensus. In the absence of a massive increase in funding, this is unlikely to happen." (*Supra* note 134, at 28.)

[147] *Supra* note 2, at 28.

[148] This was completely mischaracterized by Schwartz. See e.g., supra note 2, at 28-29 (stating "The National Integrated Ballistics Identification [Information] Network (NIBIN), formed in 1997, makes *the*

Schwartz entered into discussions questioning the accuracy of IBIS and issues involving national gun registries. Had her assertion regarding IBIS been correct, which it was not, these discussions might have had limited value. As it is, because her assertion completely mischaracterizes IBIS, these discussions are of no value. None of the material offered by Schwartz with regard to IBIS truly addresses the predominant issue of the scientific validation of firearm and tool mark identification or its admissibility.

II. The Judiciary Appears to Have a Solid Grasp of Critical Elements of Firearms and Tool Mark Identification

A review of case decisions involving evidence related to firearms and tool mark identification indicates that the court has a solid grasp on the critical elements regarding the discipline. Many elements contribute to the court's understanding regarding of a particular forensic science discipline, chief among which is the expert witness's capability to articulate the discipline's scientific foundations such that the court is able to understand that there is a solid basis for the proffered testimony. Also important to understand is that such testimony takes place in a contentious environment. The scientific witness is caught in the middle of this contentiousness with a supposed goal of impartiality, to let the evidence speak for itself. Considering that testimony is oft times restricted it is important that the two sides elicit from the expert witness the important items for a jury to consider by asking intelligent, probing questions.

If nothing else, the article by Schwartz highlights that the various forensic science disciplines should be probed and examined. Such probing and examination should lead to more intelligent and complete questioning of a witness such that the court will develop a fuller picture of the interpretations of the evidence being offered by the witness. That can lead only to better and more sound practice where it may have been lacking otherwise.

To conclude, as Schwartz does based on her review of case decisions, that the courts do not understand the critical elements regarding firearms and tool mark identification is inappropriate based on a more critical review of the case decisions. In opening her discussion, Schwartz states that, "No court, including the two recent courts that have excluded particular identification testimony, has recognized the systemic scientific problems with the field."[149] There is an alternative conclusion that is not given, that such issues have been examined by the court and they have concluded that they do not have the significance attributed to them by Schwartz. Considering the misunderstanding demonstrated by Schwartz in many of these issues, it would behoove the reader to give these case decisions a more critical read.

Following will be a review of the case decisions cited by Schwartz with some additional information being given that was lacking in Schwartz's presentation. The additional information should provide a fuller picture thought the fullest can be achieved only through an examination of the decisions.

A. Firearms Cases

1. Sexton v. State (2002)[150]- Court Recognizes Potential Subclass Impact

In this particular case, the court held that while the foundation of the discipline as a whole was sound, the specific application in this case, *e.g.*, the identification of cartridge cases to a magazine based on

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BATF's [emphasis added] computerized comparison system, IBIS (Integrated Ballistics Information [Identification] System), available to federal, state and local law enforcement agencies for inputting, storing, and *matching* [emphasis added] digital images of bullets and cartridge cases that they recover from crime scenes or use crime guns to test fire. Agencies that participate in NIBIN are linked through the FBI's telecommunications network, allowing inter-agency comparisons of digital images of ammunition components."). The reader should be aware that IBIS is not the property of the "BATF" (Bureau of Alcohol, Tobacco, Firearms and Explosives). The BATF is a customer of Forensic Technologies, Inc. who markets the system not only within this country but, worldwide. Second, the system does not "match" digital images. It compares the acquired images and provides the user of the system with a scored list of potential candidates that might be linked to the questioned bullet or cartridge case. Finally, while digital images can be compared between agencies, actual confirmation takes place using the actual evidence and standard methods and procedures for firearm and tool mark comparison and identification.

[149] *Supra* note 2, at 32.

[150] *Sexton v. State*, 93 S.W.3d 96.

magazine marks present on cartridge cases, was not reliable. Therefore, the court reversed the appellate decision which deemed that the scientific testimony was properly admitted. The case was remanded to perform harm analysis.

Schwartz vigorously opposes this more specific approach.[151] It should be noted that Schwartz offers her view as being opposed to that of "prominent commentators [who] have endorsed the *Sexton* court's decision to focus on the distinctive problems with the identification in the case and not consider the systemic scientific problems…"[152] A review of the case appears to demonstrate that this latter approach was actually more appropriate than that offered by Schwartz.

The foundation for the testimony appeared to be poor. Scant references were offered and those that were did not speak directly to the issue of marks produced by ammunition magazines. There is no indication that sufficient parallels were drawn so that the court would be able to recognize that the concepts that apply to tool marks in general could be applied to marks made by ammunition magazines specifically. Finally, when questioned regarding the manufacture of such ammunition magazines, the expert could not provide the court with an explanation of how they were manufactured. In light of the absence of the actual magazines, such knowledge is essential. Considering the poor foundation the court's decision is quite legitimate, singly applied to this issue in particular.

2. People v. Hawkins (1995)[153]- Court Recognizes Importance of Training and Experience in Forming Identification Criteria

The issue at hand in this particular was focused on the trial court's prerogative to question an expert witness for purposes of clarification of the evidence and in this the appellate court found there was no error and the evidence was properly admitted. Schwartz contends that the court erred in that they missed what she erroneously opined to be the point of Biasotti's work. She commented that, "Biasotti's point, however, was that absent a database and calculations of statistical significance, examiners cannot know when the resemblances between toolmarks are so great that they must have come from a single firearm."[154]

However, Schwartz has erroneously characterized Biasotti's point. The primary thrust was to develop a numerical threshold at which an examiner can feel confident an identification has been effected. Alternatively, he sought to identify a CMS threshold that could define the best known non-match. Therefore, the point of Biasotti's work was not at odds with any of the testimony and this was recognized by the court. The court recognized the value of training and experience as well as how Biasotti's valuable work fit into the scheme of that training.[155]

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[151] *See e.g.*, *supra* note 2, at 34 (stating "[This}Illustrates the danger that courts focus narrowly on the problems with particular expert testimony may fail to understand the systemic scientific problems with a field of expertise and therefore write opinions that set too low a bar for the admission of future expert testimony.").

[152] *Supra* note 2, at 34.

[153] *People v. Hawkins*, 10 Cal.4th 920, 897 P.2d 574, 42 Cal. Rptr.2d 636.

[154] *Supra* note 2, at 35.

[155] *See e.g.*, *People v. Hawkins*, 10 Cal.4th 920, 897 P.2d 574, 42 Cal. Rptr.2d 636 (stating "These experts explained that the copper jackets of the respective bullets were examined under a microscope to compare the striations or lines imprinted on the jackets. The striations are produced when the bullet is fired, and thus reflect the unique characteristics of each gun barrel. The experts compared the number and configuration of matching and nonmatching lines in the two jackets to determine that they were fired from the same gun. They conceded that ballistics identification is not an exact science. Rather, ballistics experts develop proficiency by microscopically observing a large number of bullets known to have been fired from the same gun, and from different guns, so that they acquire knowledge of when the similarities of the bullets' striations are sufficient to establish that the bullets were discharged from the same firearm… The court then asked Garbutt if his ballistic identification in this case 'was weakened any degree by having been reminded today of Mr. Biasotti's concerns about how a statistical model might lend an even additional dimension to your field?' Garbutt responded by stating that his opinion 'is not diminished and is as strong. Biasotti's article is part of my training and learning, and I do consider his work in part in forming the opinion which I have formed.'").

3. Commonwealth v. Ellis (1974)[156]- Court Properly Contends with Differing Identification Criteria and Changing Marks

In this case, the suspect firearm was not available.[157] The firearms evidence consisted of an evidence bullet from the victim and bullets known to been fired from the suspect weapon into a tree. Therefore, the comparisons were from the bullet from the victim to bullets from a tree. The court properly contended that the evidence was properly admitted in the discretion of the trial judge and that the weight to be given the evidence was appropriate for the jury to decide.

There were two issues in particular that were addressed by Schwartz and considered by the court. One was the issue of identification criteria. Schwartz claims one systemic failing of the discipline is the lack of specific identification criteria. In this case, two experts agreed on conclusions with regard to two bullets, differing on a third. Considering the expected condition of the evidence, it is not surprising that two experts would potentially disagree. One examiner concluded that while similarities did exist, the final results were inconclusive. The other felt enough information was available to declare that two bullets were fired from the same firearm.

While such situations are not typical, they are not surprising. The reader needs to be mindful of the fact that while observations are objective, the interpretation of those observations is subjective. In the absence of a specific criterion such as CMS, there will be some difference between examiners as to what constitutes the best known non-match situation. This is especially the case with damaged items such as bullets from trees. In those comparative examinations in which the observed correspondence is borderline it is not necessarily unexpected that one examiner would reach an inconclusive determination while another might conclude a more positive association. Therefore, with regard to this issue the court did adequately assess the limitations of the discipline and appropriately assigned the task of weight to the jury.

The second issue concerned the time elapsed between the firing of the different bullets. The court specifically addressed the issue of the character of a barrel changing over a period of time and felt that the issue was adequately addressed by the expert witnesses, and that it did not present a systemic problem to the overall discipline itself. In finding this, the court did address an appropriate concern but, unlike Schwartz, realized that it was not a systemic failing of the discipline.

B. Tool Mark Cases

1. State v. Fasick (1928)[158] and State v. Clark (1930)[159] – Court Is Capable of Assessing Sufficiency of Science

Both cases involve the state of Washington, involve marks produced by knives on branches, were decided just two years apart, and yet have two very different results. The reason for the different results are linked directly to the sufficiency of the science, the court's ability to make a proper distinction between bad and good science, and issue a proper ruling based on that understanding.

In *Fasick* the court reversed the judgment of the trial court holding that the evidence was improperly admitted. The reason was that the experimental procedure by which the examiner produced test marks and the criteria for identification were both insufficient to allow a determination that a particular knife produced marks observed on branches from a scene. In a completely appropriate ruling to reverse the ruling based on improperly admitted evidence, the court was quite scientifically inclined, addressing for itself many of the issues that can affect how a tool will mark an object[160] Based on their expectations, they

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[156] *Commonwealth v. Ellis*, 373 Mass. 1, 364 N.E.2d 808.

[157] The court cited several cases from outside its own jurisdiction that dealt with the comparison of fired ammunition components without a firearm. These cases included *State v. Lane* (72 Ariz. 220, 233 P.2d 437), *People v. Williams* (15 Mich. App. 683, 167 N.W.2d 358), and *State v. Boccadoro* (20 Gummere 352).

[158] *State v. Fasick*, 149 Wash. 92, 270 P. 123.

[159] *State v. Clark*, 156 Wash. 543, 287 P. 18.

[160] *See e.g.*, *State v. Fasick*, 149 Wash. 92, 270 P. 123 (stating "It will not do to compare this kind of evidence with the shoe tracks of a person or a horse, nor with finger prints, because in those cases the thing making the impression comes to rest in making the impression. It may be admitted that an edged tool with gaps in it firmly set in machinery and driven through two pieces of wood of the same kind would make practically the same kind of impression on both pieces of wood. Not so, however, with a knife used by the

understood what would generally be accepted as good practice for a conscientious tool mark examination. In fact, the court was more scientifically inclined than the State's own supposed expert.

In *Clark*, the court affirmed the trial court's judgment permitting the admission of tool mark evidence involving the marks produced by a knife on branches. In making that decision the court does not ignore the previous *Fasick* decision, stating "The facts in *State v. Fasick*…distinguish that case from the case at the bar. In the Fasick Case there was only one mark on the two pictures admitted in evidence which compared one with the other. In the case at the bar there are more than fifty marks appearing on the pictures of the cut surfaces of the fir boughs which can be identified as appearing on the cut surfaces of the cedar boughs."[161]

According to Schwartz, Saks characterizes this distinction as "superficial."[162] Based on what was presented in the written opinion and in associated references, this distinction is far more than superficial. Specifically, a review of the firearm and tool mark literature identifies this particular case as being published in the *American Journal of Police Science*.[163] The examination process was far superior to that exercised by the detective in the *Fasick* case.[164] The work was compelling and detailed. Accompanied by photographs there is obvious evidence that he potentially considered CMS as there is a photograph in the work with groups of CMS delineated and counted. That he considered statistics is obvious.[165] The court in *Clark* made a decision based on much more significant and compelling information than for which they are given credit by either Saks or Schwartz. Furthermore, the evidence as presented appropriately addressed and answered the concerns of Schwartz such that the courts made an appropriate and informed decision.

2. Ramirez v. State (1989, 1995, 2001)[166]- Court Questions Infallibility of Firearms and Tool Mark Identification

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hand. It is common knowledge that a knife with a faulty edge used in the right hand, one side of the blade being down, often makes a different impression on wood than if used in the left hand with the other side of the blade down. Again, such a knife used in the hand will oftener than otherwise make a different impression upon wood cut by it whether tested by the microscope or not, according to whether it is forced through wood at right angles, with the point forward or with the point following and according to the angle of the slant of the knife with respect to the wood cut. There was no attempt in the evidence in this case to overcome these things. The knife, pieces of boughs and photomicrographs were, of course, strong invitations to the jury to guess, speculate and conjecture, but they fell far short in our opinion of being admissible. It was in our opinion reversible error to admit these articles in evidence.")

[161] *Supra* note 11.

[162] See e.g., supra note 2, at 36, n. 163 (citing Saks who Schwartz purports, "acknowledges that the Clark opinion distinguishes Fasick away on the facts, but describes the distinctions as 'superficial' and criticizes the Clark court for 'fail[ing] to explain what changed in its understanding of the scientific claims of toolmark identification.'").

[163] May, L.S. "The Identification of Knives, Tools and Instruments A Positive Science." American Journal of Police Science, 1930, 246-259.

[164] *See e.g., supra* note 187, at 255 (stating "An instrument was designed by the writer resembling the human arm including shoulder, elbow and wrist joints, with variable adjustments simulating the shoulder and elbow movements. The part holding the knife has adjustments which can be controlled and varied by a series of cams, pawls and levers, allowing the holder to simulate the degree of circumduction, supination and pronation of the wrist in the act of making a given cut. With this device it is possible to duplicate repeatedly the same cut, using the same portion of the blade each time, the blade entering and passing through the wood at the same angle with relation to the plane surface of the portion cut.").

[165] *See e.g., supra* note 187, at 255 (stating "Considering only the major marks on this cut, it can be mathematically determined that no other blade in the world would make a cut like this. Invoking the law of probabilities, using the algebraic formula for determining combinations and permutations, with only one-third of the marks shown here as factors, there would only be "one" chance of there being another blade exactly like this if every one of the hundred million people in the United States had six hundred and fifty quadrillion knives each. Using all of the marks, and the factors of depth, width, shape, etc. it would be carried to infinity.").

[166] *Ramirez v. State*, 542 So.2d 352 (1989); *Ramirez v. State*, 651 So.2d 1164 (1995); *Ramirez v. State*, 810 So.2d 836 (2001).

These three cases involved the identification of tool marks in cartilage to a specific knife. Despite the holding of the court which finally resulted in the evidence to be excluded, Schwartz argues that even these holdings were misguided. Of these three, Schwartz argues that the first two cases dealt with the reversal of procedural issues and therefore does not discuss them.[167] She cites the third case in 2001 as being the one that critically examined the scientific issues, but, again, still failing to see her perceived systemic failure in the discipline as a whole. Schwartz states that, "The Ramirez III court failed to understand that its criticisms of the expert testimony in the case were applicable to firearms and toolmarks examination as a whole."[168] Later she says that the "court criticized the expert for pursuing a novel method, when his identification was based on the traditional, subjective approach."[169]

A reading of the case would show that the court did focus its direction on this particular application of firearm and tool mark identification theory and methodology. While it is true that the examiners did approach the comparative examination from the traditional perspective (evaluating and comparing patterns without quantifying them), it has already been shown that linking this traditional perspective automatically to "subjective" is not completely appropriate. Furthermore, the court was calling the method used by Hart novel based on claims of infallibility and the lack of concrete items for the court to consider as objective criteria. While the court may have erred in this characterization of a novel method, there is no question that they were rightly concerned about the claims of infallibility and poor explanation of identification criteria.

Schwartz later strongly criticizes the court for its "ignorance of the firearms and toolmark literature [which] was also betrayed in its failure to recognize that CMS is the only widely accepted alternative to the expert's traditional subjective approach."[170] A review of the literature focusing on CMS shows that it is not an alternative method different than the traditional approach, but, rather, an alternative means of articulating what one is observing. Therefore, her argument is misplaced.

She also states that "Similarly, *the court claimed that the expert's method did not have an error rate* [emphasis added], instead of recognizing that, despite its insufficient rigor, CTS testing belied the expert's claim that toolmark examiners never make mistakes."[171] The court never claimed this. They questioned it because they could not find evidence for claims of infallibility. With respect to this very issue the court said, "First, the record does not show that Hart's methodology – and particularly his claim of infallibility – has ever been formally tested or otherwise verified."[172] Later the court writes, "None [studies] address Hart's testing methodology and the absolute certainty of identification deduced from such a test."[173] The issue of infallibility has already been discussed at length and need not be repeated here.

Based on a review of this case, it appears that the court did have a good understanding of some of the critical issues with firearms and tool mark identification such that it recognized when appropriate questions were not being adequately addressed by offered testimony. However, that is not to say they could not have been. The concerns are readily answerable as has been discussed in Part 1. That they were not gave the court proper cause in excluding the evidence in this particular instance. To apply such reasoning beyond this case is not supported.

Conclusion

Firearms and tool mark identification is rooted in sound scientific foundations. A wealth of literature demonstrates that it has been critically studied according to the precepts of the scientific method. This has culminated in the AFTE Theory of Identification – the published statement of the relevant scientific community.

Three primary concerns of the discipline, identification criteria, the potential for subclass characteristics, and changes in tool surfaces over time have been adequately studied and, if accounted for, do not invalidate the identification discipline as a science. Furthermore, the firearm and tool mark

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[167] Interestingly, some of the cases that were criticized earlier were held or dismissed based on similar procedural issues.
[168] *Supra* note 2, at 39.
[169] *Ibid.*
[170] *Supra* note 2, at 40.
[171] *Ibid.*
[172] *Supra* note 194, *Ramirez v. State* (2001).
[173] *Ibid.*

identification discipline has been validated in a manner appropriate for evidence of the kind to be expected in firearms and tool mark examinations. Finally, proficiency tests and error rates have been studied and can provide the court and community with a useful guide as to the frequency with which misidentifications are reported in the community using appropriate methodologies and controls.

Based on a review of the same court decisions offered by Schwartz, it appears that the courts do have adequate and sufficient knowledge regarding the intricacies of firearms and tool mark identification. Indeed the time for testimony offers a wonderful opportunity for the science of firearms and tool mark identification to stand the test. It appears that in those instances in which the discipline and interpretation of results has been well-articulated, the courts have recognized this.

Schwartz presents some very critical issues such as the potential for subclass characteristics and identification criteria that, if not adequately addressed by an individual examiner, could lead to an incorrect interpretation of the observations made in a particular case. Questioning, as Schwartz does, is valuable in probing the sufficiency of knowledge and application on the part of the individual examiner in a particular case. Extending this discipline wide, as Schwartz does, is in definite error.