

Rival Explanations: Identifiability, Underdetermination and Auxiliary Hypotheses

Juan Segurola

3Dresyns by Resyner Technologies S.L.

© 2026 Juan Segurola. All Rights Reserved.

Correspondence: info@3Dresyns.com · www.3Dresyns.com

INF-004 · Scientific Inference and Experimental Reasoning · Version v0.2

Abstract

Scientific data often support more than one explanation. Different mechanisms can generate similar observables; different model structures can fit the same data; and the interpretation of a failed prediction can depend on auxiliary assumptions about measurement, boundary conditions, parameter values or implementation. This article defines a disciplined approach to rival explanations. It distinguishes structural identifiability from practical identifiability, underdetermination from mere imprecision, and failure of a focal hypothesis from failure of an auxiliary assumption. The article proposes a live-rival register in which each candidate explanation is linked to its assumptions, unique predictions and discriminating observations. The objective is not to force uniqueness when the evidence does not support it. A scientifically adequate outcome may be that one rival is retained, several remain live, or the data cannot distinguish them within the available resolution. INF-004 owns the decision about which structures remain live; INF-007 owns the design of severe or discriminating experiments, and INF-008 owns qualification of conclusions while structural uncertainty remains.

Keywords: identifiability; underdetermination; rival hypotheses; mechanism; auxiliary hypotheses; model structure; discriminating evidence

1. Fit does not imply uniqueness

A model can reproduce observed data without being the only model capable of doing so. This is an inferential problem, not merely a statistical one. Pearl's causal framework makes identification explicit: a causal quantity may or may not be uniquely recoverable from the observable distribution under a stated graph and assumptions [1,5]. In dynamical modelling, Raue and colleagues distinguish structural identifiability from practical identifiability: a parameter can be uniquely defined in principle yet remain poorly estimated from finite, noisy observations [2]. The same logic extends beyond parameters to rival mechanisms and model structures.

2. Structural versus practical identifiability

Structural identifiability asks whether the target quantity or structure is uniquely determined in the idealised model with perfect information of the relevant observable distribution. Practical identifiability asks whether the available finite and noisy data constrain that target with useful precision. Failure of structural identifiability cannot be repaired by collecting more data of the same type; practical non-identifiability sometimes can be improved by better experimental design, wider excitation of the system, additional observables or lower measurement noise.

3. Underdetermination

Underdetermination occurs when the evidence is compatible with more than one materially different explanation. It should not be used as a rhetorical claim that "anything is possible". The live set should be explicit and bounded by available evidence. A rival becomes scientifically relevant when it explains the observations sufficiently well and differs in predictions, assumptions or interventions that matter to the scientific question.

4. Auxiliary hypotheses

A prediction rarely follows from one focal hypothesis alone. It also depends on measurement validity, calibration, boundary conditions, background theory, parameter ranges, sample state and implementation. A failed prediction can therefore challenge the focal explanation, an auxiliary assumption, or both. This is one reason INF-004 does not treat a single apparent falsification as mechanically decisive. The appropriate response is to identify which assumptions are required for the predicted observation and test the most discriminating branches [3].

5. Live-rival register

Rival	Core explanation	Auxiliary assumptions	Observation that would discriminate
A	First structure or mechanism	Measurement and boundary assumptions required for A	Outcome predicted by A but not B/C
B	Second structure or mechanism	Alternative parameter/state assumptions	Outcome predicted by B but not A/C
C	Residual or null explanation	Noise/artefact/background process assumptions	Control or perturbation that isolates the residual process

The table is not a scoring device. It forces the analyst to state why alternatives remain live and what evidence could separate them.

6. Strong inference without false certainty

Platt advocated explicit alternative hypotheses and crucial experiments [3]. That strategy remains valuable, but real experiments can be less decisive than the phrase “crucial experiment” suggests because auxiliary assumptions and limited measurement capability can blur outcomes. Mayo’s severe-testing framework similarly emphasises that passing a test is probative only when the test had a high capability to reveal relevant discrepancies [4]. INF therefore treats discrimination as graded by capability and assumptions rather than as a ritual binary elimination.

7. Negative evidence requires capability

Failure to observe a predicted difference constrains a rival only if the measurement and design were capable of detecting the difference in the relevant state. Non-detection, censoring and inadequate dynamic range can otherwise create false eliminations. HEB-007 retains ownership of the diagnostic measurement problem; INF-004 uses it as a prerequisite for valid rival elimination.

8. Boundaries with neighbouring INF articles

- INF-004 decides which rival explanations or structures remain live.
- INF-007 designs experiments or measurements intended to discriminate among those rivals.
- INF-008 qualifies conclusions when structural alternatives remain live.
- INF-009 tests robustness across declared assumptions or model specifications without using robustness as proof of truth.

9. Minimum reporting discipline

- List the materially credible rivals, not only the preferred explanation.
- State the assumptions required by each rival to generate the observed data.
- Separate structural non-identifiability from parameter imprecision.
- State at least one observation, perturbation or measurement that would differ among rivals.
- Do not eliminate a rival using a test that lacked capability to detect its distinguishing prediction.
- Permit “multiple rivals remain live” as a scientifically adequate endpoint.

References

- [1] Pearl, J. *Causality: Models, Reasoning, and Inference*. 2nd ed. Cambridge University Press, 2009. DOI: 10.1017/CBO9780511803161.
- [2] Raue, A.; Kreutz, C.; Maiwald, T.; Bachmann, J.; Schilling, M.; Klingmüller, U.; Timmer, J. Structural and Practical Identifiability Analysis of Partially Observed Dynamical Models by Exploiting the Profile Likelihood. *Bioinformatics* 25(15), 1923-1929 (2009). DOI: 10.1093/bioinformatics/btp358.
- [3] Platt, J.R. Strong Inference. *Science* 146(3642), 347-353 (1964). DOI: 10.1126/science.146.3642.347.
- [4] Mayo, D.G. *Statistical Inference as Severe Testing: How to Get Beyond the Statistics Wars*. Cambridge University Press, 2018. DOI: 10.1017/9781107286184.
- [5] Hernán, M.A.; Robins, J.M. *Causal Inference: What If*. Boca Raton: Chapman & Hall/CRC, 2020. DOI: 10.1201/9781315374932.

Data and materials statement

No new experimental dataset was generated for this article. The article is a methodological analysis based on the cited literature and the frozen ownership architecture of the INF series.