

Analytic Multiplicity: Many Paths from the Same Data

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Abstract

A single dataset can support many plausible analytical paths. Decisions about exclusions, transformations, stopping rules, outcomes, covariates, subgroups, model forms and reporting create a multiplicity that is often much larger than the number of formal statistical tests. When those paths are selected after observing results and only favourable outcomes are emphasised, nominal error rates and evidential interpretations no longer describe the full research process. This article defines analytic multiplicity as the branching set of decisions connecting raw observations to reported claims. It separates planned multiplicity from undisclosed researcher degrees of freedom, clarifies the role of multiple-testing control and preregistration, and distinguishes this problem from transparent robustness analysis in INF-009. The objective is not to forbid exploration but to label exploration honestly and preserve a clean boundary between hypothesis generation and evidential confirmation.

Keywords: analytic multiplicity; researcher degrees of freedom; forking paths; multiple testing; preregistration; selective reporting

1. The analytical path is part of the experiment

Scientific inference is affected not only by the final statistical model but by the sequence of choices that produced it. Simmons, Nelson and Simonsohn showed how undisclosed flexibility in data collection and analysis can substantially increase false-positive risk even when each individual choice appears defensible [1]. The relevant multiplicity therefore includes both explicit tests and implicit branches created by analytical discretion.

2. Planned multiplicity versus hidden multiplicity

Planned multiplicity is visible in advance: multiple outcomes, contrasts or interim analyses are specified and their inferential consequences can be controlled. Hidden multiplicity arises when decisions are made adaptively after inspecting data and only a favourable path is presented as if it had been unique. These states require different remedies. Formal multiplicity adjustment can address a defined family of tests; it cannot reconstruct an unrecorded decision tree.

3. Forking paths without intentional misconduct

Multiplicity does not require deliberate p-hacking. Analysts can make reasonable context-sensitive decisions as results become visible. The inferential problem is that the final analysis is then conditional on data-dependent choices that conventional uncertainty calculations may not include. Good faith does not remove selection effects. The remedy is procedural transparency, prospective constraints where feasible, and explicit separation between exploratory and confirmatory claims.

4. Common branching points

- when to stop collecting data;
- which observations or outliers to exclude;
- how variables are transformed or categorised;
- which outcome or time point becomes primary;
- which covariates or interactions are included;
- which subgroup receives emphasis;
- which model family, link or variance estimator is chosen;
- which analyses are omitted from the report.

5. Multiple comparisons are only one subset

Classical multiple-comparison procedures are useful when the test family is defined. They do not solve outcome switching, selective exclusion, optional stopping, post-hoc subgroup emphasis or data-dependent model selection unless those decisions are incorporated into the inferential design. INF-010 therefore treats multiple-testing correction as one tool inside a broader analytic-governance problem.

6. Preregistration and registered analysis plans

Preregistration records hypotheses, outcomes and analysis decisions before the results are known, helping distinguish prediction from postdiction [2]. It does not make a weak design strong, guarantee adherence, or prohibit justified deviations. Deviations can be scientifically appropriate if they are disclosed. The value lies in preserving the provenance of analytical decisions so that readers know which claims were tested as planned and which emerged after seeing the data.

7. Exploration remains legitimate

Exploratory analysis is indispensable for discovery. The error is not exploration but presenting exploratory findings with the evidential status of pre-specified confirmation. A productive workflow can include exploration, generation of new hypotheses, transparent reporting of the exploratory origin, and independent or prospectively specified testing in new data when the claim requires confirmation.

8. Boundary with INF-009

INF-010 concerns the bias and interpretive risk created by many possible analytical paths when selection among them depends on observed results or is incompletely reported. INF-009 concerns deliberate and transparent analysis across a declared set of plausible specifications to assess robustness. A multiverse can therefore be a remedy for hidden multiplicity when the specification universe is justified and fully disclosed [3,4].

9. Minimum reporting

- Distinguish confirmatory analyses from exploratory analyses.
- List material deviations from the planned analysis.
- Define the family of tests for any multiplicity correction.
- Report stopping rules and major exclusion decisions.
- Disclose outcome, subgroup and model-selection decisions made after inspection.
- Preserve negative and null analyses needed to understand the branching process.

References

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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.