# A New International Standard for Forensic Science (ISO 21043), and Education in Forensic Inference and Statistics


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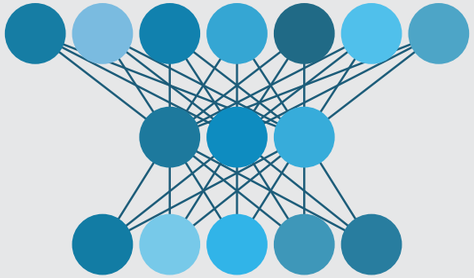


$$\frac{p(E|H_p)}{p(E|H_d)}$$

# 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 presenter is associated.

# Papers

- 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

- Morrison G.S., Elliott S., Guiness J., Sonden L., Syndercombe Court D. (2025). **A guide to ISO 21043 Forensic Sciences from the perspective of the forensic-data-science paradigm**. *Science & Justice*, 65, 101304. https://doi.org/10.1016/j.scijus.2025.101304

# Forensic data science

- In most branches of forensic science, evaluation of forensic evidence is still based on:
  - human perception
  - subjective judgement

- Evaluation of forensic evidence is undergoing a paradigm shift in which the latter methods are replaced by methods based on:
  - relevant data
  - quantitative measurements
  - statistical models

# Forensic data science

- In the new paradigm (the forensic-data-science paradigm), the methods:
  - are transparent and reproducible
  - are intrinsically resistant to cognitive bias
  - use the logically correct framework for interpretation of evidence (the likelihood-ratio framework)
  - are empirically calibrated and validated under casework conditions

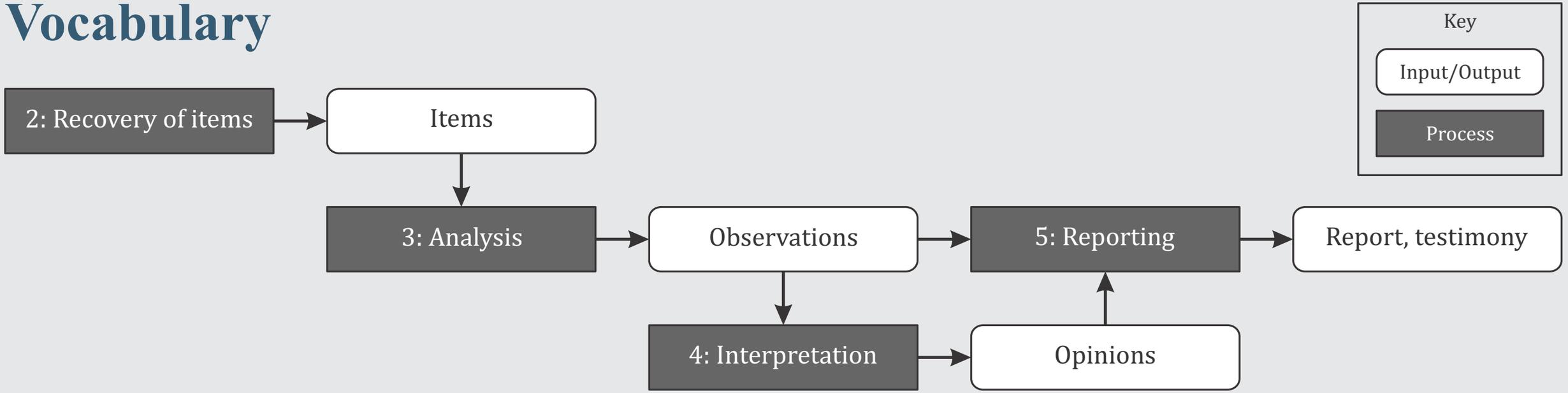
# ISO 21043 *Forensic Sciences*

- ISO 21043 is a new international standard for forensic science.
- ISO 21043 does not require use of the forensic-data-science paradigm.
- There is a pathway through ISO 21043 if the forensic-data-science paradigm is being used.
- I hope that this will encourage adoption of the forensic-data-science paradigm.

# ISO 21043 *Forensic Sciences*

- ISO 21043-1:2025 *Forensic Science* – ***Part 1: Vocabulary***
- ISO 21043-2:2018 *Forensic Sciences* – ***Part 2: Recognition, recording, collection, transport and storage of items***
- ISO 21043-3:2025 *Forensic Sciences* – ***Part 3: Analysis***
- ISO 21043-4:2025 *Forensic Sciences* – ***Part 4: Interpretation***
- ISO 21043-5:2025 *Forensic Sciences* – ***Part 5: Reporting***

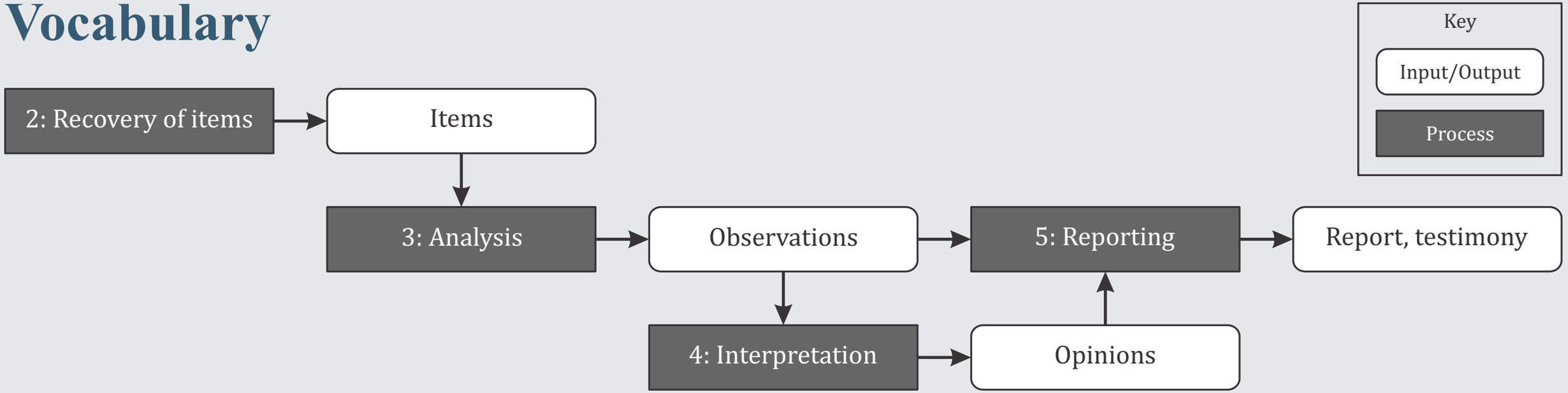
# Vocabulary




- **Item**
  - object, substance, material or mark that is collected, derived or sampled as part of the *forensic process*

[*Items* can be physical, or can be digital information.]

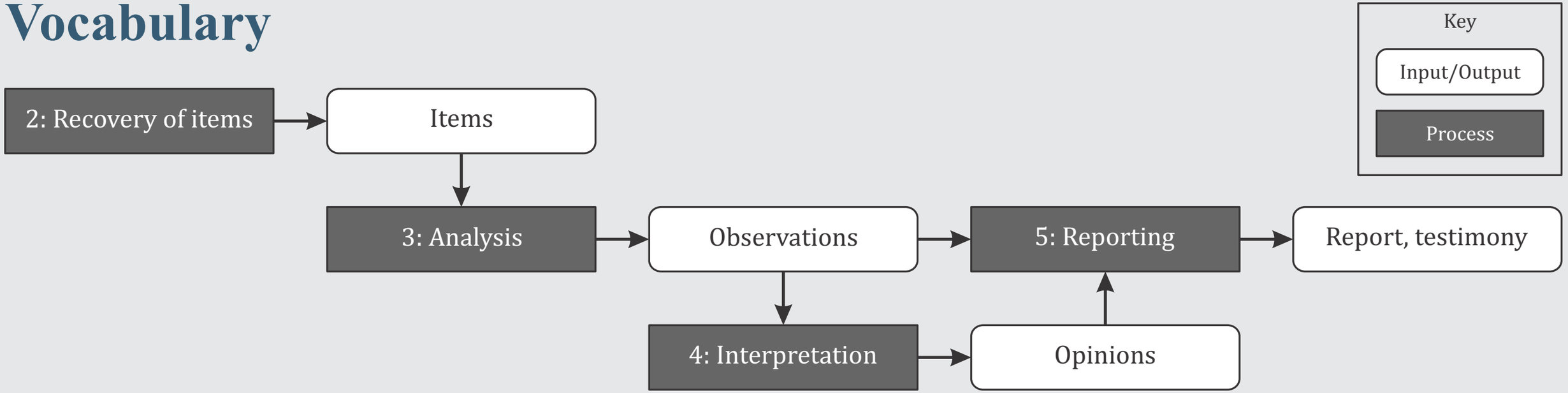
# Vocabulary




- **Analysis**
  - part of the *examination* consisting of detecting, measuring, or comparing properties of *items* in order to obtain *observations*

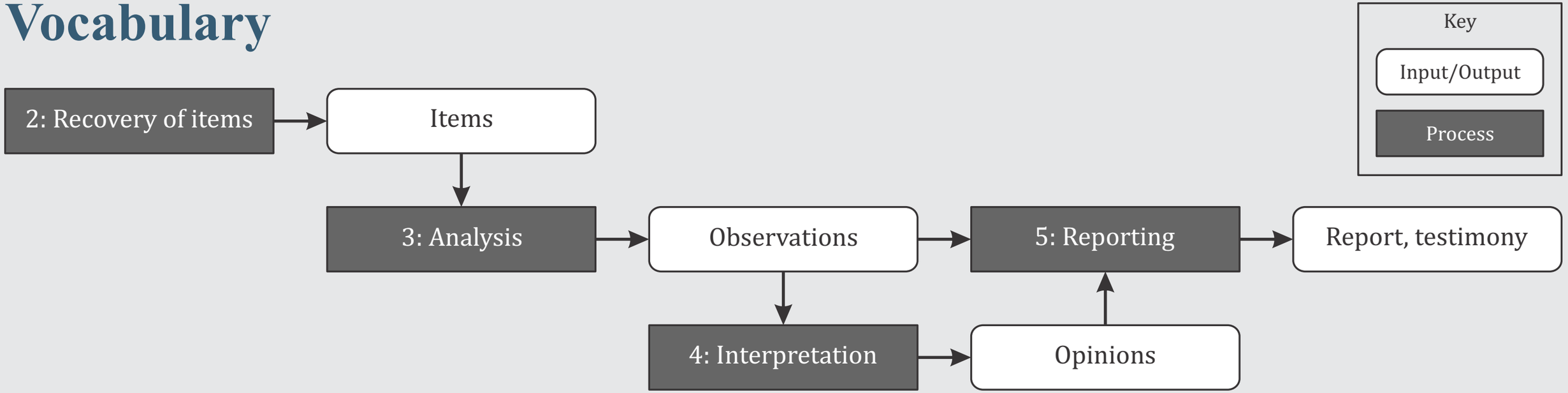
*Analysis* can be instrumental, human-perception-based, or a combination of the two.

# Vocabulary



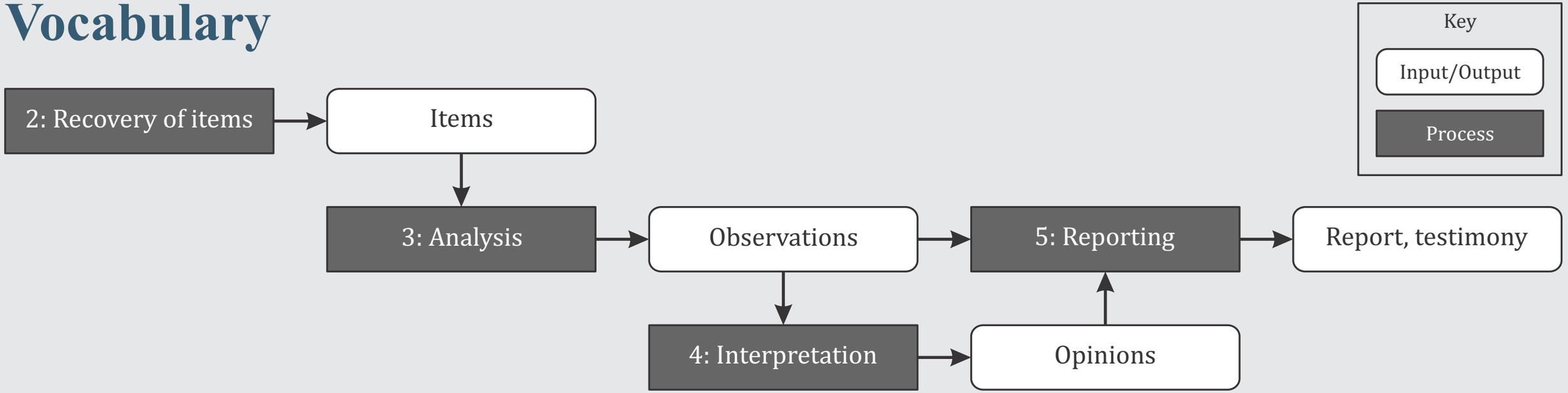

- **Observation**
  - result of *analysis* of *items* or of the *scene*

# Vocabulary




- **Interpretation**
  - part of the *examination* that uses professional judgement, logic, expertise, and relevant data and information and, if applicable, statistical models to infer the meaning of *observations* so as to provide *opinions* with respect to questions asked

# Vocabulary




- **Opinion**
  - *examiner's* judgement based on the *interpretation* of *observations*

[*Opinions* can be based directly on the *examiner's* judgement, or can be the output of statistical models.]

# Vocabulary

- Not used:
    - trace
    - evidence
    - result
    - finding
    - conclusion

# Vocabulary

- **Likelihood ratio**
    - expression of an *examiner's* assessment of the ratio of the *probabilities* of the *observations* if one of two competing *propositions* were true versus if the other *proposition* were true

[Does not exclude Bayes factors.]

[For continuously-valued data, probability density rather than *probability* is used.]

[Part 4 Annex A provides an explanation of the meaning of a *likelihood ratio*.]

# Vocabulary

- **Probability**
    - extent to which something is likely

The term *probability* includes qualitative and quantitative probabilities assigned subjectively and quantitative probabilities assigned through the use of statistical models and data.

# Vocabulary

ISO 3534-1:1993 *General Statistical Terms*

- **Probability**
    - a real number in the scale 0 to 1 attached to a random event

It can be related to a long-run relative frequency of occurrence or to a degree of belief that an event will occur. For a high degree of belief, the probability is near 1.

# Vocabulary

- **Investigative interpretation**
    - *interpretation* guided by *observations* made and aimed at generating *explanations* or estimations

*Investigative interpretation* can be used in an investigation or in a judicial setting.

- **Explanation**
    - possible cause for *observations*, generated in an *investigative interpretation*

- Those *explanations* may be turned into *propositions* for a later *evaluative interpretation*.

# Vocabulary

- **Evaluative interpretation**
    - *interpretation* guided by a set of relevant *propositions* and aimed at generating *likelihood ratios*

- **Proposition**
    - statement that is either true or false, the truth of which is uncertain

# Vocabulary

| Auxiliary verbs | | Português | |
|---|---|---|---|
| • **shall** | requirement | • **deve** | requisito |
| • **should** | recommendation | • **convém que** | recomendação |
| • **may** | permission | • **pode** | permissão |
| • **can** | possibility | • **pode** | possibilidade |

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# Interpretation

- When *propositions* are used to address case-relevant questions, they shall be specified before the *analysis* is conducted.

- The examiner shall consider at least two competing *propositions* which shall be:
  a) relevant to answering the question posed in the case;
  b) mutually exclusive;
  c) explicit and specific;
  d) considered during *analysis*, *interpretation*, and reporting.

- [Either specific-source *propositions* or common-source *propositions* can be used.]

# Interpretation

- [The *examiner* shall take between-source variability, within-source variability, and measurement variability into account.]

- [The *examiner* shall take "rarity" with respect to the *relevant population* into account.]

- [The *examiner* may calculate *likelihood ratios* using feature-based *methods* or similarity-score-based *methods*.]

# Interpretation

- The *examiner* shall document how *probabilities* are assigned, including the basis for such assignments. The *examiner* shall be transparent about the sources of information used to assign *probabilities*. Any assumptions used to assign *probabilities* should be clearly recorded.

- Data used for assigning *probabilities* shall be as representative as possible of the *relevant population* of *items* and as representative as possible of the conditions of the case.

- Data shall only be used for assigning *probabilities* if, in the *examiner's* judgement, they are sufficiently representative of the *relevant population* and the conditions of the case.

# Interpretation

- The value of a *likelihood ratio* may be assigned and expressed quantitatively or qualitatively.

- A *likelihood ratio* can be assigned quantitatively using statistical models, or quantitatively or qualitatively based on professional judgement.

- Subjective assignments of *probabilities* may be used in the absence of existing data or statistical models.

# Interpretation

- If a numerical value (e.g., a *probability* or a *likelihood ratio*) is calculated using quantitative observations, quantitative data, and a statistical model, the *opinion* should be expressed using that numerical value.

- Qualitative *opinions* [including subjectively assigned *likelihood ratios*] shall be drawn from a predefined *opinion scale* on which each level has a verbal expression.

[Part 4 Annex B provides examples of *opinion scales*.]

# Interpretation

- The *interpretation methods* shall be suitable for the intended use and should be supported by relevant *validation* studies.

- **Validation**
  - provision of objective evidence that a ... *method* ... fulfils specified requirements, where the specified requirements are adequate for an intended use

[ISO 21043 does not provide requirements or recommendations for to how to *validate interpretation methods* that calculate *likelihood ratios*.]

# Paper

Guidance on how to *validate interpretation methods* that calculate *likelihood ratios*:

- Morrison G.S., Enzinger E., Hughes V., Jessen M., Meuwly D., Neumann C., Planting S., Thompson W.C., van der Vloed D., Ypma R.J.F., Zhang C., Anonymous A., Anonymous B. (2021). **Consensus on validation of forensic voice comparison**. *Science & Justice*, 61, 229–309. https://doi.org/10.1016/j.scijus.2021.02.002

# Reporting

- Reports that contain *opinions* shall include:

  a) the questions to be answered;

  b) the set of *propositions*, where applicable;

  c) a description of assumptions that are relevant for forming the *opinion*;

  d) the basis of the *opinion*.

- Reports that contain *opinions* should include or reference:

  a) a description of any data used;

  b) a description of any statistical models used.

# Reporting

- [*Probabilities* and *likelihood ratios* may be expressed quantitatively or qualitatively.]

- [If a method calculates a numerical *likelihood-ratio* value, the numerical *likelihood-ratio* value should be reported.]

- [If a qualitative *opinion* is presented, the whole *opinion scale* should be included or referenced in the report.]

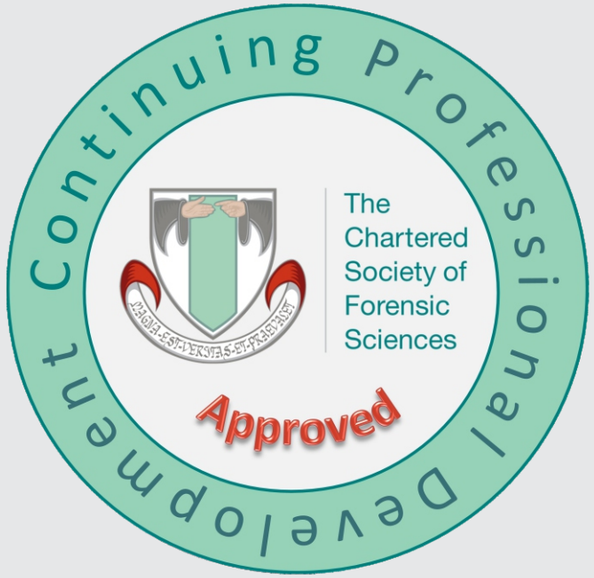
# Reporting

- When reporting a *likelihood ratio* the *examiner* ... shall not transpose the conditional [i.e., shall not commit the prosecutor's fallacy.]

- [When reporting source-level *opinions*, the examiner should state that the *opinion* only relates to source level and not to activity level.]

# Education

- **Concepts of forensic inference and statistics**
  - Master's level continuing professional development course
  - Online delivery – can be taken from anywhere in the world
  - Delivered in 22 weeks spread over 6 months
  - ~1 day per week workload
  - Active learning, flipped classroon, didactic testing and feedback
  - Weekly interactive sessions
  - Competency assessment



# Education

- **Concepts of forensic inference and statistics**
  - Logical reasoning for evaluation of forensic evidence
  - Concepts of statistical modelling for evaluation of forensic evidence
  - Empirical calibration and validation of forensic-evaluation systems
  - Cognitive bias in evaluation of forensic evidence
  - Standards and guidelines related to evaluation of forensic evidence (inc. ISO 21043)
  - Legal admissibility of forensic evidence from a scientific perspective
  - Examples from multiple branches of forensic science

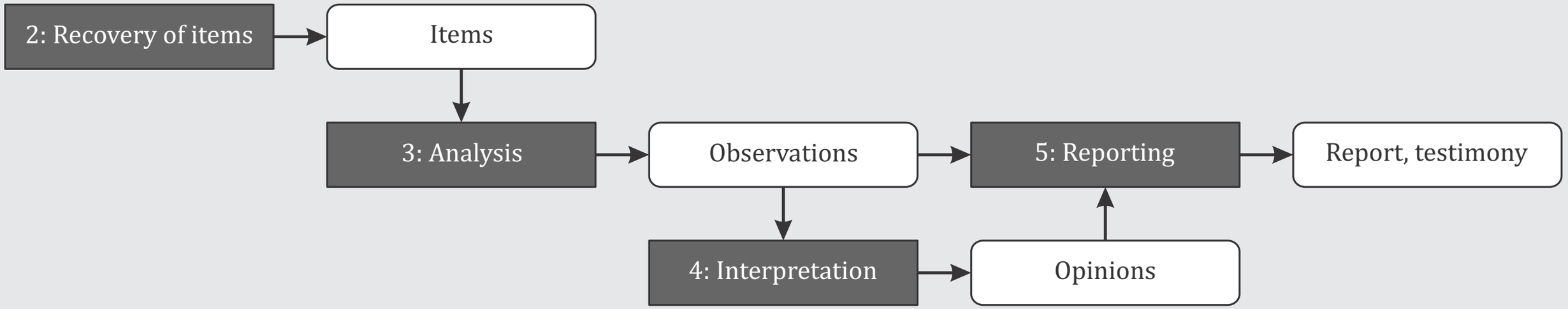
# Education

- **Concepts of forensic inference and statistics**

  - “This course is unique in the concepts it teaches. I love that Prof Morrison has realised the need of this type of statistical understanding across the majority of forensic disciplines and is forging ahead to promote the paradigm shift. This course has had a positive influence on me as a forensic practitioner. All forensic practitioners should undertake a course like this one.”

  - “I have absolutely hated anything mathy my entire life, but this module has introduced things so steadily and sequentially that I not only feel capable but have enjoyed the module.”

# Thank You


2: Recovery of items
Items
3: Analysis
Observations
5: Reporting
Report, testimony
4: Interpretation
Opinions