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Technical Report on the Articulation of the Reasoning and Foundational Principles Behind Friction Ridge Examinations

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Foreword

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This document was revised, prepared, and finalized as a standard by the Friction Ridge Consensus Body of the AAFS Standards Board. The draft of this standard was developed by the Friction Ridge Subcommittee of the Organization of Scientific Area Committees (OSAC) for Forensic Science.

Questions, comments, and suggestions for the improvement of this document can be sent to AAFS-ASB Secretariat, asb@aafs.org or 401 N 21st Street, Colorado Springs, CO 80904.

All hyperlinks and web addresses shown in this document are current as of the publication date of this standard.

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1 Scope

This document provides reference information to aid in articulating the reasoning and foundational principles behind the examination of friction ridge evidence. It provides additional explanations and references in support of fundamental statements made within the friction ridge discipline. The statements in the document include basic premises of friction ridge examination, the execution of the examination process, and the communication of the results of examinations. This document does not address the specific friction ridge examination conclusions or wording of those conclusions which are the subject of a separate document.

2 Normative References

There are no normative reference documents. Annex A contains bibliographical references.

3 Terms and Definitions

For purposes of this document, the following definitions apply.

3.1
agreement (synonym of correspondence and corresponding friction ridge detail)
Observed similarities in pattern type, ridge flow, and friction ridge features in sequence, of the same or similar type, in the same relative position to each other, with associated intervening ridge counts. An accumulation of similarities between two impressions resulting in overall conformity that supports a conclusion of source identification.

3.2
analysis (phase of the examination process)
The interpretation of observed data in a friction ridge impression in order to categorize its suitability/utility.

3.3
clarity
The fidelity and coherence with which the anatomical details of friction ridge skin are reproduced in a friction ridge impression, and are able to be visualized.[a]

3.4
comparison (phase of the examination process)
The search for and detection of similarities and dissimilarities in observed data between friction ridge impressions.

[a] Kalka, N.D., M. Beachler, R.A. Hicklin. "LQMetric: A Latent Fingerprint Quality Metric for Predicting AFIS Performance and Assessing the Value of Latent Fingerprints", *JFI* 70(4): 443-463. 2020.

3.5
complexity (of a comparison)
A characteristic of a comparison in which the attributes of one or both impressions may require additional consideration and quality assurance measures relating to the evaluation of a source conclusion. Usually refers to the quality and clarity of at least one of the impressions in the comparison set, affecting the difficulty of the comparison.

3.6
complexity (of an impression)
A characteristic of an impression whose attributes may require additional consideration and quality assurance measures. Usually refers to the quality and clarity of the impression being analyzed, having the potential to affect the difficulty of a subsequent comparison.

3.7
conclusion (synonym of source conclusion)
Opinion stated by an examiner after interpretation of observed data. The opinion is the professional judgment that the observed data can offer support for one proposition over another. A conclusion is distinct from a "*proposition.*"

3.8
disagreement
A dissimilarity, or an accumulation of dissimilarities, that is deemed to be outside of expected variations in the appearance of impressions from the same source, resulting in overall nonconformity.

3.9
discriminability
The degree to which information in an impression can be used to distinguish it from impressions made by different sources. The discriminability of an impression is a combination of the quantity, spatial arrangement, clarity, and rarity of features observed.

3.10
dissimilarity
An observation that two impressions have a general difference of appearance when comparing an individual feature or detail. Not to be confused with *"disagreement"*.

3.11
evaluation (phase of the examination process)
The weighting of the aggregate strength of the evidence (observed similarities and dissimilarities when considering two competing propositions) between the observed data in the friction ridge impressions being compared in order to formulate a source conclusion.

3.12
exemplar impression (synonym of exemplar or known and exemplar prints)
exemplar or known (synonym of exemplar impression and exemplar prints)
exemplar prints (synonym of exemplar impression and exemplar or known)
The deliberately recorded images or impressions from the friction ridge skin of an individual.

NOTE Examples may include, but are not limited to, inked tenprints, inked palm prints, Livescan prints, powder and lift prints, casted/molded prints, or photographs of friction ridge skin.

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.

3.14
pattern force area
A region of friction ridge skin which in theory, minutiae were forced to form due to pattern type and existing ridge fields during friction ridge formation. As these minutiae form more predictably, their configurations are more common and less random.

NOTE For example, in the outflow of a loop, many ridges converged during formation, which forced many ridge endings to form as space ran out.

3.15
probability
An expression of the chance that a particular event occurs.

3.16
propositions
Statements about the actual state of nature or an event, which is unknown or unknowable. Not to be confused with "*conclusions*," nor "*source conclusions"* (refer to those definitions for further clarification).

3.17
questioned impression (synonym of questioned image or questioned item)
questioned image (synonym of questioned impression and questioned image)
questioned item (synonym of questioned impression and questioned image)
An impression or image of friction ridge skin whose source or identity is unknown; it can include latent impressions, impressions from an unknown source or a known source.

NOTE For example the questioned impression may be a "known impression" in tenprint to tenprint examinations.

3.18
rarity (of a feature type)
The frequency or prevalence of a friction ridge feature, either in isolation or in conjunction with other information about its local context.

NOTE For example, the prevalence of a type of feature could be affected by its proximity to a pattern force area, the finger number or palmar region on which it is located, or the pattern type in which it is located.

3.19
similarity
An observation that two impressions share a general likeness when comparing an individual feature or detail. Not to be confused with "*agreement*."

3.20
source
An area of friction ridge skin of an individual from which an impression originated.[b]

3.21
strength of the evidence
The relative support the evidence lends to one proposition over another. It may be described verbally or numerically.

3.22
suitability (synonym of utility)
The usefulness of an impression for a further step in the examination process, such as comparison or Automated Biometric Identification System (ABIS) entry.

4 General

This document presents a series of statements, in sequence, that build upon one another. Together these provide a roadmap for articulation of the foundational principles and reasoning for current friction ridge examination practices. This document does not provide a script for examiners; rather, this series of statements taken together provides a high-level overview of the main concepts behind the current practice of friction ridge examination. Each brief statement is followed by a more in-depth explanation of the theory behind the statement.

Supporting references are provided in each section. The references cited are meant to be representative, not all-inclusive.

5 Discriminating and Persistent Nature of Friction Ridge Skin

5.1 Statement

Friction ridge skin contains persistent morphological structures that can be highly discriminating.

5.2 Further Explanation

5.2.1 Research and practical application have shown that the combination of the features present in friction ridge skin can be highly variable between different sources. Research and practice have also shown that, barring injury, disease, or other conditions damaging to the skin the essential structure and ridge arrangements of these features remain unchanged (except for growth) over the life of an individual.

5.2.2 An entire complement of a particular anatomical source of friction ridge skin is highly discriminating. However, it is less certain at what point a subset of the skin's features, imperfectly reproduced as an impression, are no longer discriminating enough to distinguish between similar sources. Furthermore, while research has demonstrated that some configurations of friction ridge features are highly discriminating, others, particularly in pattern force areas, are less so. Since

[b] National Institute of Justice (U.S.). *The Fingerprint Sourcebook*. Washington DC: U.S. Dept. of Justice Office of Justice Programs National Institute of Justice; 2011. http://purl.fdlp.gov/GPO/gpo18039. Accessed November 11 2022.

impressions are often incomplete or indiscernible in part, their degree of discriminability is considered at all stages of the examination.

5.3 References Supporting Statement and Explanations

The following references support the statement and explanations for the discriminating and persistent nature of friction ridge skin.

a) *Discriminability, persistence, and morphology*. Wilder and Wentworth (1932), Cummins and Midlo (1943), Hale (1952), Babler (1979), Maceo (2011), Wertheim (2011), Kücken and Champod (2013), Yoon and Jain (2015)

b) *Historical use of friction ridge skin for personal identification*. Barnes (2011)

c) *Recent scientific studies of friction ridge discriminability*. Neumann et al. (2007), Neumann et al. (2012)

d) *Features in pattern force areas (e.g., deltas, outflows of a loop) tend to be more common*. Champod and Margot (1997)

6 Transfer of Friction Ridge Features to Impressions

6.1 Statement

An impression, or recording, of the features of friction ridge skin can result when contact is made with a receptive surface.

6.2 Further Explanation

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, differences in composition and substrate, and environmental effects. Each impression from the same area of friction ridge skin will record a subset of that skin's features that will vary in appearance from other impressions of the same source skin. This is true of both questioned and exemplar impressions.

6.3 References Supporting Statement and Explanation

The following references support the statement and explanations for the transfer of friction ridge features to impressions.

a) *Ridgeology*. Ashbaugh (1999)

b) *Distortions*. Maceo (2009)

c) *Reproducibility of friction ridge skin features in an impression.* Monson et al. (2019)

7 Analysis of Impression to Observe Data for Suitability Assessment

7.1 Statement

During analysis of a friction ridge skin impression, the data present in the impression is observed and its discriminability is assessed in order to categorize its suitability for comparison. Analysis is applied both to questioned and exemplar impressions.

7.2 Further Explanation

Examiners have demonstrated an ability to observe data such as ridge events, creases, and scars in friction ridge impressions that surpasses that of untrained individuals. Examiners are capable of observing data even in highly distorted impressions. Confidence in the existence and type of observed data increases with the clarity of the data observed in an impression.

7.3 References Supporting Statement and Explanation

The following references support the statement and explanations for the analysis of impression to observe data for suitability assessment.

a) *Effects of expertise and human factors on analysis and comparison*. Busey and Parada (2010), Busey and Vanderkolk (2005)

b) *Expertise/novice ability.* Tangen, Thompson, and McCarthy (2011)

c) *Qualitative analysis and comparison*. Hicklin et al. (2013), Langenburg (2012), Maceo (2009)

d) ANSI/ASB Best Practice Recommendation 165, *Best Practice Recommendation for Analysis of Friction Ridge Impressions*, 1st Ed., 2024

8 Comparison of Observed Data to Assess Similarity and Dissimilarity

8.1 Statement

During comparison, the observed data in comparable areas of two friction ridge impressions are assessed for similarity and dissimilarity.

8.2 Further Explanation

A ridge-to-ridge comparison between two side-by-side impressions assesses whether there is similarity or dissimilarity in the observed data in comparable areas of the two impressions. Similarity and dissimilarity are assessed with respect to both the observed data and its spatial relationships. Every recording of the same area of friction ridge skin is different. As a result, the assessment of similarity and dissimilarity takes into account tolerances for distortion and other environmental effects.

8.3 References Supporting Statement and Explanation

The following references support the statement and explanations for the comparison of observed data to assess similarity and dissimilarity.

a) *Quantitative comparison and evaluation*. Ashbaugh (1999), Fagert and Morris (2015), Ulery et al. (2014)

b) ANSI/ASB Best Practice Recommendation 166, *Best Practice Recommendation for Comparison and Evaluation of Friction Ridge Impressions*, 1st Ed., 2024

9 Accumulated Similarity Decreases Probability of Repetition in a Different Source

9.1 Statement

The larger the set of similarities observed between two impressions the greater the likelihood of those observations if the impressions originated from the same source versus if they originated from different sources. Furthermore, the greater the clarity and/or rarity of those similarities, the greater the likelihood of those observations if the impressions originated from the same source versus if they originated from different sources.

9.2 Further Explanation

9.2.1 In general, the variability in appearance of observed data is greater for impressions that originated from different sources than for multiple impressions that originated from the same source.

9.2.2 Not all observed data carry the same weight. Observed data with higher clarity generally indicate more accurate representations of the source friction ridge skin. Observed data that are rarer allow the examiner to better discriminate between two sources.

9.2.3 Quantity, spatial arrangement, clarity, and rarity combined make up the discriminability of the impression. A more discriminating impression is less likely to have similar observed data in impressions originating from different sources.

9.2.4 Conversely, the stronger the dissimilarity, or larger the set of dissimilarities, observed between two impressions the greater the likelihood of those observations if the impressions originated from different sources versus if they originated from the same source.

9.2.5 Likelihoods, probabilities, and rarity may be empirically derived (e.g., from validated statistical models) and/or subjectively assigned by the examiner based on their professional judgment.

9.3 References Supporting Statement and Explanations

The following reference supports the statement and explanations for the accumulated similarity decreases probability of repetition in a different source.

a) *Quantifying variability and weight of evidence*. Egli et al. (2007), Gutiérrez et al. (2007), Neumann et al. (2007), Neumann et al. (2012), Stoney and Thornton (1986)

10 Evaluation of the Observed Data Under Two Competing Propositions

10.1 Statement

During evaluation, the examiner assesses observed similarities and dissimilarities to determine whether there is agreement or disagreement in the observed data. Within this assessment, two competing propositions are considered: 1) that the two impressions originated from the same source, and 2) that the two impressions originated from different sources.

10.2 Further Explanation

10.2.1 The examiner considers the support for each proposition and if the support for one proposition outweighs the other.

10.2.2 The relative weighing of propositions determines the direction, if any, the examiner moves from the neutral position (i.e., Inconclusive).

10.2.3 To determine the strength of the evidence, the examiner weighs the probability of observing the similarities and dissimilarities in two impressions assuming they were made by the same source against the probability of observing the similarities and dissimilarities assuming they were made by different sources. The strength of the evidence is the degree to which the probability of one proposition outweighs the probability of the other proposition.

10.2.4 The combination of the direction and the strength of evidence is recorded as one of the conclusions documented in ASB Standard 013, *Standard for Friction Ridge Examination Conclusions (Draft available from asb@aafs.org)*.

10.3 References Supporting Statement and Explanations

The following references support the statement and explanations for the evaluation of the observed data under two competing propositions.

a) *Two competing propositions are considered.* Aitken et al (2010), Neumann et al. (2012), Robertson et al. (2016)

b) *Using likelihoods to indicate support for propositions.* Champod (2015), Cole (2009), Cole (2014), Swofford (2015)

c) *Probability can be an expression of your degree of belief in the truth of an event.* Lindley (2014)

d) ASB Standard 013, *Standard for Friction Ridge Examination Conclusions (Draft available from asb@aafs.org)*

11 Articulation of Error Rates from Examiner Performance Studies

11.1 Statement

Examiner performance studies have shown that friction ridge examiners (when taken as a whole) can reach accurate and reliable conclusions under specific testing conditions.

11.2 Further Explanation

11.2.1 A number of friction ridge examiner performance studies have been conducted in recent years. These studies varied in design, participation, subject matter, and limitations. These studies have reported relatively low instances of false negative errors and even lower (albeit non-zero) instances of false positive errors by study participants. (see references in section 11.3a) for reported error rates).

~~**11.2.2** The error rates from performance studies do not represent the probability of error in any specific situation (i.e., the probability of error associated with a specific examiner, FSP, case, or examination) as all measured error rates are only directly applicable to the specific study and its participants.~~

~~11.2.3~~11.2.2 The chance of error in a specific examination is generally dependent on a number of factors including, but not necessarily limited to: the quality and quantity of information in the impression, the complexity of the impression/comparison, the conclusion effected, the ~~"skill"~~error rate of the examiner, and whether or not the comparison was a result of a large database search (i.e., the exemplar impression already has some amount of similarity to the questioned impression).

~~11.2.4~~11.2.3 Error rates may be presented in differing ways with differing values depending on how the data was analyzed. Regardless of how an error rate is calculated, the underlying data (i.e., the performance of the participants) does not change.

11.3 References Supporting Statement and Explanations

The following reference supports the statement and explanations for the articulation of error rates from examiner performance studies

a) *Examiner Performance Studies*. Ulery, Hicklin et al. (2011), Pacheco, Cerchiai et al. (2014), Eldridge, De Donno et al. (2021)

b) *Error Rate and Impression Complexity***.** Kellman, Mnookin et al. (2014)

12 Communication of Results of Examinations

12.1 Statements

Because target audiences for the results of friction ridge examinations vary, the specific wording used to convey the reasoning and foundational principles behind friction ridge examinations can vary.

Some statements made by examiners, while wholly understandable to a subject matter expert, can be prone to misinterpretation by the layperson.

12.2 Further Explanation

12.2.1 Historically, when articulating the results of friction ridge examinations, examiners have used words and phrases that are now considered inappropriate or misleading (including their usage under the caveat that it is an examiner's "opinion"). A prohibition against the use of such problematic phrases is documented in ASB Standard 013, *Standard for Friction Ridge Examination*

Conclusions (Draft available from asb@aafs.org). The documented prohibited language includes the following:

a) *Individualization, Made by, Originated from the same source, Exclusion of all others*.
Use of the term "individualization" or phrases such as "originated from the same source" (outside of the presentation of propositions), "made by", "matched to", and "exclusion of all others" imply the reduction of an open population (i.e., the world's population) to a single source. These terms and phrases de facto exclude all other possibilities. Unless case related contextual information is considered when making this determination, such as a closed-set population, this claim is not supportable by the current research and empirical testing.

b) Zero error rate, Infallible.
A claim of a zero error rate for the examination of friction ridge impressions is demonstrably false; errors have occurred in practice, proficiency testing, and performance studies. Furthermore, the concept of a zero error rate is incompatible with the practice of science.

c) *Citing a personal degree of confidence as a measure of accuracy*
While an examiner may express confidence in their conclusion, there is no established metric by which to measure a degree of confidence in a specific conclusion (e.g., 100% confident, extremely confident, etc.). Even a documented personal error rate does not account for the variability in the chance of error due to the specific circumstances of the comparison at hand.

Examiners may erroneously conflate confidence with accuracy by asserting or implying that because an examiner has confidence in the conclusion it is therefore accurate. Examiners can be both confident and inaccurate in their conclusions as is evidenced by documented errors both in practice and performance studies.

d) *Certainty, Practical impossibility, Reasonable degree of scientific certainty, and equivalents.*
The concept of certainty is incompatible with the practice of science. Science is inherently an endeavor to generate the best possible answers to questions that are never knowable with certainty. Arguments such as "I would not have signed the report unless I was certain" are not sufficient support for a claim of certainty. Furthermore, statements that include a measure of certainty are similarly inappropriate because certainty is generally perceived as a categorical statement as opposed to a scalable measure.

In practice, the concept of certainty is often inappropriately conflated with confidence. Whereas certainty is associated with the accuracy of a result, confidence is associated with a person's conviction in that result.

e) *Citing a number of friction ridge comparisons as a measure of accuracy*
Performance studies have demonstrated that an examiner's years of experience is not correlated with reduced error rates. Given this lack of correlation, the number of comparisons performed by an examiner is not a reliable measure of the accuracy of the proffered conclusion. Research has shown that the chance of error in a given comparison is most heavily influenced by the attributes of the impressions examined as opposed to the examiner performing the comparison.

f) *The concept of the uniqueness of friction ridge skin alone is sufficient to justify a conclusion*
While the friction ridge skin can be considered highly discriminable, and is essential for the reliable practice of friction ridge examination, the examination of friction ridge impressions

does not involve the direct comparison of the friction ridge skin. Instead, friction ridge examiners perform comparisons on reproductions of that skin.

Within the process of reproduction (e.g., deposition), discriminating information is lost. The amount of loss is variable, but loss always occurs. Furthermore, distortion, composition, substrate, and environmental effects may influence the appearance of the resulting subset of information recorded.

Examiners and lay audiences alike are vulnerable to reasoning incorrectly that the discriminability of friction ridge skin vouches for the accuracy of friction ridge conclusions. The skin's discriminability is not a guarantor of the accuracy of the conclusion.

12.3 References Supporting Statement and Explanations

The following references support the statement and explanations for the communication of results of examinations.

a) *Use of these phrases is inappropriate and unsupported*. Campbell (2011), Champod (2013), Cole (2014), Garrett (2009), National Research Council (2009), NIST (2012)

b) *Studies on the accuracy of experienced friction ridge examiners***.** Langenburg (2009), Ulery, Hicklin et al. (2011), Tangen, Thompson et al. (2011)

c) *Forensic statistics*. Robertston et al. (2016), Aitken and Taroni (2004)

d) *Decision-making in forensic identification*. Biedermann et al. (2008)

13 Limitations

13.1 Statement

Friction ridge examinations and conclusions are subject to limitations both fundamental and practical

13.2 Futher Explanation

13.2.1 Friction ridge examination is subjective in nature.

While performance studies have demonstrated that friction ridge examiners in the aggregate can reach accurate conclusions (under specific test conditions), friction ridge examination is fundamentally an exercise in personal (professional) judgment. Decisions are made based on human observations. Examiners also apply personally-derived thresholds to effect examination decisions. While these personal observations and thresholds are not arbitrarily derived or applied they can vary from examiner to examiner.

Studies have demonstrated that individuals can develop expertise in friction ridge examination by acquisition of relevant knowledge, experience, and training. Furthermore, studies have shown that examiners often reach consensus and that variability amongst examiners was most strongly associated with high complexity impressions and with decisions at or near sufficiency thresholds.

The subjective nature of friction ridge examination means that examiners will not always agree with each other, necessitating the application of strong and transparent quality assurance practices.

13.2.2 The age of a friction ridge impression cannot be determined from the appearance of the impression.

Absent exceptional circumstances, friction ridge impressions do not provide information indicative of when the deposition of a print took place. Numerous factors affect the appearance of an impression both at the time of deposition and over time. The influence of these factors is variable and not an indicator of age.

13.2.3 The presence of a friction ridge impression generally indicates contact was made but not the specific activity resulting in the deposition.

In general, the presence of a friction ridge impression on an item of evidence indicates that a contact was made between a source and an item. The anatomical source of an impression along with its orientation and location on an item may also reveal information about how that item was handled. Absent exceptional circumstances, an impression cannot be directly associated with a specific event or activity. For example, the presence of a friction ridge impression on a firearm does not necessarily indicate that the impression was deposited during the firing of that firearm.

Under specific circumstances, an impression may not directly originate from a source contact but instead be a result of a transfer from one item to another (e.g., lifted by an adhesive surface).

13.2.4 The absence of, or failure to detect, a friction ridge impression does not indicate that contact did not occur.

The deposition of a friction ridge impression is a chance event. A variety of factors may impede the deposition of an impression (e.g., absence of a matrix to deposit, non-receptive surfaces, etc.) or the longevity of a deposited print (e.g., wiping a surface, exposure to the elements), and the detection of friction ridge impressions on items of evidence is not always successful. As such, a lack of friction ridge impressions on an item of evidence does not indicate that the item was not contacted. Furthermore, the exclusion of a source to a detected impression does not indicate that that source did not contact the item.

Conversely, the absence of, or failure to detect, a friction ridge impression can also result from an item not being handled. As such, this observation provides no evidentiary support for either proposition (i.e., that the item was handled but no impression was deposited or detected or that the item was not handled).

13.2.5 Ground truth is unknown.

In case work, the examiner cannot truly know whether any particular person is the source of an unknown impression since they did not observe the deposition of the impression. It is for this reason that the expression of professional judgment of the source of the unknown impression, along with a description of the strength of the evidence supporting that professional judgment, be limited. It is inappropriate to give the impression that any conclusion is a known fact.

13.2.6 The strength of the evidence supporting the examiner's professional judgment is variable.

All conclusions are not equal in strength. When presenting a conclusion, it is important to be transparent about the quality, quantity, and complexity of the data that were used to reach the conclusion and how that quality, quantity, and complexity affect the strength of the evidence supporting the conclusion.

13.2.7 Reproducibility is not a guarantee of accuracy.

It is inappropriate to assert that because a conclusion has been reproduced by others (through verification or other means) it is therefore accurate. In both practice and performance studies, errors have occurred that have been reproduced by other examiners. The only way to be certain of accuracy is to know ground truth. In the absence of ground truth, the most appropriate way to support the accuracy of a conclusion is by clearly demonstrating the support the data provide for the conclusion.

13.2.8 Case type can be relevant to whether a comparison is performed, but is not relevant as support for a conclusion.

Agencies have different policies regarding the prioritization of cases based upon crime type. However, crime type is not an appropriate basis for adjusting the threshold for a conclusion. For example, it is not appropriate to reach a conclusion using less supporting data for a homicide than one would consider sufficient for a burglary.

13.2.9 Friction ridge examiners and their conclusions can be influenced by cognitive biases.

Cognitive bias is pervasive in and a fundamental component of human decision making.

~~Studies~~Some studies have demonstrated that examiners and their conclusions can be influenced by the introduction of biasing information~~. However, studies have also shown that, in general, examiners are resistant to the effects of biasing information or, when influenced, generally default to more conservative conclusions.~~ (i.e. contextual information), while other studies have shown little to no impact to examiner conclusions. While bias could influence any examination, the vulnerability of examiners and their conclusions within contextual bias studies appears to be dependent on the nature of the impression and/or comparison being performed. In contextual bias studies, friction ridge impressions/comparisons that were rated as difficult or complex showed the greatest influence from biasing information whereas friction ridge impressions/comparisons that were rated as easy or moderate showed little to no impact from biasing information.

~~The presence of biasing information alone does not necessarily indicate that an examiner or their conclusion is inaccurate or unreliable. The vulnerability of an examiner/conclusion to be impacted by bias is dependent on the nature of the impression and/or comparison being performed. Friction ridge impressions/comparisons that are highly complex and/or closest to decision thresholds require the examiner to apply greater levels of personal judgment and as a result tend to be the more vulnerable to the effects of bias. Conversely, lower complexity/non-complex impressions/comparisons require less personal judgment and as a result tend to be more resistant to the effects of bias.~~

Awareness of bias does not make an examiner immune from its effects. The influence of bias may be mitigated by the application of appropriate quality assurance measures (e.g., blinding or masking).

13.3 References Supporting Statement and Explanations

The following references support the statement and explanations for limitations.

a) *Examiner variability.* Ulery, Hicklin et al. (2015, 2016)

b) *Examiner expertise*. Busey and Vanderkolk (2005), Busey and Parada (2010), Tangen, Thompson, and McCarthy (2011)

c) *Age determination of friction ridge impressions.* Girod et al. (2016)

d) *Reproducibility of friction ridge conclusions.* Ulery, Hicklin et al. (2012), Tangen, Kent, and Searston (2020)

e) *Bias.* Dror and Charlton (2006), Dror, Charlton, and Pèron (2006), Hall and Player (2008), Busey and Dror (2011), Pena, Stoiloff et al. (2024)

Annex A
(informative)

Bibliography

The following bibliography is not intended to be an all-inclusive list, review, or endorsement of literature on this topic. The goal of the bibliography is to provide examples of publications addressed in the standard.

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