"An Empirical Study to Improve the Scientific Foundation of Forensic Firearm and Tool Mark Identification Utilizing 10 Consecutively Manufactured Glock EBIS barrels"

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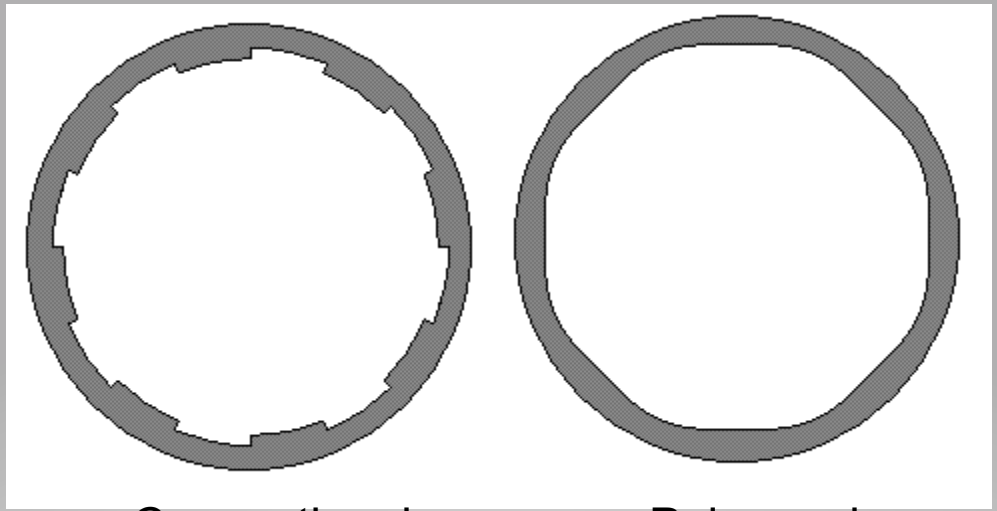
Presented by Gabriel A. Hernandez, M.S.

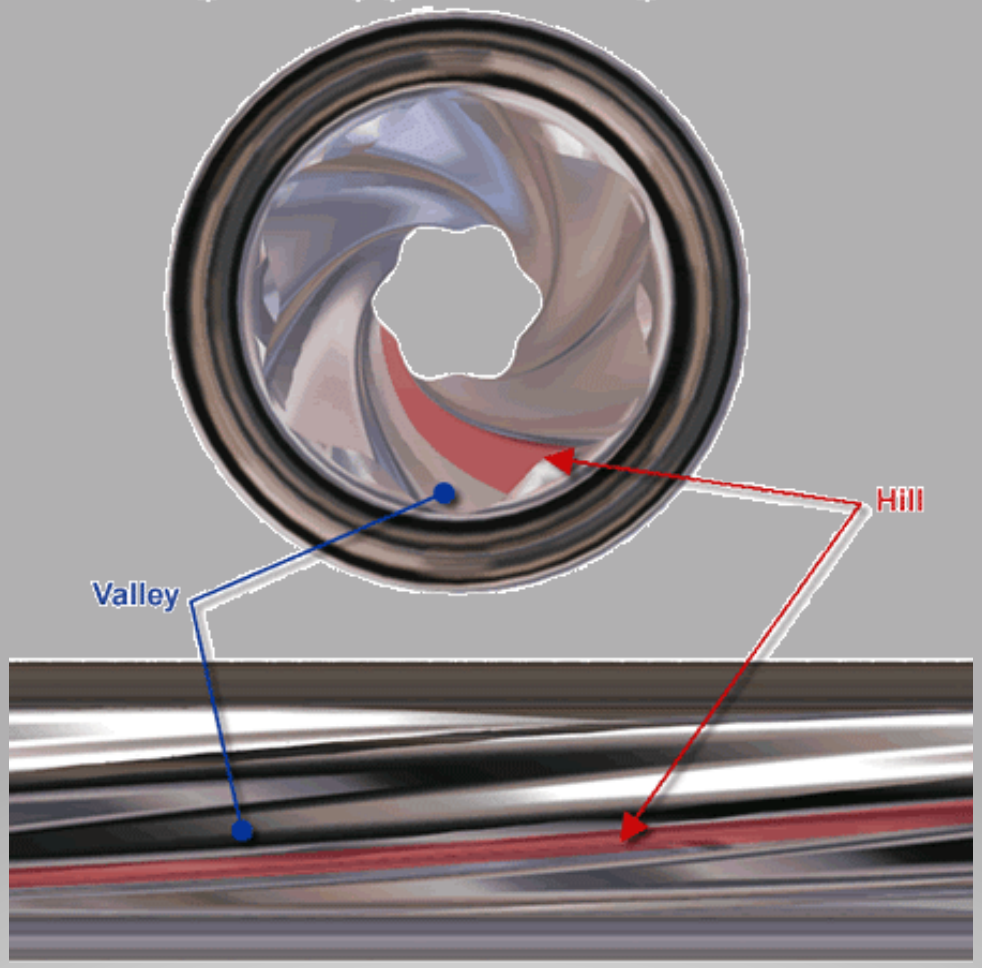
- Standard issue Glock barrels are polygonally rifled and, as a result, they mark bullets poorly.

- Inconclusive results are the norm.

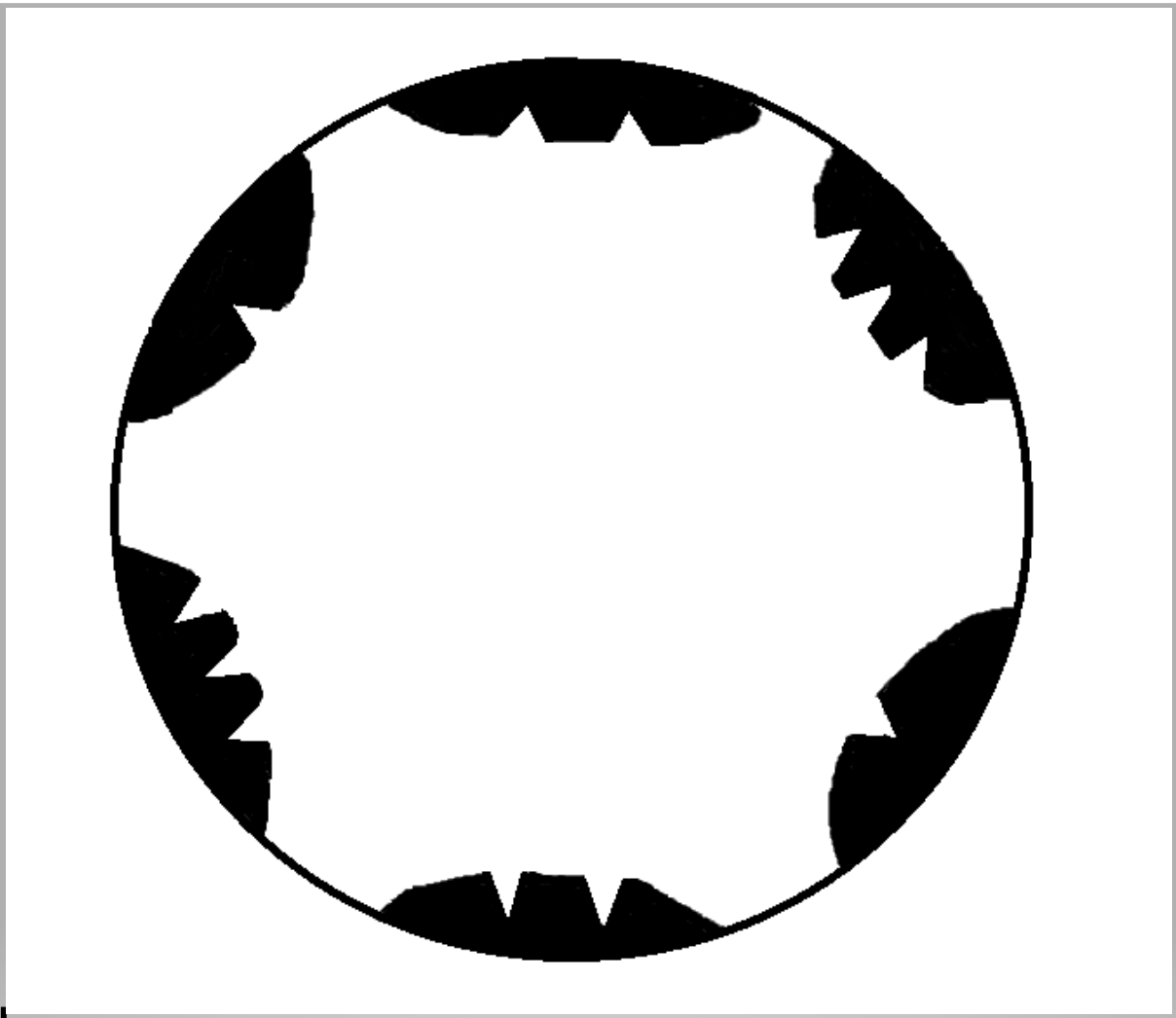


Conventional Polygonal

Hammer Forged
6-Right Polygonal Rifling Pattern

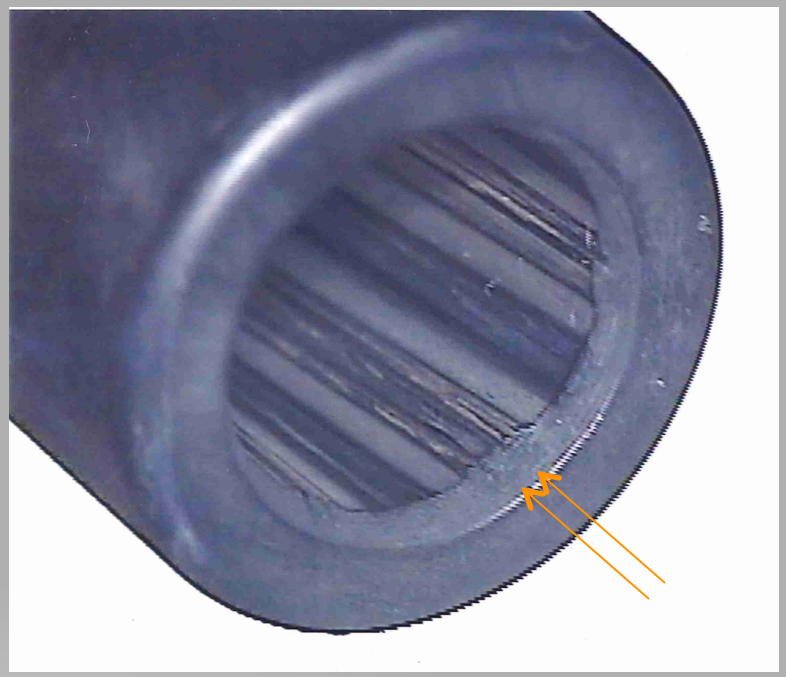


- Police involved shootings where officers all use standard issue Glock barrels of the same caliber are typically inconclusive.
- The EBIS (Enhanced Bullet Identification System) barrel was created for law enforcement to address this issue.

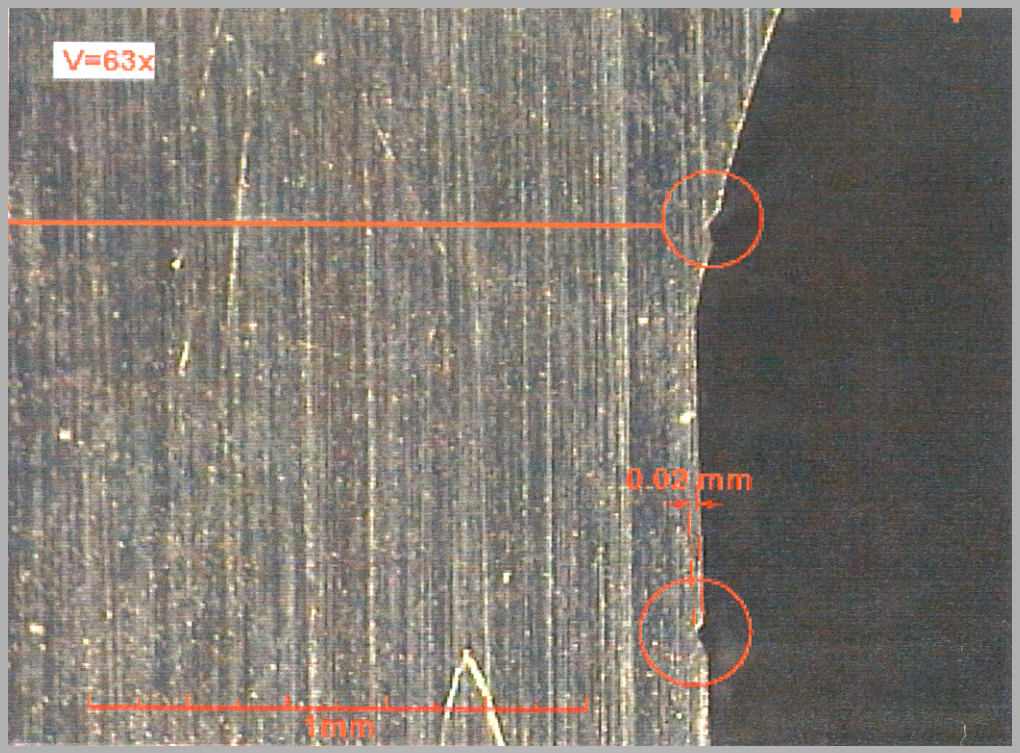


- 180 degrees
- Barcode patterns (channel cuts) vary

Standard Issue

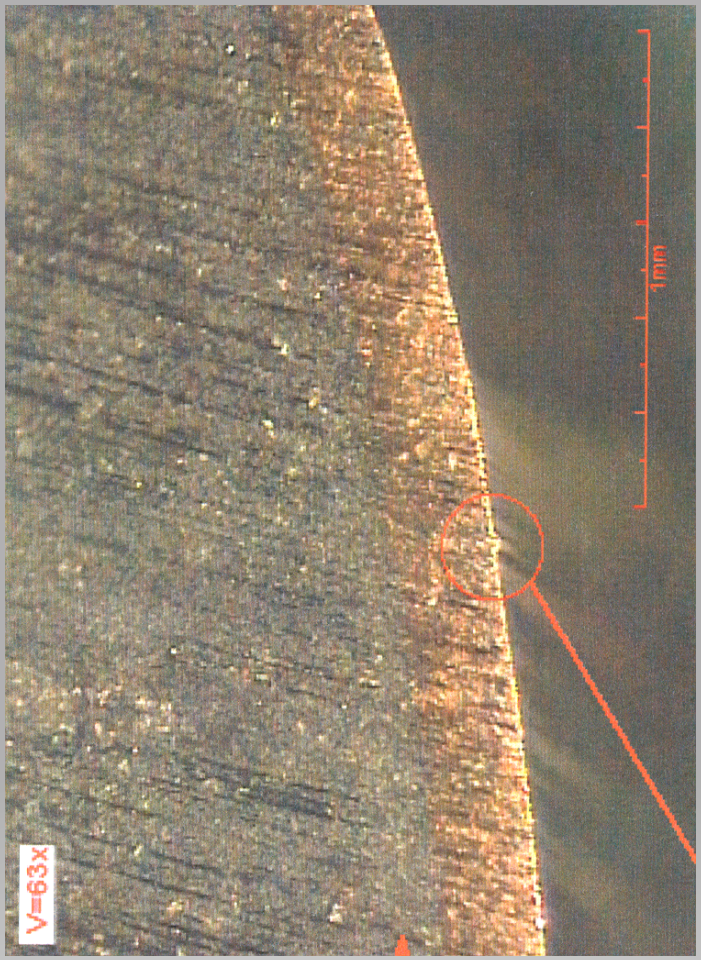


EBIS



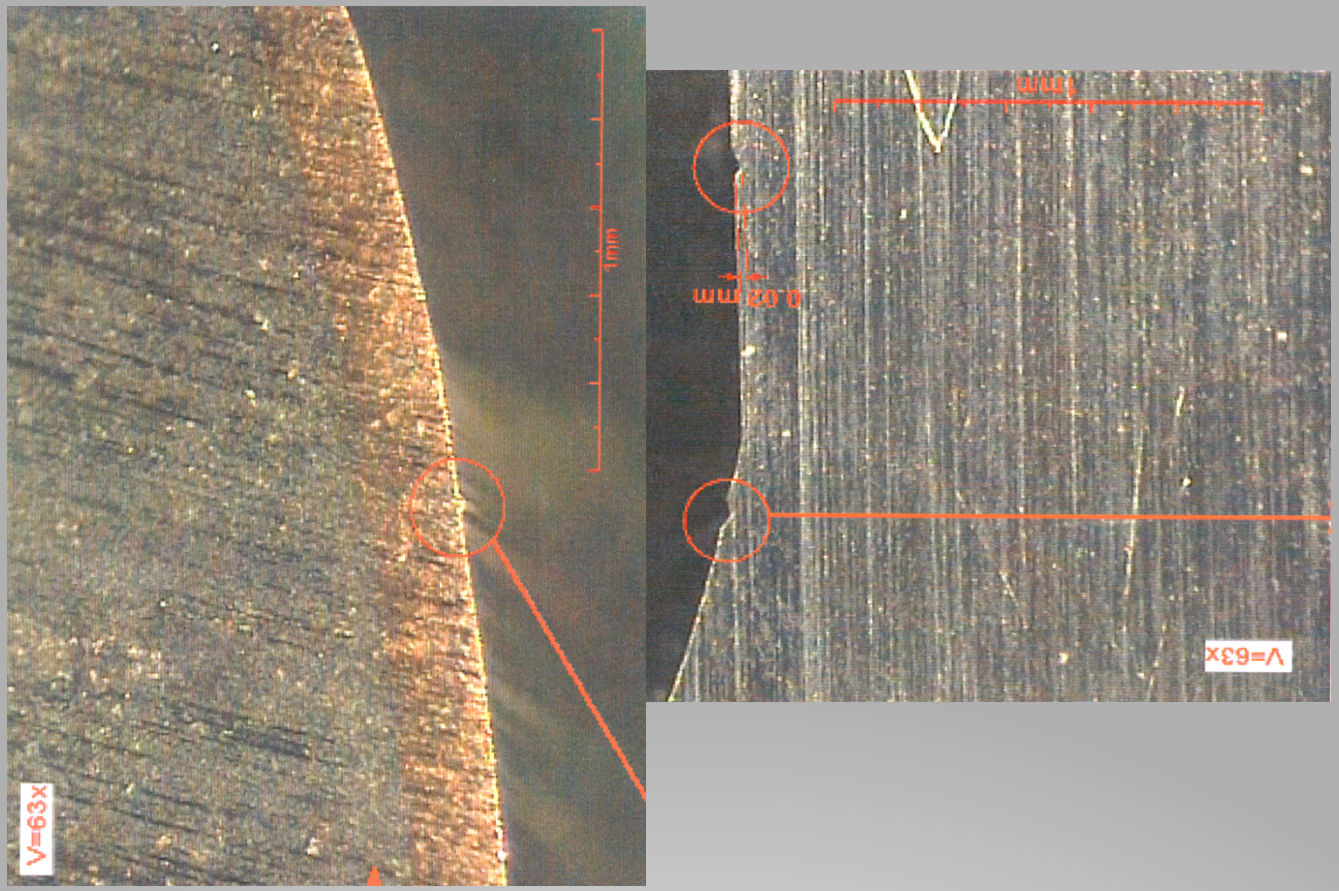
Cut in Barrel Produced by Glock Tool

(Hirschheiter 2002)



Mark in Bullet from Cut in Barrel

(Hirschheiter 2002)



Mark Produced by Cut

(Hirschheiter 2002)

Land Impression from a bullet fired in an EBIS barrel

- Barcode gross marks allow for quick indexing.
- Fine stria surrounding gross marks allow for identification.

Fadul 2011

- 10 Consecutively Manufactured Glock Miami Barrels (EBIS Barrels)
  - The researcher was not present for the manufacture of the barrels.
  - The barrels did not have same barcode pattern.
- Test sets: 15 Unknowns, 10 sets of Knowns.
- 183 participants
- 176 Examiners 100% Correct.
- 7 Examiners did not achieve 100% (11 errors total)
  - 5 = 1 Error
  - 1 = 2 Errors
  - 1 = 4 Errors
- 2734 Correct Identifications
- 0.4% error rate

Further research required:

A better understanding of the manufacturing that adds the barcode-like gross markings was necessary.

Acquiring 10 consecutively manufactured barrels with the same barcode-like gross markings.

Witnessing the process.

- Visit to Glock facility in Deutsch Wagram and Ferlach, Austria.
- Standard Glock polygonal barrels are taken to another machine after the cold hammer forging operation.
- This machine imparts a bar code like pattern on the surfaces of the lands.
- The machine does this by inserting a rod that is outfitted with two cutter wheels situated 180° from each other into the barrels.
- Barcode pattern is locked based on series number.

- Empirical study:
  - To evaluate the repeatability and uniqueness of striations/impressions imparted to bullets from consecutively manufactured EBIS barrels.
  - Determine an error rate for the identification of same gun evidence.
  - Evaluate if experience level of greater than or less than 10 years of experience has any affect on results.

Key Personnel/ Collaborators

- Miami-Dade Police Department Firearm and Toolmark Examiners
  - Acquire materials, prepare the tests for mail out, quality control, etc.
- Statistician from Florida International University
  - Establish error rate from returned data sheets.
- Firearm and Toolmark Examiners from agencies across the United States and Internationally.
  - Pool of Participants.

Research Question and Hypothesis 1

- Q1. Will firearm and tool mark examiners be able to correctly identify the firearms that fired the questioned bullets when examining bullets fired through consecutively manufactured barrels with the same EBIS pattern?

- H1. Firearm and tool mark examiners will be able to correctly identify unknown bullets to the firearms that fired them when examining bullets fired through consecutively manufactured barrels with the same EBIS pattern utilizing individual, unique and repeatable striations/ impressions.

Research Question and Hypothesis 2

- Q2. Will firearm and tool mark examiners with less than 10 years of experience reach the same conclusions than those with greater than 10 years of experience when examining bullets fired through consecutively manufactured barrels with the same EBIS pattern?

- H2. The experience level of firearm and tool mark examiners will not affect identification results when examining bullets fired through consecutively manufactured barrels with the same EBIS pattern.

Participants

- Had to meet the following criteria:
  - Practicing Firearm & Toolmark Examiner
  - Completed a 2 year training program
- Blast email to the Association of Firearm and Tool Mark Examiners (AFTE) membership

Data Collection Methods

- Participants received via mail:
  - Questionnaire/answer sheet
  - 10 questioned projectiles (Unknowns)
  - 8 sets of test fired standards (Knowns)

- Instructions:
  - Examine the questioned projectiles and the known standards
  - Complete the questionnaire/answer sheet
  - Fax, or mail the questionnaire/answer sheet

Questionnaire/Answer sheet

Miami-Dade Police Department
Crime Laboratory
9105 NW 25th Street, Miami, Florida 33172
(305) 471-2050

Firearm & Toolmark Unit

Answer Sheet: Consecutively Rifled **EBIS-2** Test Set Test Number: _____

Name:_____ Male or Female? (Please circle one) Date:_____

Years Experience:_____Years Training:_____Type of Training:_____

Brand & Model of Microscope:_____Type of Lighting:_____

QCMS Trained? Yes No Did you use Pattern Matching, QCMS or Both for this test?_____

Is your Laboratory ASCLD/Lab Accredited? Yes No Other Accreditatation? _____

AFTE Certified? Yes No ABC Certified? Yes No Other Certification? _____

Have you ever encountered the Miami or EBIS Barrel in your case work? Yes No If yes, How many times?_____

Did you participate in the First Miami Barrel / EBIS Study? Yes No

Please microscopically compare the known test shots from each of the 8 barrels with the 10 questioned bullets submitted. Indicate your conclusion(s) by circling the appropriate known test fired set number designator on the same line as the alpha unknown bullet. You also have the option of Inconclusive and Elimination. This test does not have to be done all at one time, but sufficient time to adequately examine this material is necessary. Although the bullets have been scribed on the nose, you may elect to confirm the 'identifier' on the nose and re-scribe it on the base of the bullet.

Unknowns **Knowns** (Barrels 1 through 8)

A. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

B. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

C. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

D. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

E. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

F. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

G. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

H. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

I. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

J. 1……2……3……4……5……6……7……8……Inconclusive……Elimination

Other Results/Comments: _____

Adapted from the Indianapolis-Marion County Forensic Services Agency with the permission of Dr. James E. Hamby

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C.	1……..2…….3……..4…….5…….6……..7……..8……..Inconclusive…….Elimination
D.	1……..2…….3……..4…….5…….6……..7……..8……..Inconclusive…….Elimination
E.	1……..2…….3……..4…….5…….6……..7……..8……..Inconclusive…….Elimination
F.	1……..2…….3……..4…….5…….6……..7……..8……..Inconclusive…….Elimination
G.	1……..2…….3……..4…….5…….6……..7……..8……..Inconclusive…….Elimination
H.	1……..2…….3……..4…….5…….6……..7……..8……..Inconclusive…….Elimination
I.	1……..2…….3……..4…….5…….6……..7……..8……..Inconclusive…….Elimination
J.	1……..2…….3……..4…….5…….6……..7……..8……..Inconclusive…….Elimination

Other Results/Comments: _____

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Questionnaire/Answer Sheet

- For each alpha Unknown, the test taker could choose from eight numeric Knowns, Inconclusive, or Elimination.

- The Questionnaire/answer sheet included an “Other Results/Comments” section as well.

Answer Key

Barrel #	Known	Unknown
Barrel 1	Known 1	C
Barrel 2	Known 2	H
Barrel 3	Known 3	A, F
Barrel 4	Known 4	None
Barrel 5	Known 5	D
Barrel 6	Known 6	I
Barrel 7	Known 7	E
Barrel 8	Known 8	B
Barrel 9	Not provided	G, J
Barrel 10	Not provided	None

Test Answers

- Out of the 8 sets of Known standards, one set did not match any of the Unknowns. (Known 4)
- Two of the Unknowns were eliminations to the 8 sets of Known test fires. However, the two were fired from one barrel and therefore could be matched to each other.
  (G = J)
- Two of the Unknowns were fired in one of the barrels used to fire a set of Known test fires. (A=F=Known 3)
- Each of the remaining Unknowns matched one Known test set.

Data

- 201 participants
- 36 participants with less than 2 years of training
- 165 usable participants → 1650 possible answers.
- There were 12 total incorrect answers made by nine Participants.
- 3 participants from one agency all made the same error.

Straightforward Responses

- 1: **Correct** response: The appropriate Known (barrel designation 1-8) or correct Elimination was circled in correspondence with the Unknowns (letters). 1496
- 2: **Incorrect** response. The incorrect Known (or erroneous Elimination) was circled for the Unknown. 12 (9 participants)

Responses That are Neither Correct nor Incorrect

- 3: **Inconclusive** response. Inconclusive circled for a particular unknown. When referring to G and J specifically, the test taker DID NOT identify Unknowns G and J as having come from one firearm. 46 (42 of which were for G and J)
- 4: **Inconclusive** response. Relating only to Unknowns G and J. Inconclusive circled, test taker DID identify Unknowns G and J to each other. 78 (39 participants)
- 5: "**No Answer"** response. Relating only to Unknowns G and J. NO ANSWER was circled, but the test taker DID identify Unknowns G and J as having come from one firearm. 4 (2 participants)
- 6: "**Elimination, but no Identification"** response. Relating only to Unknowns G and J. The Elimination answer was circled, but the test taker DID NOT identify Unknowns G and J as having come from one firearm. 14 (7 participants)

Inconclusives, "No Answer", and "Elimination, but no Identification" Responses

- The answers that were neither correct nor incorrect were not used to calculate the overall average error rates for this research because they were not considered errors.

- According to Peterson and Markham (1995), inconclusive responses are neither incorrect nor correct and may indeed be the *most appropriate* response in a situation in which the sample, lab policy, and/or examiner capabilities do not permit a more definitive conclusion.

Unknown breakdown

Unknown	Incorrect	Neither Correct nor Incorrect
A	0	2
B	4	0
C	0	0
D	0	0
E	2	1
F	1	1
G	2	69
H	1	0
I	0	0
J	2	69
Total	12	142

Average Error Rate*:

*If responses that are "neither correct nor incorrect" were counted as *incorrect* then the average error would increase.

Error Rate*	Number of Respondents
0	91
0.1	2
0.2	64
0.3	8

[(91x0) + (2 x 0.1) + (64 x 0.2) + (8 x 0.3)] / 165 = 0.09333

0.09333 → 9.333%

Average Error Rate:

An average error rate is calculated by dividing the sum of the error rates per respondent by the total number of respondents.

Error Rate	Number of Respondents
0	156
0.1	6
0.2	3

$$[(156 \times 0) + (6 \times 0.1) + (3 \times 0.2)] / 165 = 0.00727$$

0.00727 → 0.727%

(Responses that are neither correct nor incorrect were not counted as wrong.)

Participants with Incorrect Responses

Participant	Incorrect	Neither Correct nor Incorrect
1	2	0
2	1	2
3	1	2
4	1	2
5	1	2
6	1	0
7	1	0
8	2	0
9	2	0
Total	12	8
	9	6

Same Laboratory

Average Error Rate with Removal of Errors from Same Lab*:

*If responses that are "neither correct nor incorrect" were counted as *incorrect* then the average error would increase.

Error Rate*	Number of Respondents
0	91
0.1	2
0.2	64
0.3	5

[(91 x 0) + (2 x 0.1) + (64 x 0.2) + (5 x 0.3)] / 165 = 0.09333

0.08788 → 8.788%

Average Error Rate with Removal of Errors from Same Lab:

Error Rate	Number of Respondents
0	156
0.1	3
0.2	3

[(156 x 0) + (3 x 0.1) + (3 x 0.2)] / 165 = 0.00727

0.00545 → 0.545%

(Responses that are neither correct nor incorrect were not counted as wrong.)

Results

- **Q1**. Will firearm and tool mark examiners be able to correctly identify the firearms that fired the questioned bullets when examining bullets fired through consecutively manufactured barrels with the same EBIS pattern?
  - **Average Error Rate = 0.00727 (0.727%)**
  - Wilcoxon Signed Rank Test (nonparametric test)
    - p-value = 0.0027
    - Null hypothesis of average error rate equal to zero rejected and conclude that the average error rate is greater than zero
- **H1.** Firearm and tool mark examiners will be able to correctly identify unknown bullets to the firearms that fired them when examining bullets fired through consecutively manufactured barrels with the same EBIS pattern utilizing individual, unique and repeatable striations/impressions.
  - Findings support this hypothesis

Results Continued

- **Q2.** Will firearm and tool mark examiners with less than 10 years of experience reach the same conclusions than those with greater than 10 years of experience when examining bullets fired through consecutively manufactured barrels with the same EBIS pattern?
  - **No significant difference in the error rate**
  - Wilcoxon Signed Rank Test (nonparametric test)
    - p-value = 0.9735
- **H2.** The experience level of firearm and tool mark examiners will not affect identification results when examining bullets fired through consecutively manufactured barrels with the same EBIS pattern.
  - Findings support this hypothesis

Strengths

- The test materials
  - Assembled in a crime laboratory setting
  - Questioned casings and known standards labeled with a letter or number, respectively
  - Containers utilized to keep the questioned casings separated into groups
- Every 10th test set was examined/validated for quality control
- Instrument (Questionnaire/Answer sheet)
  - Documented & used in previous studies
- All testing was conducted in a crime laboratory setting
- Comparison Microscope (Leeds, Leica)
- Trained Firearm & Toolmark Examiners
- Training & Experience of participants
- Large number of participants
- Open test sets in that not every unknown matched a known standard

Limitations

- The researchers had to assume that each participant independently completed the experimental exercise on their own with no outside assistance.

- The researchers had to assume that the equipment utilized was appropriate, properly maintained and in a functional condition.

- The possibility exists that the questioned projectiles and known standards failed to mark clearly. Since every set was not microscopically examined to ensure that the projectiles were comparable and identifiable, some sets may have contained projectiles that were not suitable for identification.

- The validity of this study was dependent upon the accuracy of the assembly of the tests.

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- The opinions, findings, and conclusions or recommendations expressed in this publication/ program/exhibition are those of the authors and do not necessarily reflect those of the Department of Justice.

Questions