Evaluating Phases of Forensic Practice

Comparative Bullet Lead Analysis
There is nothing so useless as doing efficiently that which should not be done at all.

Peter F. Drucker
Definition:

comparative bullet lead analysis  
(CBLA)

The process of comparing compositions of ‘questioned’ & ‘known’ bullets or bullet fragments in an effort to associate them as originating from a common “molten source of lead” (“batch” or “lot”)
“[T]he bullets must have come from the same box or from another box that would have been made by the same company on the same day”

United States v. Davis, 103 F.3d 660 (8th Cir. 1996)

“[B]ullets from the victim and [suspect’s custody]…came from the same source, were manufactured in the same batch, and probably came in the same box.”

Billet Production

Secondary refiner
“molten source”
~100 tons

Bullet Mfr. A

Bullet Mfr. B

ingots

re-melt

premium

billet
to extrusion presses
Billet Extrusion Into Wire

force

billet

wire

extrusion die cross-section

- lead alloy
Phase 1: Compositional Analysis
(data acquisition by NAA or ICP)

Phase 2: Composition grouping

Phase 3: Inference (conclusions)
Forensic Practice

Phase 1

Compositional Analyses
Analytes (Elements) Measured to Characterize “Source”

- antimony (Sb)
- arsenic (As)
- copper (Cu)
- tin (Sn)
- bismuth (Bi)
- silver (Ag)
- cadmium (Cd)
Comparative Bullet Lead Analysis (CBLA)

Basic Underlying Theory:

same composition = same source
Questions To Be Addressed

(1) What assumptions are required for inference to be valid?

(2) What required phase is missing from ‘perceived’/actual process?
Q. What assumptions are required for inference to be valid?*

A. (a) sample is **representative**
   (b) source is **homogeneous**
   (c) source is **unique**

* generic inference: *same composition = same ‘source’*
Number of 50 mg. forensic samples in 100 tons:

1.81 billion
Homogeneous Analyte Distribution in Source

- Analyte Concentration
- Sample Timing

B M E
Antimony Distribution in 100 Ton Source

Antimony Content of Source vs. Sample Timing

G Source, 28 lots at ~ 100 tons (200,000 lbs.) each

Sample Timing
Antimony (Sb) Content (wt.%)
Research Study Observations

- “Repeat” compositions not uncommon (disproving premise of source uniqueness)

- Dramatic composition differences within lots (disproving premise of source homogeneity) (disproving premise of representative sample)

- No meaningful studies of homogeneity

- No meaningful studies of “repeats”

- No meaningful studies of distribution
Forensic Practice

Phase 2

Composition Grouping
<table>
<thead>
<tr>
<th>Specimen</th>
<th>Antimony (Sb) Content (wt.%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.7512</td>
</tr>
<tr>
<td>A2</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td></td>
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<tr>
<td>B1</td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>0.7601</td>
</tr>
<tr>
<td>B3</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>0.7699</td>
</tr>
<tr>
<td>C3</td>
<td></td>
</tr>
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<td>D1</td>
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</tr>
<tr>
<td>D2</td>
<td>0.7800</td>
</tr>
<tr>
<td>D3</td>
<td></td>
</tr>
</tbody>
</table>
“Distinguishable” Specimens

Composition

........................................

........................................

........................................

........................................
“Indistinguishable” Specimens
Composition Grouping

- Unofficial 1 sigma “match” criterion until June 1998

- Official 2 sigma “match” criterion after June 1998

- Chaining of data (vs. clustering)
How distinguishable specimens can become indistinguishable

► by data chaining

► change “match criterion”
By chaining, ‘D’ can become “analytically indistinguishable” from ‘A’ if ...
...enough samples are submitted
“Distinguishable” Specimens

Composition

A

D
By changing ‘match’ criterion from 1 sigma to 2 sigma, ‘D’ becomes “analytically indistinguishable” from ‘A’
Imprecision Creates Artificial ‘Matches’
Imprecision Creates Artificial ‘Matches’

The more ‘sloppy’ the analysis, the more incriminating the same evidence becomes.
Phases of CBLA Practice

Phase 1: Compositional Analysis
Phase 2: Composition grouping
Phase 3: Assess probative value
Phase 3: Inference (conclusions)
Inference must have probative value
“A originated from B”
(“individualization” or “specific source attribution”)

Examples:

(a) The A bullets were fired from the B gun
(b) The A item came from the B source
Specific Source Attribution

Two Critical Issues:

1. Is it true?
2. Is it probative?
Logical Argument Classifications

Induction

Caution 1: Most vulnerable to fallacious reasoning from various fallacies of presumption, such as false dichotomy, *principio petitii*, suppressed evidence, *inter alia*.

Caution 2: There exists no combination of samples that will allow 100% confidence (as exists for deductive reasoning).
Principle 2
(for source attribution)

Inference from empirical induction (all forensic practices) should have associated scientifically founded statement of confidence.
Principle 3
(for source attribution)

Insure all metrics are relevant
Discriminants

“I examined for, and compared, all 103 elements in the periodic table. I conclude the items are identical and from the same source.”
Principle 4
(for source attribution)

In sure all metrics are scientifically established as effective discriminants
Realities of Analyte Presence

- Cadmium (Cd) is almost never present
- When it is present, is usually ~ 1 or 2 ppm
- Tin (Sn) is most frequently not present
- Bismuth (Bi) is almost always in very narrow range (~85-110 ppm)
- Silver (Ag) is almost always in very narrow range (15-30 ppm)

These realities reduce effective analyte discriminants to 3, determined by Lukens, *et al.*, to be inadequate.
Analytes (Elements) Presently Measured to Characterize “Source”

- antimony (Sb)
- arsenic (As)
- copper (Cu)
- tin (Sn) (not generally present)
- bismuth (Bi) (very narrow range)
- silver (Ag) (very narrow range)
- cadmium (Cd) (almost never present)
Discriminants

“I examined for, and compared, all 7 relevant chemical elements. I conclude items are analytically indistinguishable and from the same source.”
Even if it is a “match”:

So what?
Assessment of Probative Value
(‘match’ significance)

Seminal Issue

What is the likelihood of a coincidental "match"?
## Retail Sampling

**Fred Meyer, Juneau, Alaska, 04/16/03**

<table>
<thead>
<tr>
<th>Remington (Thunderbolt .22 LR)</th>
<th>Remington (.22 LR)</th>
<th>Federal (.22 Win Mag, JHP)</th>
<th>CCI (.22 LR)</th>
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</thead>
<tbody>
<tr>
<td>K02P1D</td>
<td>K02P1D</td>
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<td>M08G08</td>
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<tr>
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<td>M08G08</td>
</tr>
<tr>
<td>K02P1D</td>
<td>K02P2A</td>
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<td>M08G08</td>
</tr>
<tr>
<td>K02P1D</td>
<td>K02P2A</td>
<td>MF2089</td>
<td>M08G08</td>
</tr>
<tr>
<td>K02P1D</td>
<td>K02P2A</td>
<td>MF2089</td>
<td>M08G08</td>
</tr>
<tr>
<td>K02P1D</td>
<td>K02P2A</td>
<td>MF2089</td>
<td>M08G08</td>
</tr>
<tr>
<td>K02P1D</td>
<td>79%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Phases of CBLA Practice

Phase 1: Compositional Analysis
Phase 2: Composition grouping
Phase 3: Assess probative value
Phase 3: Inference (conclusions)
**Inference**
(conclusion)

CBLA Analogy: blood testing

**Analyses:** (blood) Fe, K, Na, HDL, LDL

**Comparisons:** “analytically indistinguishable”

**Conclusion:** same source (parents)
Summary of Research

- Bullets not necessarily representative samples of their source. Forensic examiner has no way of making that determination.

- Compositional bullet “matches” are invalid for both inclusion and exclusion inference as to source.

- The only possible probative value of a “match” supported by present information and data is that ‘questioned’ bullet(s) could have originated from same “source” as ‘known’ bullet(s).

- Composition “match” is less probative than caliber.

- No validation studies ever conducted of “same composition = same source” hypothesis
Systemic Bias

Observer effects

- Expectation bias
- Confirmation bias
- Contextual bias
Evett / Williams Report

- British 16-point standard
- Rooted in historical anecdote
- No scientific basis (arbitrary)
- Examiners evaluate to standard
- test asked examiners how many pts. of similarity w/same fingerprint
- 16 pt. British “standard” for many agencies
- when respondents found 15, they looked extra hard for 16th
- i.e., examiners evaluated to the standard
Myth of Infallibility

“Fingerprints are absolute and infallible.”

“It’s error rate is zero.”

IAI certification exam failure rates were documented at 48% (1993) allowing 3 false negatives but no false positives on 15 source attributions (12 required)

1 David Meagher, FBI fingerprint head to Leslie Stahl, 60 Minutes, Jan. 5, 2003.
Error Rates for Pattern Matching

How can a process commit so many errors and still be considered “infallible”? “rhetorical strategy to isolate, minimize and otherwise dismiss all exposed cases of error as “special cases”, “one-offs”, etc.” by attributing error exclusively to practitioner error and never to methodology.

Five LFP experts as participants
Total of 85 years’ experience (mean = 17)
International LFP expert pool
(US, UK, Israel, Netherlands, Australia)
Experts not familiar with Mayfield’s fingerprints
Experts with past archival source attributions
Each pair of fingerprints had been identified by same expert as “match” in 2000 (test in 2005)

Contextual Biasing Information Affects Judgment & Decision-Making

80% changed source attribution decisions

- Changed to "no match" (3)
- Changed to "can't decide" (1)
- Consistent decision (1)
Navigating the Minefield of Pragmatism in Forensic Practice

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