

A. Evaluating Existing Research

I. Be skeptical, not cynical, when reading published research. Poor study design (including inadequate statistical power) and selective reporting are common features that, along with many forms of bias, decrease the reliability of most published research. Be wary of studies that (i) are published in predatory journals; (ii) emphasize statistical over biological significance, or *P*-values over effect sizes; (iii) report results from analyses that are unplanned or not reproducible; (iv) draw causal inferences from non-experimental research without sufficient evidence; (v) reference primarily supportive works while downplaying/ignoring contrary findings; or (vi) fail to discuss study limitations or alternative interpretations of their findings. These points should also inform sections B-D below.

II. Distinguish exploratory (hypothesis generating) from confirmatory (hypothesis testing) research. Exploratory research (ER) is valuable and critical for generating hypotheses, but research culture favours confirmatory research (CR). This encourages researchers to disguise ER as CR, and to Hypothesize After Results are Known (HARKing), decreasing research reliability.

III. Interpret *P*-values with care. Their meaning is clearest in pre-planned CR addressing plausible hypotheses.

IV. Consider conducting a systematic review following standardized protocols, including ways to critically evaluate study validity.

B. Planning Your Research

I. Consider research partnerships from the outset, including ethical, cultural, and practical dimensions. Who benefits from your research? Who bears risk? Ideally, those potentially impacted by the research should have the opportunity to contribute meaningfully to the design, implementation, and dissemination of the research. Embrace and foster respectful collaboration.

II. At all project stages, keep track of all contributors and contributions. Transparently report these using CRediT or MeRIT frameworks. Encourage contributors to acquire an ORCID. Plan for appropriate licenses for all outputs.

III. Consider pre-registering your study design and analysis plan in a public repository. Make a data management plan (DMP). Deviations from pre-registered plans are absolutely okay if transparently reported. Consider pre-planned protocols for ER.

IV. Specify whether your study is experimental or observational. Unless subjects/units are randomly assigned to treatments, the study is observational. Ensure proper randomization and blinding when appropriate. Causation is more readily inferred from experiments, but logistical and/or ethical constraints often necessitate observational studies. Reliable inference of causation from observational studies is possible, but requires careful pre-planning, and meeting myriad criteria and assumptions. Clearly define questions (ER) and hypotheses (CR), and specify what will constitute evidence consistent with or contrary to said hypotheses.

V. Define target population, scope of inference, dependent and independent variables, units of observation, and sample sizes. Infographics can be effective in this context. For CR, consider a prospective power analysis using plausible effect sizes. Acknowledge uncertainty and focus on sound study design and data useability. Plan for statistical models to accommodate non-Gaussian error distributions, multivariate responses and/or any hierarchical/non-independent sampling designs where appropriate. Specify how model assumptions will be checked. Plan to adjust *P*-values for multiple testing when needed. Consider planning a multiverse analysis for assessing the robustness of findings to alternative data pre-processing and/or statistical analysis pipelines.

VI. Have your research plan reviewed by both subject matter experts and others. Foster a peer community that values providing and receiving constructive criticism. Leverage supports and resources at your institution (often found through the library).

C. Conducting Your Research

I. Document data & procedures honestly and transparently as per planned protocols and DMP. Document unexpected incidents, data exclusions, and deviations from planned protocols. Consider using transparent/open, version-controlled reporting systems.

D. Reporting, Interpreting, and Communicating Your Research Findings

I. Use effective visualizations: reveal, don't conceal data. Maximize the accessibility and inclusivity of outputs. Emphasize effect sizes over *P*-values. Be transparent about unplanned versus planned analyses. Only the latter have the intended statistical meaning. Unplanned analyses yield inflated false positive rates (e.g. due to researcher degrees of freedom). Use diagnostic tools to evaluate all model assumptions, and report these checks transparently. Ensure that each analysis is linked to a pre-specified question/hypothesis. Clearly state sample sizes for all treatments, each analysis, and in each figure and table. Prioritize reporting and interpreting effect sizes, their uncertainty (e.g. confidence intervals), and their real-world relevance. When appropriate (CR) report *P*-values (adjusted for multiple-testing where appropriate) alongside effect sizes. A non-significant result does not equate with "no effect". Carefully consider merits of dichotomous criteria (e.g. $P < 0.05$). Statistical significance ≠ biological significance.

II. Avoid overselling and over-generalizing your findings. Interpret findings objectively and discuss alternative interpretations. Avoid using persuasive language. Do not extrapolate findings beyond the target population without sufficient justification. Speculation can be valuable when labeled clearly. Evaluate your draft manuscript against points in section "A-I" above.

E. Enhancing the Transparency, Reach, and Impact of Your Research

I. Ensure data and executable analysis code are as open as possible and as closed as necessary according to FAIR and CARE guidelines, and archived with appropriate metadata in an appropriate repository. Publish Open Access and/or a pre-print, and follow best practices when writing your title, abstract, and keywords. Consider creating a broadly-accessible infographic.