PATTERN MATCHING INDIVIDUALIZATION

Firearms/Toolmarks

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Basis of F/TM Examinations

tribology

the study of *friction*, *lubrication* and *wear*, of objects in *contact* and *relative motion*

Basis of F/TM Examinations

Characteristics used by F/TM examiners for comparisons:

- striations (striae)
- impressions

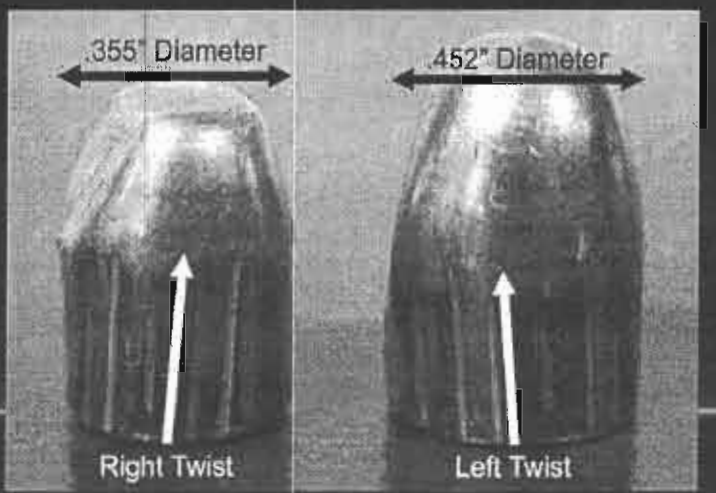
Basis of F/TM Examinations

Categories of Characteristics

- Class (design)
- Subclass (manufacturing)
- Individual (incidental)

Basis of F/TM Examinations

- **Class** characteristics are those of the largest group (population) of possible samples and generally originate in the design phase. Examples are # of lands & grooves, and direction of twist, of bullets:



Basis of F/TM Examinations

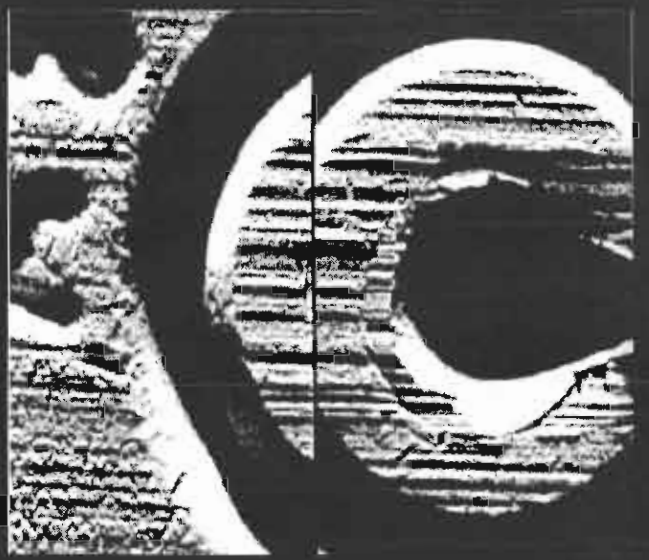
- **Subclass** characteristics are those shared by a subset of the previously defined population, and generally originate in the production phase. Examples are striations (scratches) imparted to work pieces during reaming, broaching, forging, blanking, *etc*.

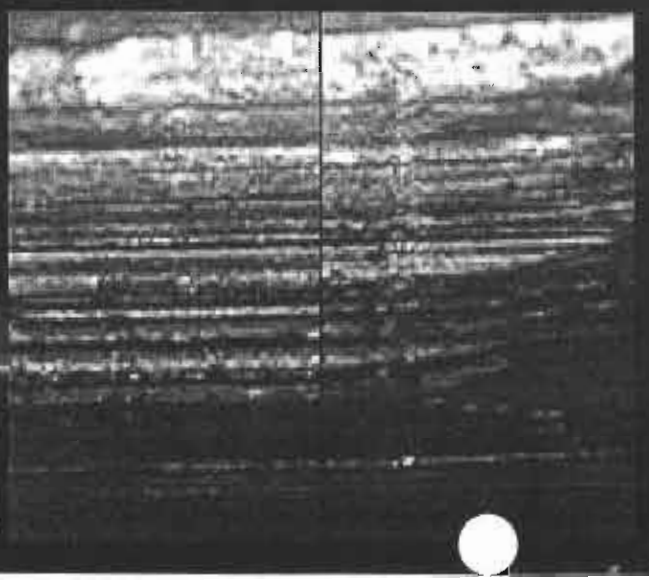
Basis of F/TM Examinations

- Individual characteristics are, *by definition*, unique to a particular tool/firearm & typically derive from irregularities in the production process and/or events incidental to service use.

Basis of F/TM Examinations

Tools: *Comparison Microscope*





Basis of F/TM Examinations

AFTE Theory of Identification

"... toolmarks enables opinions of common origin to be made when the *unique* surface contours of two toolmarks are in *sufficient* agreement."

"... [t]his *sufficient* agreement is *related* to the *significant* duplication of random toolmarks 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... Agreement is significant when it exceeds the best agreement demonstrated between two toolmarks known to have been produced by different tools and is consistent with agreement demonstrated by toolmarks known to have been produced by the same tool. The statement that sufficient agreement exists between two toolmarks means that the likelihood another tool could have made the mark can be considered a practical impossibility.

The current interpretation of individualization/identification is subjective in nature, founded on scientific principles and *based on the examiner's training and experience*."

In Other Words...

The examiner is told to think back to the best matching *non-match* he can remember. If he can't remember a better match than what he's seeing now, it's an individualization.

AFTE Recognition of Underlying Problems & Courts Rejecting or Limiting Testimonies

"Problem Statement and Potential Benefits: The absence of established objective criteria for what constitutes identity or non-identity has prevented the discipline of toolmark identification (includes firearms identification, see Ref. 1) from attaining the status of a true science. The traditional reliance on subjective criteria of identification is both *inefficient & ineffective*..."

Biasotti, A. A., Research Proposal to FBI Academy, 10/21/83

Basis of F/TM Examinations

Two Required Premises for Validity of Specific Source Attributions

- Uniqueness
- Repeatability

Basis of F/TM Examinations

Uniqueness

- How unique is 'unique'?
- Two issues:
  - Esoteric, idealistic: existence of
  - Pragmatic: discernible

Basis of F/TM Examinations

Repeatability:

- repeated firings
- manufacturing

Problematic Aspects of AFTE Theory of Identification

1) no articulated protocol[1]
2) no parameters of detection[2]
3) no rules of application[3]
4) "subclass" *vs*. "individual"

1 "*Strengthening Forensic Science in the United States: A Path Forward*," National Academy of Science; National Acad. Press (2009), p.155.
2 Cole, S., "Forensics without uniqueness, conclusions without individualization: the new epistemology of forensic identification," *Law, Probability & Risk*, (2009) 8, at 244.
3 *Ibid*.

Basis of F/TM Examinations

4) "Subclass" *vs.* "Individual"

"Subclass" characteristics:

- belong to group (population subset) of samples
- derive from manufacturing processes

"Individual" characteristics:

- F/TM examiners believe are unique to firearm
- derive from anomalies in manufacturing processes and/or from product service use

Basis of F/TM Examinations

4) "Subclass" *vs.* "Individual"

- no defined criteria for discerning "individual"
- no literature describing process of discerning
- no meaningful or comprehensive studies
- completely subjective labeling of "individual"
  (What makes mark 'unique'? How do you know it's 'unique'?)
- basically "I know it when I see it
- no feedback loop for error detection

THIS PROCESS

Subclass vs. Individual

- To this day, there is still no working methodology for distinguishing individual from subclass characteristics.
- Subclass marks are, by all appearances, "individual" marks that easily turn out not to be individual after all
- Literature provides examples where subclass characteristics are/were easily confused with purportedly individual characteristics

Subclass vs. Individual

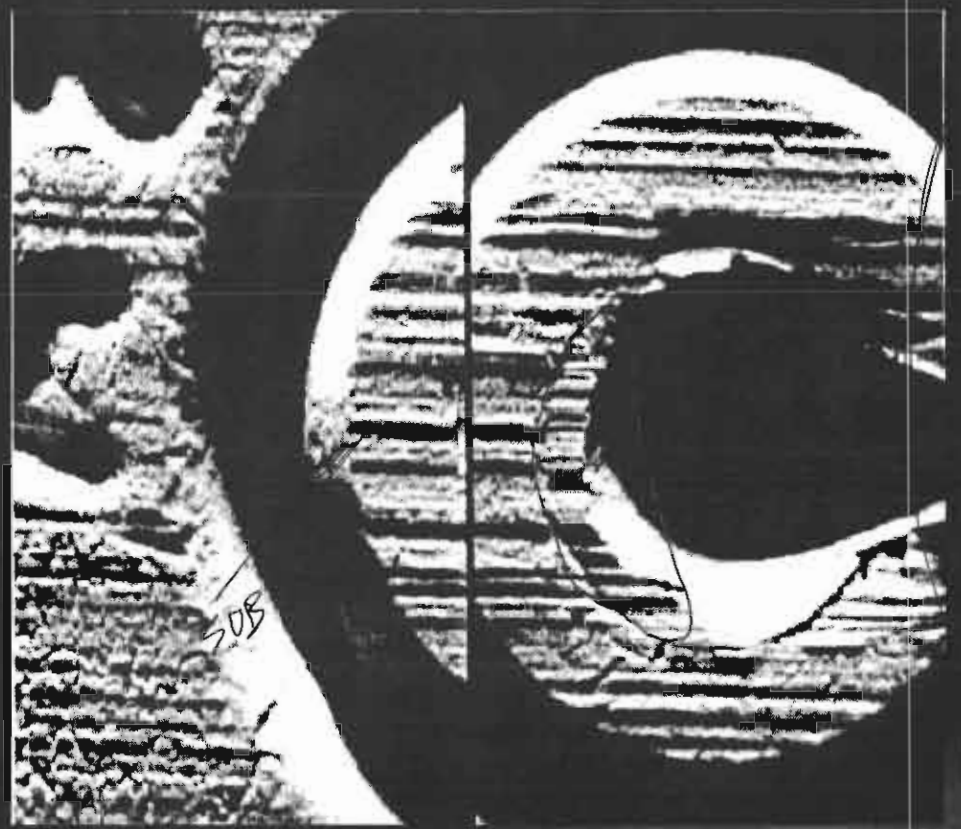
Warning Signs that Problem is Real

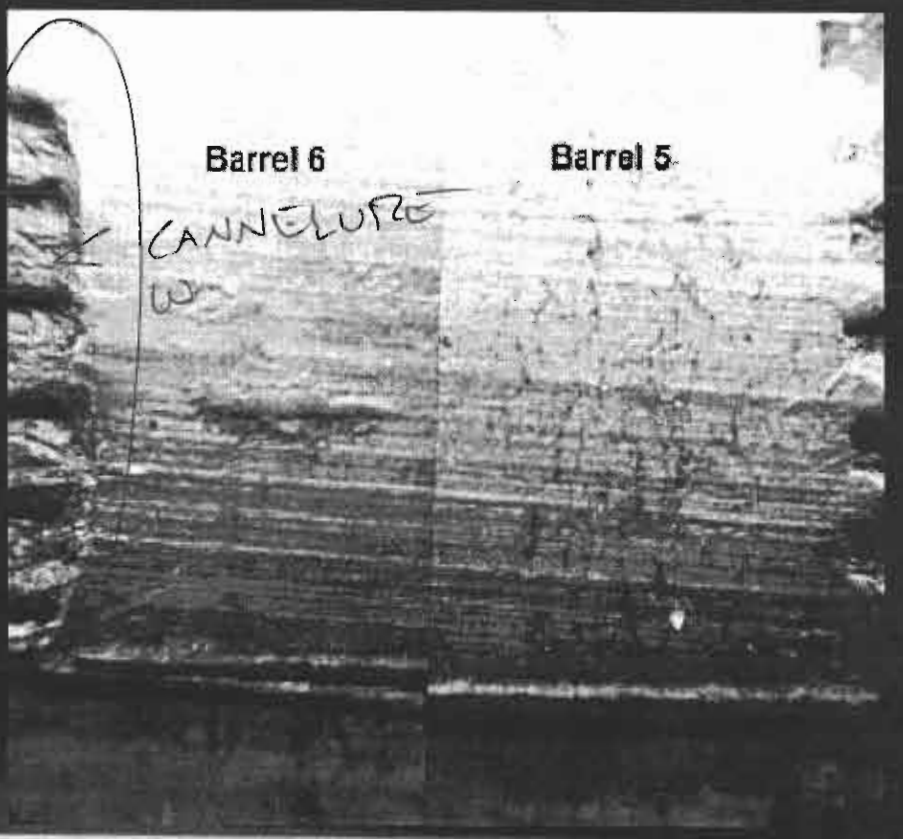
- Studies show that bullets and cartridge cases fired from different weapons can and sometimes do have more matching marks than bullets fired from the same weapon. (Miller)
- As federal databases have grown, known non-matches have appeared closer to the top of the candidate list than known matches

SOURCE?

Subclass vs. Individual

Identification, Inconclusive, or Elimination?





Left: Rivera, Gene C., "Subclass Characteristics in Smith & Wesson SW40VE Sigma Pistols", *AFTE J.* 39(3), Summer 2007, at 247.
Right: Tulleners & Hamiel, "Sub Class Characteristics of Sequentially Rifled 38 Special S&W Revolver Barrels", *AFTE J.* 31(2), Spring 1999 at 118.

Subclass vs. Individual

Effects of Technology

- "[M]ass production of guns has replaced hand-manufacturing" *US v. Mouzone*
- Manufacture under "precisely controlled" conditions imparts "recurring patterns" of marks. D. Baldwin, *Statistical Tools*
- Tools used to create firearms have become more durable, enabling their use in ever-larger production runs. P. Kirk, *Crime Investigation*

Basis of F/TM Examinations

"Validation Studies"

Firearms/Toolmarks

Practice Lacks Indicia of Scientific Reliability:

- *no articulated protocol*
- *no parameters of detection defined*
- *no rules governing evaluation to define "same" or "different"*
- *no indicia for repeatability*
- *no indicia for reproducibility*

Firearms/Toolmarks

Cannot "validate" subjective practice:

- *no parameters of detection*
- *rules of evaluation*
- *no access to "ground truth"*
- *no scientifically acceptable probabilistic model*

Firearms/Toolmarks

Hamby & Brundage 10-Gun Study

Many Problems Identified With Study

- Number of guns studied (10) is too small to be meaningful
- Only one type of firearm studied (& mfrd. in 1985)
- Only one type of ammunition studied
- Bullets fired into water tank, so they were not damaged as they often are in casework
- The study is a "subjective evaluation" without documentation, such as photography, and is "only of value to the examiner who conducted the study." Biasotti & Murdock
- Entire sample pool presented contemporaneously
- Many more...(non-blind, respondent selection, *inter alia*)

Firearms/Toolmarks

Internal vs. External Validity

Internal validity: *basic minimum without which any experiment is uninterpretable ("Did experimental treatments make a difference in this specific experimental instance?")*

External validity: *generalizability. ("To what populations, treatment variables, inter alia, can this effect be generalized?")*

Firearms/Toolmarks

Analysis of Studies

Firearms/Toolmarks

"Analysis of Experiments in Forensic Firearms/Toolmarks Practice Offered As Supoport for Low Rates of Practice Error and Claims of Inferential Certainty"[1]

[1]Spiegelman, C. & Tobin, W. A., accepted for publication in *Law, Probability & Risk*, available online `late 2012, publication ~ spring 2013.

Firearms/Toolmarks

Abstract: This paper critically evaluates experiments used to justify inferences of specific source attribution ('individualization') to "100% certainty" and "near-zero" rates of error claimed by firearm toolmark examiners in court testimonies, and suggests approaches for establishing statistical foundations for firearm toolmarks practice that two recent National Academy of Science reports confirm do not currently exist. Issues that should be considered in the earliest stages of statistical foundational development for firearm toolmarks are discussed.

Numerous Flaws Identified in Purported "Validation Studies" & "Proficiency Tests"

- Do not replicate casework
- Entire possible sample pool presented (deduction *vs*. induction)
- Neither double-blind nor blind
- Do not count "inconclusives"
- No external validity
- Sample sizes too small to be meaningful
- Only one type of firearm studied
- Only one type of ammunition studied
- Bullets pre-examined to insure clarity of characteristics
- Bullets in pristine condition (fired into water tank, not damaged as they often are in casework)
- Studies are subjective evaluations without documentation, such as photography and descriptions of which characteristics used for "match" (Type III errors) and "only of value to the examiners who conducted the study." Biasotti & Murdock
- No controls over collaborative efforts
- Unlimited time
- Self-selected respondents
- Survivorship bias

Firearms/Toolmarks

Rates of Error

(Misattributions, Misidentifications)

Firearms/Toolmarks

Rates of Error
(Misattributions, Misidentifications)

Practitioners claim 0 to 1% rate of error in the profession

Firearms/Toolmarks

Rates of Error

(Misattributions, Misidentifications)

2.3% (#2: 3/130) Lowell Bradford, "Forensic Firearms Identification: Competence or Incompetence?", *AFTE J.*, Vol.2, No.2, Apr. 1979

3.8% (#2 test (5/132) reported by Bradford, correction of), Thornton, J, Nationwide Crime Lab Proficiency Project, *AFTE J.*, Vol.2, No.2 (Apr. 1979)

5.7% **misidentifications**; Lowell Bradford & John Thornton, no disagreement (see both Bradford & Thornton articles cited here); probably referring to LEAA testing (see 28.2% comments, below)

3-8% Peterson, Markham, "Crime Laboratory Proficiency Testing Results, 1978-1991, II: Resolving Questions of Common Origin", *J.For.Sci.*, (1995), at 1019.

8.8% (#3-5/57) Lowell Bradford, "Forensic Firearms Identification: Competence or Incompetence?", AFTE J., Vol.2, No.2, Apr. 1979

9.1% "**clearly in error**" (excludes 'inconclusives'): Randolph Jonakait, "Forensic Science: The Need for Regulation", *Harvard J. of Law & Tech.* Vol. 4, Spring 1991 at 111, citing LEAA rept of Peterson, Fabricant & Field, "Crime Laboratory Proficiency Testing Research Program 26 (1978), at 238.

10% "Detroit PD Firearms Unit, Prelim.Audit Findings as of Sept.23, 2008", Rept. of MSP For.Sci.Div: available at: http://www.sado.org/crimelab/MSP%20Audit%20Findings%20of%20September%2023%202008.pdf

12% Peterson & Markham (1995), "Crime Lab Prof.Tstg Results 1978-1991 II", *J.ForSci* 1009, et al.

24%

28% "**unacceptable results**" as "**misidentifications**", Lowell Bradford, "Forensic Firearms Identification: Competence or Incompetence?", AFTE J., Vol.2, No.2, Apr. 1979, poss. referring to LEAA testing, below

28.2% "**unacceptable results**", include wrong outcomes, Type 3 errors, inconclusive unsupported by analytical results

Firearms/Toolmarks

Notable Misattributions (Misidentifications)

- ✓ Evan Thompson (F/TM examiner), claimed during TV interview that firing pin impressions are unique. Audit of 13 of his cases found errors in all; investigation expanded. (www.komonews.com/news/7231231)
- ✓ "Review of LAPD ballistics unit after botched test in murder case; charges dropped against LA sheriff's deputy", *Law Enforcement News*, Vol. XV, No. 295, June 30, 1989. Article makes reference to "…wrong identifications were made, statements were made about evidence that were clearly incorrect." Article also cites DeWayne Wolfer, former LAPD criminalist who misread evidence in 1968 assassination of Senator Robert F. Kennedy.

Firearms/Toolmarks

Notable Misattributions (Misidentifications)

"Review of LAPD ballistics unit after botched test in murder case; charges dropped against LA sheriff's deputy", *Law Enforcement News*, Vol. XV, No. 295, June 30, 1989. Account of false positives in CA used to charge deputy with murder; similarities observed between marks on cartridge casings (breech marks) and bullets but, according to independent experts, undue significance was attributed to those similarities which happened to be coincidental & insufficient to support ID (and, in fact, showed an exclusion). Independent examiner Morton: "It was clearly an exclusion. It was not an identification at all. It was flat-out error on the part of LAPD. *Id.* at 7." John Murdock quote: Firearms identification is an "area that is somewhat problematic in forensic science because the determinations that are made are mostly subjective in nature and they're based on the experience of the examiner. Let's face it, *an examiner can be around for a number of years and not have the right kinds of experience*." *Id.*

"What a skilled examiner has to do is know what's significant & what's not significant...I think what happened in this case was they simply misinterpreted the limited agreement that was present, Murdock said, alluding to the breech block striations left on cartridge casings after firing." *Id.*

Examiner was 19-year veteran Det. Jimmy Trahin, who trained scores of police officers in subject of weapons & ammunition analysis. His report did not mention differences in marks made…said test bullets fired from deputy's gun were "positive" matches to those which killed victims, and underlined the word "positive." Said shots "could have been fired only by [deputy's] gun & no other weapon." *Id.*

Firearms/Toolmarks

Notable Misattributions (Misidentifications)

***Ronald E. Trotter, Appellant v. State of Missouri, Respondent*, No. 38939,**
736 S.W.2d 536 (Aug. 4, 1987).

Police officer Phillip Miller shot at scene. Officer's service revolver, a .38 caliber Smith & Wesson, not found on his body. Subsequently died from gunshot wounds to his chest. ***538** Initially the police thought Officer Miller was killed with his own revolver, since revolver was missing and a .38 caliber slug was removed from his body. Theory later abandoned when Larry Hall was apprehended after shooting at Officer Fred Phillips and gun used by Hall was recovered.

Ballistic tests performed by John Cayton of Regional Criminalistics Laboratory on Hall's gun. Mr. Cayton testified at defendant's trial that it was his opinion that the .357 magnum revolver used by Hall to assault Officer Phillips also fired the .38 caliber slug removed from Officer Miller's body. No direct connection between Hall & defendant, nor between defendant & the .357 revolver, was shown at trial.

Sometime after trial, Officer Miller's gun was recovered & examined by John Cayton. Mr. Cayton subsequently testified that **he is now of the opinion** that it was Officer Miller's gun, and not the .357 magnum recovered from Hall and used by the State in defendant's trial, which caused the death of Officer Miller.

Firearms/Toolmarks

Notable Misattributions (Misidentifications)

Williams v. Quarterman

551 F.3d 352 (Dec. 9, 2008)
(Westlaw 10_48_42)

F/TM expert (Baldwin) testified bullet was .25 caliber & fired from specific .25 caliber pistol; later determined to be, in fact, a .22 caliber bullet.

(Note also class characterization error)

Firearms/Toolmarks

Examiner Conclusions

Firearms/Toolmarks

Conclusions of "same firearm", "same barrel" (individualizations) constitute the same inferences addressed by NAS as implicit "extreme probability statements" that are without scientific foundation.

Firearms/Toolmarks

National Academy of Sciences Reports:

- "2008 Ballistic Imaging"
- "2009 Strengthening Forensic Science in U.S."

National Academy of Sciences

"Conclusions drawn in firearms identification should not be made to imply the presence of a firm statistical basis when none has been demonstrated. ...[E]xaminers tend to cast their assessments in bold absolutes, commonly asserting that a match can be made "to the exclusion of all other firearms in the world." *Such comments cloak an inherently subjective assessment of a match with an extreme probability statement that has no firm grounding and unrealistically implies an error rate of zero.*"

"Ballistic Imaging", National Research Council, NAS, (2008) at 82.

National Academy of Sciences

"With the exception of nuclear DNA analysis, however, no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between evidence and a specific individual or source".[1]

[1] "Strengthening Forensic Science in the U.S.", National Research Council, NAS, (2009) at S5.

National Academy of Sciences

"Since the basis of all forensic identification is probability theory, examiners can never really assert a conclusion of an identification to the exclusion of all others in the world [individualization]....

It is ironic that those areas of forensic science that have real underlying data offer more modest statements of individualization, while those limited to subjective or impressionistic data make the strongest statements, sometimes of absolute certainty."

"Ballistic Imaging", National Research Council, NAS, (2008) at 82.

Practitioner Error Influences

- Observer effects
  - Expectation bias
  - Confirmation bias
  - Contextual bias
- Cognitive retention

(for pattern recognition)

Practitioner Error Influences

Examples

Position of Expert's Client

In asbestos damage study, plaintiff-hired radiologists found evidence of possible asbestos-related abnormalities in 95.9% of the cases presented.*

When independent radiologists at Johns Hopkins University reinterpreted the same x-rays, they found abnormalities in just 4.5% of the cases.

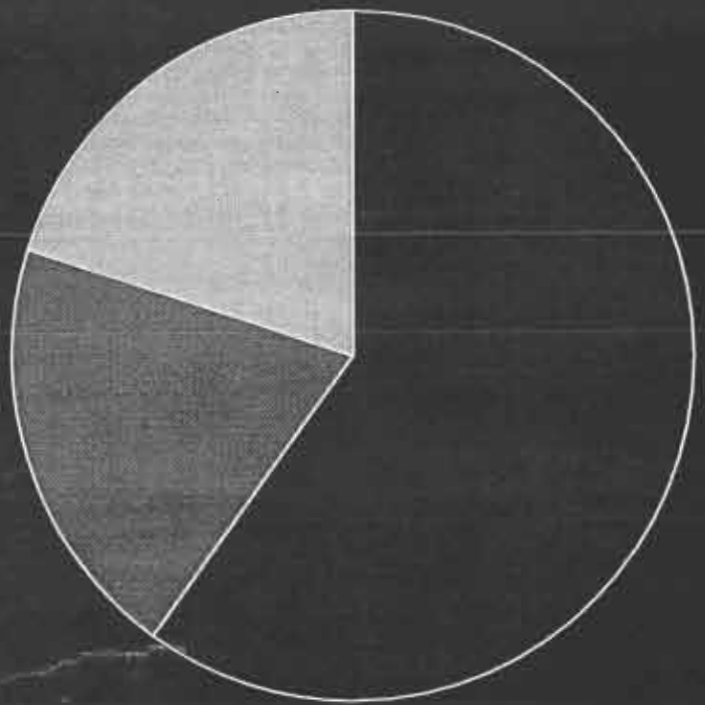
* "Study Points to Abuse", Mark A. Behrens & Phil S. Goldberg, *Nat Law J*, Nov. 1, 2004, at 19.

Contextual Biasing Information Affects Judgment & Decision-Making

- Five LFP experts as participants
- Total of 85 years' experience (mean = 17)
- International LFP expert pool
  (US, UK, Israel, Netherlands, Australia)
- Experts naïve re 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)

Dror, Itiel E., *et al.*, "Contextual Information Renders Experts Vulnerable to Making Erroneous Identifications", *For Sci Intl.* 156 (2006) 74-78.

Contextual Biasing Information Affects Judgment & Decision-Making



- Changed to "no match" (3)
- Changed to "can't decide" (1)
- Consistent decision (1)

80% changed source attribution decisions