

What a future forensic-data-science model for fingerprint-fingerprint comparison might look like

Geoffrey Stewart Morrison

Forensic Data Science Laboratory
Aston Institute for Forensic Linguistics



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Disclaimer

- All opinions expressed are those of the presenter and, unless explicitly stated otherwise, should not be construed as representing the policies or positions of any organizations with which the presenters are associated.

Slides

- <https://geoff-morrison.net/#ICFIS2023>

Paradigm shift

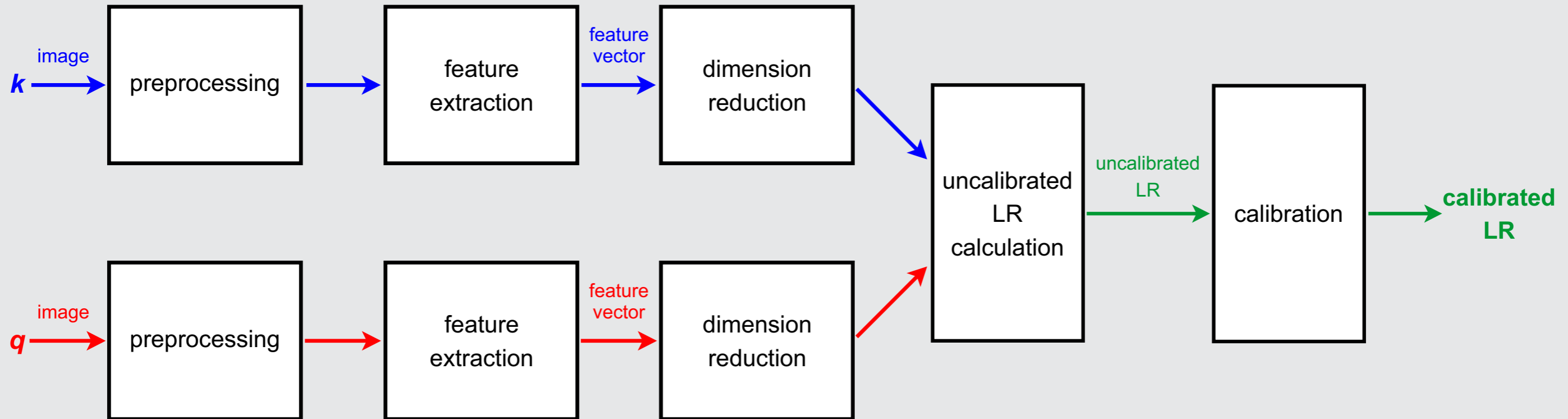
- A **paradigm shift** in evaluation of forensic evidence is underway in which methods based on human perception and subjective judgement are replaced by methods based on **relevant data, quantitative measurements, and statistical models**; methods that:
 - are **transparent and reproducible**;
 - are **intrinsically resistant to cognitive bias**;
 - use the **logically correct framework for interpretation of evidence (the likelihood-ratio framework)**; and
 - are **empirically calibrated and validated under casework conditions**.

Morrison G.S. (2022). **Advancing a paradigm shift in evaluation of forensic evidence: The rise of forensic data science.**

Forensic Science International: Synergy, 4, 100270. <https://doi.org/10.1016/j.fsisyn.2022.100270>

Architecture of a statistical-model / machine-learning system

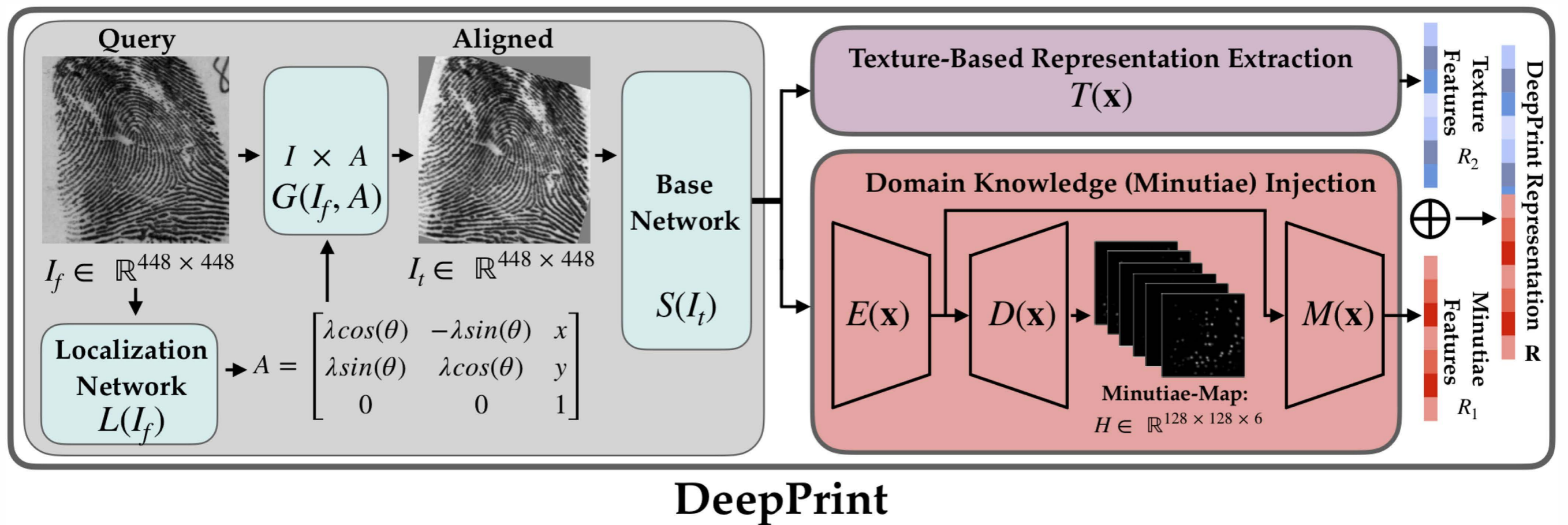
- Pipeline based on state-of-the-art forensic voice comparison



Morrison G.S., Weber P., Enzinger E., Labrador B., Lozano-Díez A., Ramos D., González-Rodríguez J. (2023). **Forensic voice comparison: Human-supervised-automatic approach**. In Houck M., Wilson L., Eldridge H., Lewis S., Lothridge K., Reedy P. (Eds.), *Encyclopedia of Forensic Sciences* (3rd Ed.), vol. 2, pp. 720–736. Elsevier. <https://doi.org/10.1016/B978-0-12-823677-2.00182-3> Preprint at <https://forensic-voice-comparison.net/encyclopedia/>

Quantitative measurement

- Feature-extraction using a Deep-Neural-Network (DNN) embedding



Engelsma J.J., Cao K., Jain A.K. (2021). **Learning a fixed-length fingerprint representation**. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 43, 1981–1997. <https://doi.org/10.1109/TPAMI.2019.2961349>

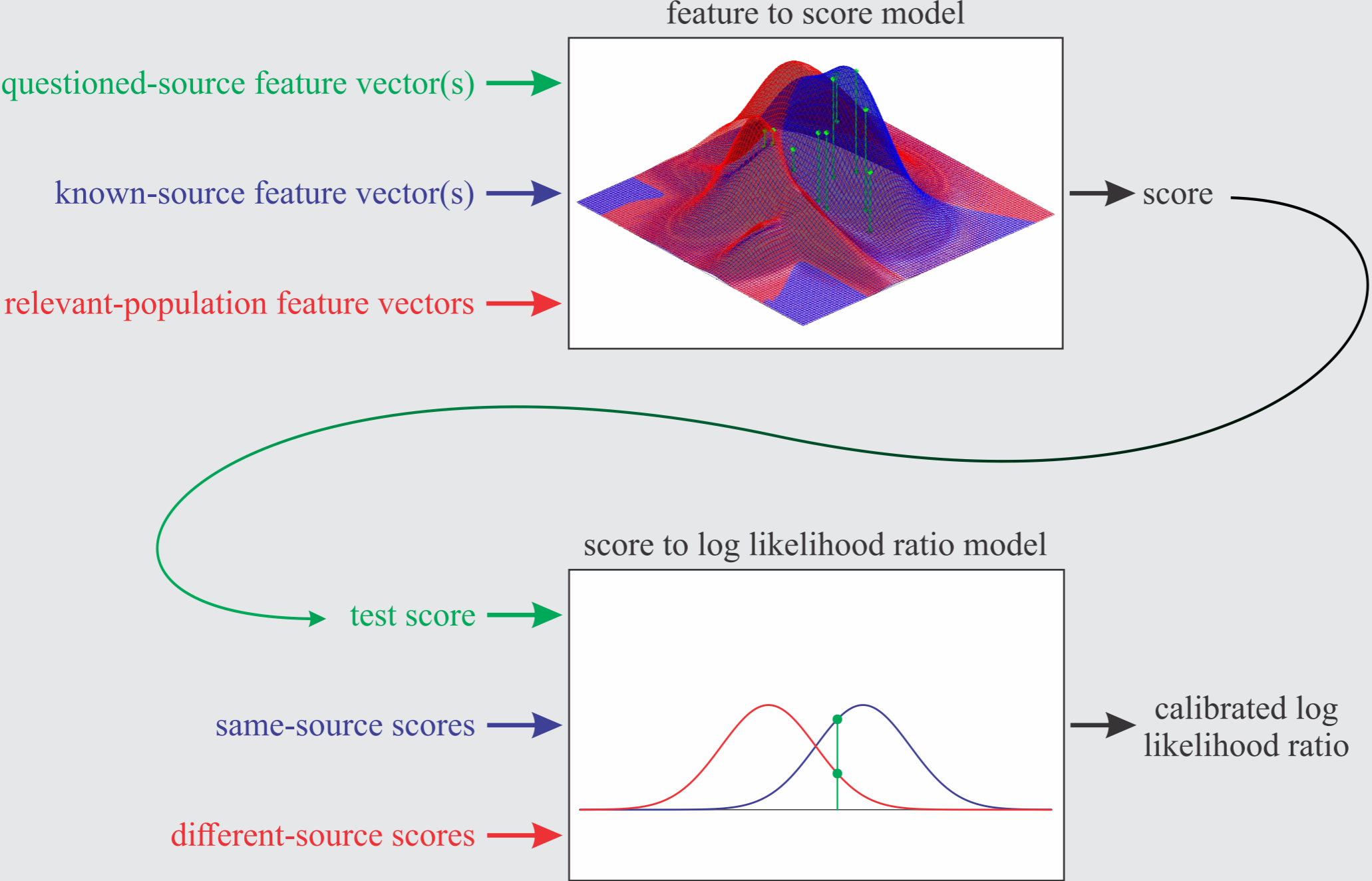
Relevant data

- For training, calibration, and validation we need data:
 - Fingermarks and fingerprints from a large number of donors
 - Fingermarks representing conditions commonly encounter in casework
 - In each condition, a large number of fingermarks from each donor
- Model between-source and within-source variability in casework-relevant conditions

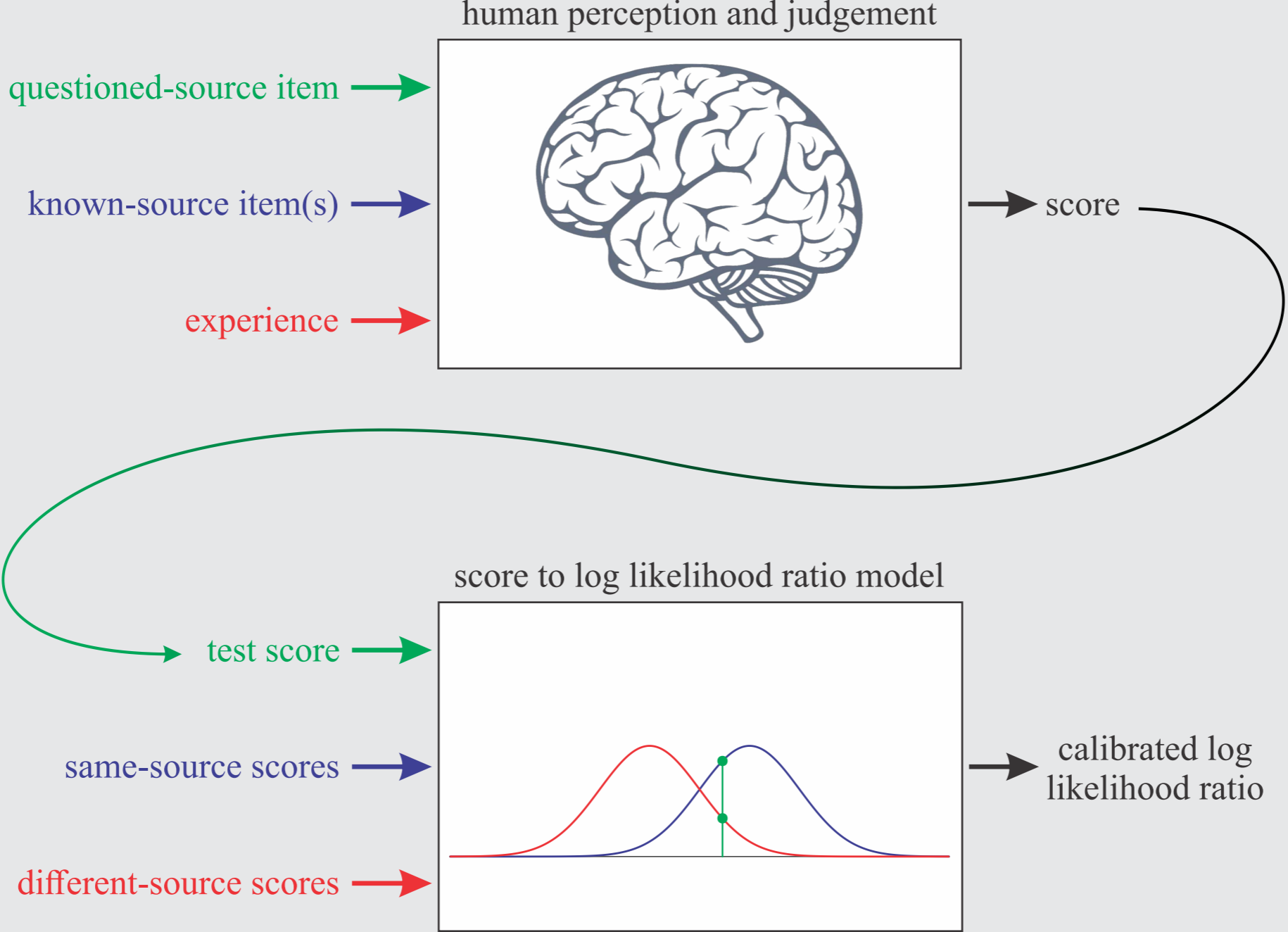
Human expertise

- The quantitative-measurement & statistical-model system is a tool used by a human expert.
- Human expertise is required:
 - Selection of appropriate data (fingermak and fingerprint images) for calibrating and validating the system under conditions reflecting those of the fingermak and fingerprint from the case.
 - Otherwise: Garbage in, garbage out.
 - Communicating the meaning of the output.

Calibration



Calibration



Strategy

- **Work with researchers and practitioners who want to adopt the forensic-data-science paradigm.**
- Work with them on **addressing practical impediments** to applying the forensic-data-science paradigm in casework:
 - provide training leading to understanding of the new paradigm
 - build relevant databases
 - develop and validate statistical-models / machine-learning systems

Aalbers S.E., Khan A.T., Weir B.S. (2023). **Perceptions of forensic scientists on statistical models, sequence data, and ethical implications for DNA evidence evaluations: A qualitative assessment.** *Forensic Science International: Synergy*, 6, 100335. <https://doi.org/10.1016/j.fsisyn.2023.100335>

Thank You