SHAPES, LABELS, and TERMS
IN
FORENSIC COMPARATIVE SCIENCE

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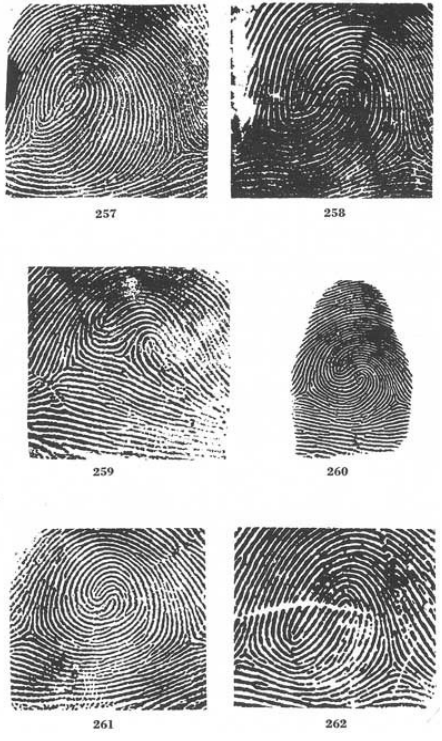
If we all thought alike, we would not be here today.

Shapes and Labels in Forensic Comparative Science -

Comparing shapes!

1985: I was almost done with criminalist (latent prints, shoe/tire prints, firearm/tool marks, fracture/comparative examination) training when I attended a three-week fingerprint school, watched others participate in mock trials, and awaited my turn while others struggled, struggled especially with fingerprint classification terms.

What is a Double Loop Whorl?



I answered something like:

It is a term used in the application of an alpha-numeric classification system for the ten fingerprints on a fingerprint card. The cards are filed, maintained, and retrieved based on the assigned alpha-numeric classification code.

I do not classify cards.
Classification is not needed for identifying latent prints.

I awaited the next question….

I realized labels are not required to compare shapes!

SHAPES AND LABELS IN FORENSIC COMPARATIVE SCIENCE

Article

A Survey of Naming Conventions for Different Minutia Types in Friction Ridge Examination

H. Eldridge[1]
A. Quigley-McBride[2]
B. Gardner[3]

Abstract: Latent print examiners (LPEs) consider the type and rarity of the features found within friction ridge impressions when determining the suitability of questioned impressions for comparison and when forming opinions about the source of an impression. During training, minutiae are generally grouped into basic minutiae (ridge endings, bifurcations, and dots) and combined, or compound, minutiae (minutiae comprised of combinations of basic minutiae). However, there are no standardized naming conventions for either group of minutiae, which can lead to ambiguity and confusion when communicating what features were observed and relied upon during examinations. In this study, LPEs were presented with images of 14 different basic and combined minutia types and asked to report the labels they use to describe each. A lack of consistency between LPEs in their use of labels for nearly all minutia types was observed, with consensus figures for the most-used label for each minutia type ranging from 12.1% (divergence) to 99.2% (bifurcation). Many reported labels were used by only a single respondent and other single labels were used by LPEs to describe multiple minutia types. The authors developed three desirable naming criteria (short, descriptive but unambiguous, and popular) and applied these to the survey responses, thereby selecting a single, unambiguous label for each of the 14 minutia types. It is recommended that the LPE community adopt these labels to reduce ambiguity and confusion in the communication of LPE results and opinions.

1 George Washington University
2 Simon Fraser University
3 University of Virginia

Journal of Forensic Identification
74 (3), 2024 \ 251

"**Abstract:** Latent print examiners (LPEs) consider the **type and rarity of the features** found within the friction ridge impressions when determining the suitability of questioned impressions for comparison and when forming opinions about the source of an impression."

How rare are any feature types of friction skin throughout the volar surfaces?

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SHAPES AND LABELS IN FORENSIC COMPARATIVE SCIENCE

Introduction

Minutiae, which comprise the end of a ridge or the junction of one or more ridges, are the foundation upon which comparison decisions rest, with the comparison process relying heavily on the degree to which latent print examiners (LPEs) think combinations of minutiae in different impressions appear similar.

Journal of Forensic Identification
252 / 74 (3), 2024

“Minutiae, which comprise the end of a ridge or the junction of one or more ridges, are the foundation upon which comparison decisions rest, ...

Why do we need more labels after this introduction?

Are friction skin features unique or rare since they are the foundation?
If rare, we need to know how rare, or how often they actually repeat in any area, so we can apply statistics.

Much has been written about the need to reduce variability between examiners in Analysis, Comparison, and Evaluation decisions [see, e.g., 13–37] and several studies have highlighted the need for clear definitions of what constitutes a minutia [13, 34]. An important part of standardizing definitions and practice includes using consistent, standardized terminology to describe the data being relied upon by LFPs. This is key because clearly communicating the process and results of analysis is as important, if not more so, than the analyses themselves.

The OSAC proposed feature standard provides definitions and specifications for combined minutiae but has not yet completed the standards development process for publication and does not have research or criteria underpinning the selection of these labels other than the fact that many of them have been selected by researchers in the past. This research aimed to capture a broader range of existing labels within the community when it comes to naming conventions and to contribute to the work of naming and defining minutia types by identifying three criteria by which to evaluate a minutia label. The label should be **short, descriptive and unambiguous, and popular** (i.e., likely to be accepted by most practitioners).

The results of this survey with 132 latent print practitioner respondents have allowed the authors to apply these criteria to propose a set of labels for the 14 different minutia types that were considered in this survey (see Table 5). Additionally, we also recommend discontinuing the use of some labels that are ambiguous and highly likely to lead to confusion. The adoption of these recommendations is an additional step toward clearly defining minutiae to reduce variability in Analysis, Comparison, and Evaluation decisions by latent print examiners.

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SHAPES AND LABELS IN FORENSIC COMPARATIVE SCIENCE

"...the need for clear definitions of what constitutes minutiae."
"...An important part of standardizing definitions and practice includes using consistent, standardized terminology to **describe the data** being relied upon..."

What about:
Standard for Examining **Friction Ridge Impressions**
ASB Approved May 2024 ANSI Approved February 2023
3.13
observed data: **Any information** seen within an impression that an examiner may rely upon to reach a decision, conclusion, or opinion. This not only includes minutiae, but **attributes such as clarity, scars, creases, edge shapes, pore structure, and other friction ridge features**.

"...to apply these criteria to propose a set of labels for the 14 different types that were considered in this survey."

If ridge features need 14 labels, do scar, crease, edge, pore, and other friction skin features need a number of standardized labels?

Shapes and Labels in Forensic Comparative Science -

Comparing shapes!

OSAC:

Charter and Bylaws

https://www.nist.gov/system/files/documents/2021/10/28/OSAC%20Charter%20and%20Bylaws_V1.9%20FINAL%2010-2721.pdf

(LA 2025/07/18)

Core Principles:

3. Core Principles

All standards approved for inclusion on the OSAC Registry must be developed by a process that follows the core OSAC principles of openness, balance, consensus, and harmonization:

3.4 Harmonization: The OSAC standards efforts shall encourage **harmonization to minimize redundant, overlapping or conflicting standards**.

SIGN ME UP!

OSAC Proposed Standard Standard Scale of **Source Conclusions** and Criteria for **Toolmark** Examinations Prepared by Firearms & Toolmarks Subcommittee Version: 1.0

https://www.nist.gov/system/files/documents/2024/10/21/ND-73%20Standard%20Scale%20of%20Source%20Conclusions%20and%20Criteria%20for%20Toolmark%20Examinations.pdf
(LA 2025/07/18)

3.2
Individual Characteristics
Marks produced by the random imperfections or irregularities of tool surfaces. These random imperfections or irregularities are produced incidental to manufacture and/or caused by use, corrosion, or damage.

Individual Characteristics – Not Rare Characteristics!

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OSAC 2024-S-0002 Standard Test Method for the Examination and Comparison of **Toolmarks** for Source Attribution

https://www.nist.gov/document/osac-2024-s-0002-standard-test-method-examination-and-comparison-toolmarks-source-0 (LA 2025/07/18)

3.10 individual characteristics: marks produced by the *random imperfections* or irregularities of tool surfaces. These random imperfections or irregularities are produced incidental to manufacture and/or caused by use, corrosion, or damage.

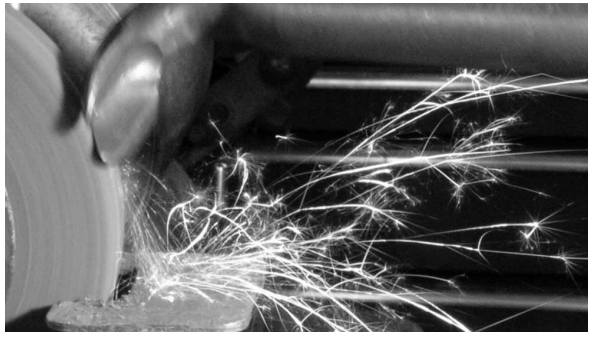
1.The following **non-exhaustive list of attributes are indicative of individual characteristics**:

- A toolmark that is the result of the intersection of two polished or machined surfaces (e.g., firing pin aperture shear)
- A toolmark bearing linear features that are discontinuous and/or non-parallel.
- A toolmark bearing isolated marks such as random chip separation, chatter, etc.
- **Toolmarks that resulted from hand filing, grinding, media blasting, tumbling, or other abrasive or burnishing processes.**
- Toolmarks bearing characteristics that are indicative of **post-manufacturing defects such as damage, use, corrosion, etc.**

ARE INDIVIDUAL CHARACTISTICS UNIQUE, RARE, or REPEATABLE FEATURES?

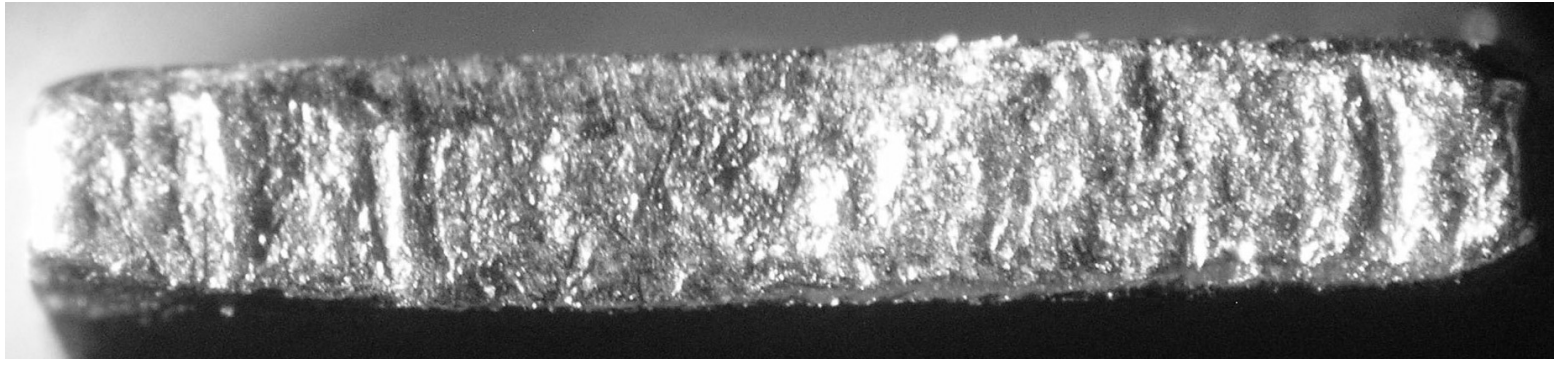
Is there a need or desire to label these shapes?

Study the tool: Screwdriver blade tip

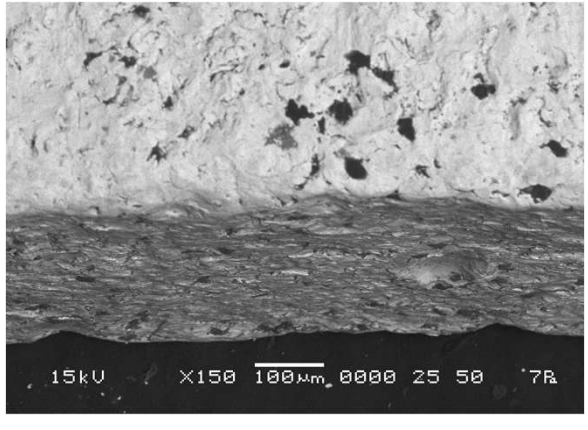


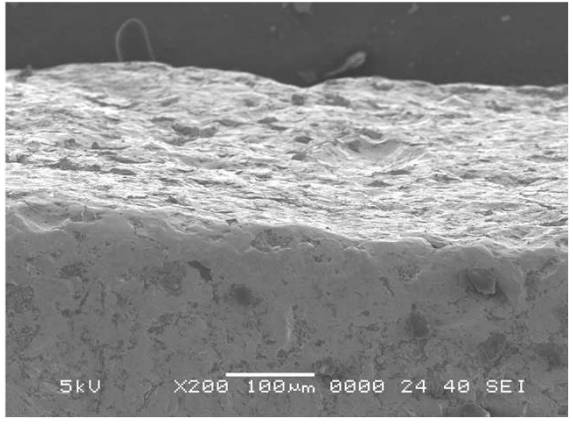
From:

Forensic Comparative Science – Qualitative Quantitative Source Determination of Unique Impressions, Images and Objects, Chapter 8. Vanderkolk



MAG





SEM

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Then the Tool Mark

From:
Human factors in forensic science practice sourcebook

"The benefits of errors during training"
Chapter

H. Eldridge,
J. Stimac,
J. Vanderkolk

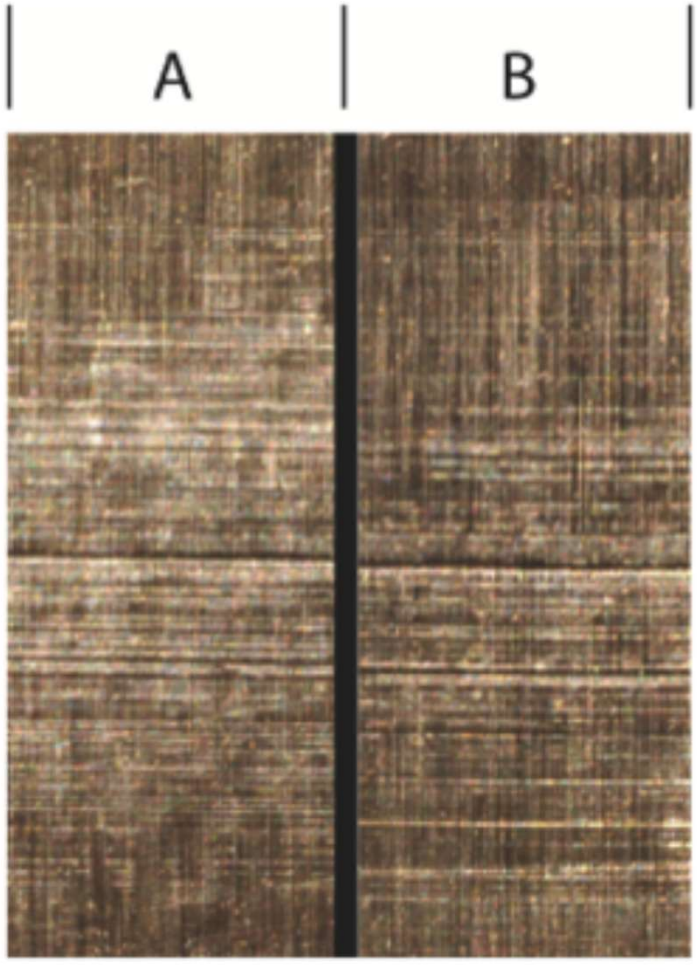

Fig. 2. Two consecutive segments of the tool mark. Note the similarity of the striations.

Does each striation need a label to describe its width, depth, angle?

NO!

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OSAC Proposed Standard Standard Scale of **Source Conclusions** and Criteria for **Toolmark** Examinations Prepared by Firearms & Toolmarks Subcommittee Version: 1.0

https://www.nist.gov/system/files/documents/2024/10/21/ND-73%20Standard%20Scale%20of%20Source%20Conclusions%20and%20Criteria%20for%20Toolmark%20Examinations.pdf
(LA 2025/07/18)

4.2.5 **Identification**. An **expert opinion** that **two items** of toolmark evidence were **marked by the same tool**. Source identification is the strongest statement of association expressed in forensic firearm and toolmark examination.

An IDENTIFICATION!

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OSAC Proposed Standard Standard Scale of Source Conclusions and Criteria for **Toolmark** Examinations Prepared by Firearms & Toolmarks Subcommittee Version: 1.0

https://www.nist.gov/system/files/documents/2024/10/21/ND-73%20Standard%20Scale%20of%20Source%20Conclusions%20and%20Criteria%20for%20Toolmark%20Examinations.pdf
(LA 2025/07/18)

4.2.5.1.1 **An Identification conclusion** is based on an examiner's determination that **all discernible class and individual characteristics** agree such that the extent of agreement exceeds that which has been demonstrated by toolmarks made by different tools (KNM) and is consistent with the agreement demonstrated by toolmarks known to have been made by the same tool (KM).

An IDENTIFICATION!

Is there a need or desire to label each individual characteristic shape?

Firearm Breech Mark: LABEL?

Florida Marlin!

OSAC Proposed Standard
OSAC 2023-S-0017 Standard for the Articulation of **Footwear and Tire** Interpretations
Prepared by Footwear & Tire Subcommittee
Version: 2.0 November 2024

https://www.nist.gov/system/files/documents/2024/11/05/OSAC%202023-S-0017%20Standard%20for%20the%20Articulation%20of%20Footwear%20%26%20Tire%20Interpretations_REGISTRY%20VERSION%202.0.pdf (LA 2025/07/18)

2 Terms and Definitions

2.4 **discriminability or (distinctiveness)**[2]
The property of **an observed characteristic** or an item of footwear or tire that **distinguishes it from different sources**.

[2] The discriminability of a characteristic includes its shape, size, complexity, and reliability. The discriminability of an impression encompasses its features' quantity, spatial arrangement, quality, and **rarity/perceived rarity.**

If **an observed characteristic (ONE CHARACTERISTIC)**
distinguishes an item from different sources,
is that characteristic unique, rare, or repeatable?

OSAC Proposed Standard
OSAC 2023-S-0017 Standard for the Articulation of **Footwear and Tire** Interpretations
Prepared by Footwear & Tire Subcommittee
Version: 2.0 November 2024

https://www.nist.gov/system/files/documents/2024/11/05/OSAC%202023-S-0017%20Standard%20for%20the%20Articulation%20of%20Footwear%20%26%20Tire%20Interpretations_REGISTRY%20VERSION%202.0.pdf (LA 2025/07/18)

2 Terms and Definitions

2.6 **distinguishing characteristic(s)**
Feature(s) on a footwear or tire, including manufacturing variables/defects and characteristics of use, that may be used to **differentiate the item from others of the same class.**

If a feature (singular) can differentiate one item from others of the same class, is that characteristic unique, rare, or repeatable?

Guideline for the **Articulation** of the Decision-Making Process Leading to an **Expert Opinion of Source Identification** in **Friction Ridge** Examinations

https://www.nist.gov/system/files/documents/2024/10/24/OSAC%20ND-76%20Best%20Practice%20Recommendation%20for%20Articulating%20a%20Source%20Identification%20in%20Friction%20Ridge%20Examination.pdf (LA 2025/05/03)

3. Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1. **Discriminability**: The **degree** to which information in an impression can be used to reliably **distinguish between impressions made by different sources**. The discriminability of an impression encompasses its features' quantity, spatial arrangement, clarity, **and rarity.**

DEGREE???/Reasonable degrees of scientific certainty????

If we can distinguish between impressions made by different sources,
are the features
unique, rare, or repeatable?

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Guideline for the **Articulation** of the Decision-Making Process Leading to an **Expert Opinion of Source Identification in Friction Ridge** Examinations

https://www.nist.gov/system/files/documents/2024/10/24/OSAC%20ND-76%20Best%20Practice%20Recommendation%20for%20Articulating%20a%20Source%20Identification%20in%20Friction%20Ridge%20Examination.pdf (LA 2025/05/03)

3. Terms and Definitions

3.3. **Rarity (of a feature type):** Rarity of a type of feature of friction ridge skin refers to **how frequently that type of feature is encountered** in a **group of people (its prevalence)**, either in isolation or in conjunction with other information about its local context. ...

A Type of Feature is a Simple Label, Not a Measurement!

What about frequency within one person and not just a group of people?

Guideline for the **Articulation** of the Decision-Making Process Leading to an Expert **Opinion of Source Identification in Friction Ridge Examinations**

https://www.nist.gov/system/files/documents/2024/10/24/OSAC%20ND-76%20Best%20Practice%20Recommendation%20for%20Articulating%20a%20Source%20Identification%20in%20Friction%20Ridge%20Examination.pdf (LA 2025/05/03)

4.1. Discriminating and Persistent Nature of Friction Ridge Skin

4.1.2.3. While the **highly discriminating nature of friction ridge skin is often expressed as "uniqueness", this claim has not been empirically proven.** Additionally, it has been suggested that the concept of uniqueness is **neither a guarantee of an examiner's ability to make an accurate source identification, nor a necessary precondition to reaching a reliable forensic conclusion.**

Have the rarities of generalized labeled features been empirically proven throughout all friction skin, for all people, for all time?

If no, why should we hold rarity to a lesser standard than uniqueness?

What does uniqueness have to do with the examiner's ability?
Does rarity guarantee reaching a reliable forensic conclusion?

Guideline for the **Articulation** of the Decision-Making Process Leading to an Expert Opinion of **Source Identification in Friction Ridge Examinations**

https://www.nist.gov/system/files/documents/2024/10/24/OSAC%20ND-76%20Best%20Practice%20Recommendation%20for%20Articulating%20a%20Source%20Identification%20in%20Friction%20Ridge%20Examination.pdf (LA 2025/05/03)

4.2.2.1. Contact with a surface can result in an impression, or recording, of the friction ridge skin. The **resulting impression is not a perfect recording** of the skin, as it is subject to distortions and environmental effects. Each impression from the same area of friction ridge skin **will reproduce (? jrv)** a subset of that skin's features that **will vary in appearance from other impressions of the same source** skin. **This is <u>true</u> of both questioned and known impressions.**

It has been stated all friction skin has not been studied for uniqueness; therefore, uniqueness has to be stricken from our vocabulary.

So, how can it be stated all past, current, and future impressions – across disciplines – will vary in appearance if ALL IMPRESSIONS have not been empirically studied?

I accept and support each impression – across disciplines – varies in appearance from other impressions from the same source.

IF each impression from a unique (or rare) **source varies, each impression unique!**

Standard for Examining Friction Ridge Impressions
ASB Approved May 2024 ANSI
Approved February 2023

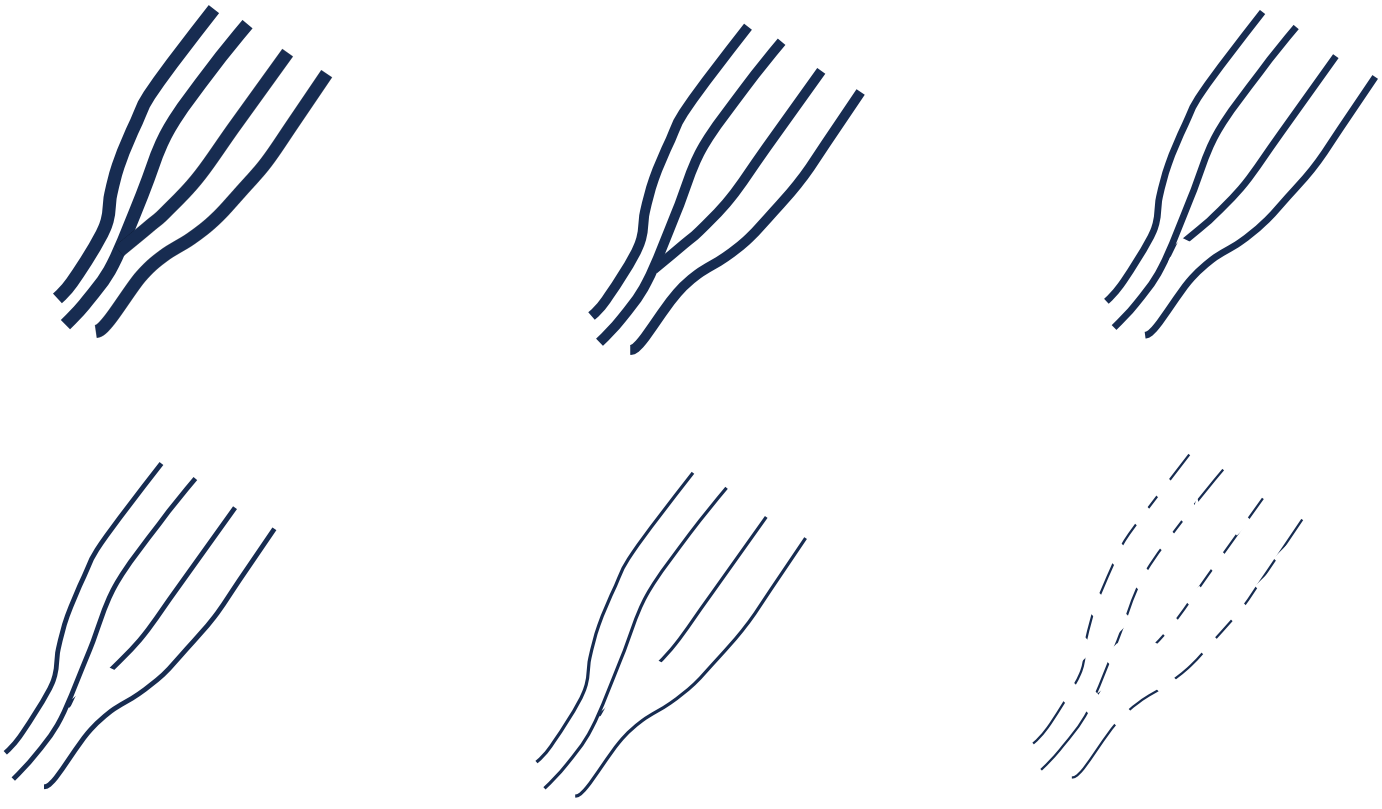
https://www.nist.gov/system/files/documents/2024/10/24/OSAC%20ND-79%20Standard%20for%20Examining%20Friction%20Ridge%20Impressions.pdf (LA 2025/05/03)

I searched for 'rar:' Could not find any form of RARE/RARITY within this Standard for Examining Friction Ridge Impressions process.

If the consideration of rarities of labeled friction skin structures and their occurrences within impressions are not in the standard, how do we make a decision?

We decide based on comparative measurements of shapes – with or without labels.

IMPRESSION:
Bifurcation or Ending Ridge?

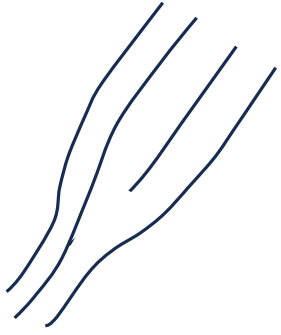


Comparative Measurement of Positions, Lengths, Ridge Widths, Furrow Widths. Or is it comparing a Bifurcation to an Ending Ridge?

Similar or Dissimilar?

Comparative Measurement of Positions, Lengths, Ridge Widths, Furrow Widths. Or is it comparing a Bifurcation to an Ending Ridge?

Similar or Dissimilar?

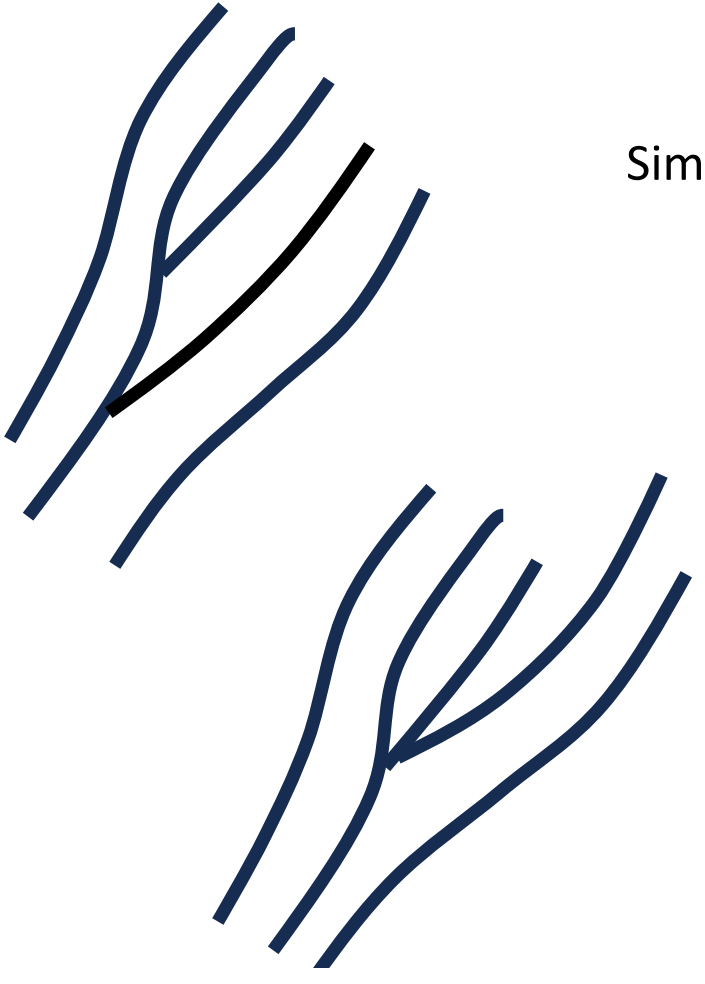


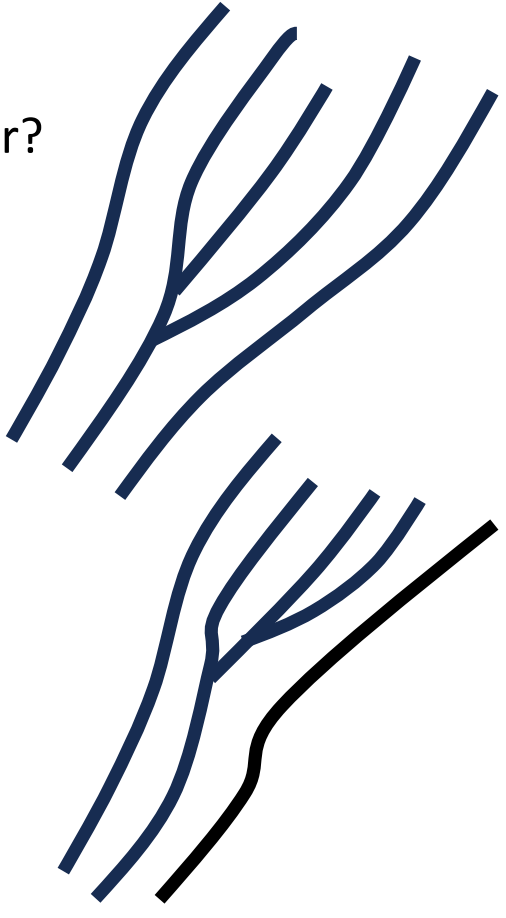
Comparative Measurement of Positions, Lengths, Ridge Widths, Furrow Widths. Or is it comparing a Bifurcation to an Ending Ridge?

Similar or Dissimilar?

Bifurcations, Double Bifurcation, or Trifurcation?

Similar or Dissimilar?





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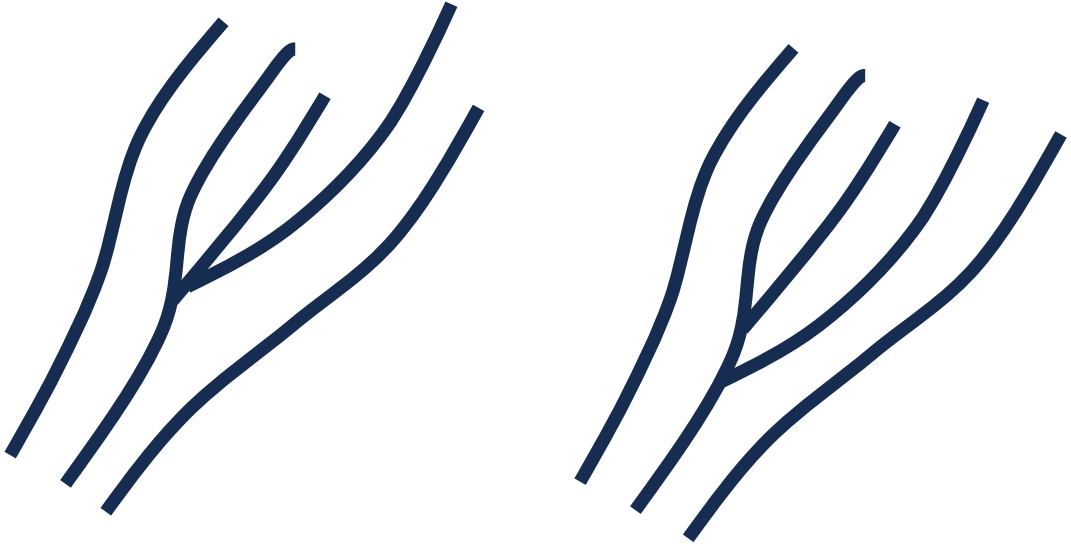
Comparative Measurement of Positions, Lengths, Ridge Widths, Furrow Widths. Or is it comparing a Bifurcation to an Ending Ridge?

Similar or Dissimilar?



SHAPES AND LABELS IN FORENSIC COMPARATIVE SCIENCE

- Double bifurcation (n = 65)
- Two bifurcations (n = 30)
- Trifurcation (n = 8)
- Bifurcation; Branch; Near trifurcation; Stacked bifurcations; Trident or Trifurcation (each n = 1)
- Familiar with this type of minutia but no label for it (n = 24)

- Trifurcation (n = 105)
- Two bifurcations (n = 15)
- Trident; Trifurcation or Pitch fork; Trident or Trifurcation (each n = 1)
- Familiar with this type of minutia but no label for it (n = 9)

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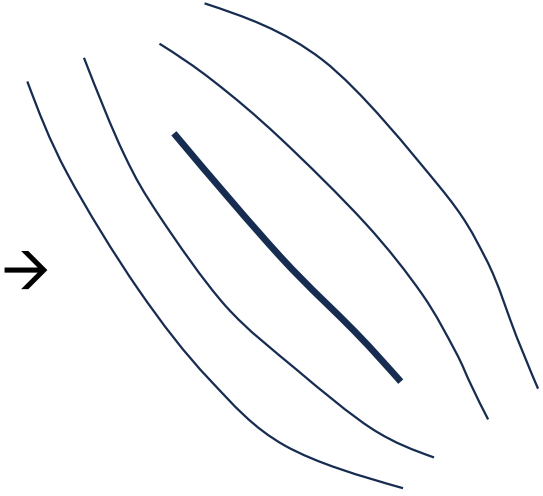
Can these features that have the same label be distinguished?

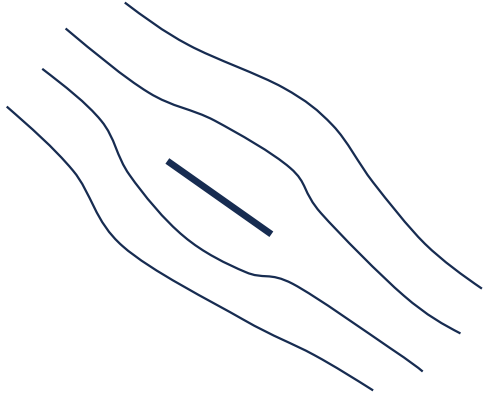
If yes, what ultimate purpose does the label serve?

SHAPES AND LABELS IN FORENSIC COMPARATIVE SCIENCE

THIS short ridge →



Is different than
THAT short ridge →



Can these features that have the same label be distinguished?

If yes, what ultimate purpose does the label serve?

It is all about comparative measurements.

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Terminology and mathematics serve a purpose for the taxonomist (and the forensic scientist) by providing tools that enable them to study and describe natural phenomenon. **However, terminology and mathematics cannot completely describe the variations within each of nature's patterns**. **Terminology describes what remains after mathematics averages out the irregularities, imperfections, little bumps, edges, textures, or contours *that will vary for each natural pattern* within any general form.**

SUMMARIZED FROM: **Ball, Philip**. *The self-made tapestry: pattern formation in nature* Oxford University Press, New York, 1999, 10-11.

General terms tend to average the uniqueness and depict similarity among the unique parts. The perception of uniqueness has the potential to be lost because of the generalization caused by terminology and mathematics.

SHAPES AND LABELS IN FORENSIC COMPARATIVE SCIENCE

Trifurcation?
Double Bifurcation?
Two Bifurcations?
Two Bifurcations with
Four Ending Ridges?

Ovals/Circles/Curves/Angles?

Dots/Shapes of Dots?

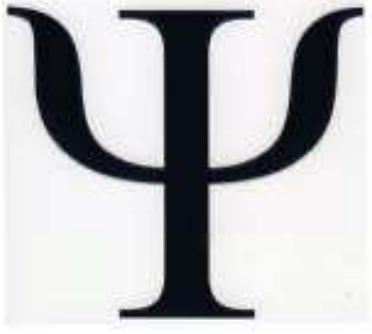
# of Measurements/Relative Positions/Within an Area?

SHAPES AND LABELS IN FORENSIC COMPARATIVE SCIENCE

Trifurcation?
Double Bifurcation?
Two Bifurcations?
Two Bifurcations with
Four Ending Ridges?

IU FINGERPRINT?

PSI?



Ovals/Circles/Curves/Angles?

Dots/Shapes of Dots?

# of Measurements/Relative Positions/Within an Area?

"The presence of such recognizable landmarks as dots, ridge endings and bifurcations are necessary to the mechanism of identity, but have produced a detrimental consequence to the identification process. Unknown impressions tend to be **viewed as mere summaries of their landmarks**, expressed in shallow descriptions according to **the number of named formations** they contain. By reducing an impression to a collection of specific areas that lend themselves to nomenclature, **the totality of the mark is shattered into a myopic concern over the quantity of the parts. An impression which exists as an unique entity is transformed during observation into a series of formations that must be rebuilt into something individual**. **This dismantling of ridge structure into a quantification of selected characteristics, or Galton points, may facilitate verbal descriptions or written standards, but does so at an enormous sacrifice to the remaining information in the impression."**

Grieve, David, 'Reflections on Quality Standards – An American Viewpoint,' *Fingerprint Whorld*, April 1990, 110.

"The more we, as examiners, attempt to describe something that is inherently unique, the more it will appear like something else, and, therefore, seem to lose its uniqueness. By confining our description of either latent or inked prints to labels such as whorls, loops, arches, bifurcations, ending ridges, and dots, we can easily lose track of the uniqueness of the ridge unit arrangements that comprise all the ridge structure.

Uniqueness must not be compromised for the convenience of labels."

Vanderkolk, John R. 'Class Characteristics and "Could Be" Results, *Journal of Forensic Identification*, 43 (3), 1993; 121-122.

SHAPES, LABELS, and TERMS
IN
FORENSIC COMPARATIVE SCIENCE

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Retired Indiana State Police Laboratory

If we all thought alike, we would not be here today.