

post hoc power analysis

post hoc power analysis is a statistical technique used to determine the power of a test after data collection and analysis have been completed. It evaluates the probability that a study correctly rejects a false null hypothesis, based on the observed effect size, sample size, and significance level. This method is often utilized in research fields to assess the reliability and validity of study conclusions. Understanding post hoc power analysis is crucial for interpreting negative or inconclusive results and for planning future studies. This article explores the definition, applications, limitations, and interpretations of post hoc power analysis, providing a comprehensive guide for researchers and statisticians. Additionally, the article discusses common misconceptions and best practices associated with this statistical method. The following sections outline the key aspects of post hoc power analysis in detail.

- Understanding Post Hoc Power Analysis
- Applications of Post Hoc Power Analysis in Research
- Methodology and Calculation of Post Hoc Power
- Limitations and Criticisms of Post Hoc Power Analysis
- Interpreting Results and Best Practices

Understanding Post Hoc Power Analysis

Post hoc power analysis is a retrospective evaluation of the statistical power of a hypothesis test after the data have been collected and analyzed. Power, in statistical terms, refers to the probability of correctly rejecting the null hypothesis when it is false, thus avoiding a Type II error. The concept of power is integral to study design, typically assessed before data collection as a priori power analysis. However, post hoc power analysis uses observed data to estimate the likelihood that the test detected an existing effect.

Definition and Key Concepts

Power analysis measures the sensitivity of a statistical test. In the context of post hoc analysis, it examines the observed effect size, sample size, and significance level (α) to estimate the achieved power. The effect size reflects the magnitude of the difference or association detected in the study. The significance level defines the threshold for Type I error, or false positive rate. Sample size impacts the precision and reliability of the test outcomes. Post hoc power analysis integrates these factors, providing insight into whether a non-significant result was due to insufficient power or the true absence of effect.

Difference Between A Priori and Post Hoc Power

While a priori power analysis is conducted before data collection to determine the sample size necessary for detecting a meaningful effect, post hoc power analysis is performed after the study's completion. A priori analysis helps design studies with adequate power, whereas post hoc analysis evaluates how well the study achieved this goal. However, post hoc power is often controversial because it depends heavily on the observed effect size, which can vary due to sampling variability.

Applications of Post Hoc Power Analysis in Research

Post hoc power analysis is commonly applied in various research disciplines to interpret study findings and guide subsequent investigations. It assists researchers in understanding the implications of statistically non-significant results and in assessing the robustness of their studies.

Evaluating Non-Significant Results

When a study fails to reject the null hypothesis, researchers may use post hoc power analysis to determine whether the lack of significance is due to a true absence of effect or inadequate statistical power. Low post hoc power suggests that the study may not have been sensitive enough to detect an existing effect, whereas high power with non-significant results indicates that the effect is likely negligible or absent.

Informing Future Research Design

Results from post hoc power analysis can inform the planning of future studies by highlighting whether larger sample sizes or different study designs are necessary. Researchers can use this information to optimize resource allocation and improve study validity.

Supplementing Meta-Analyses and Systematic Reviews

In meta-analytical contexts, post hoc power calculations help evaluate the aggregated evidence from multiple studies. They provide additional context to the strength of findings across studies with varying power levels.

Methodology and Calculation of Post Hoc Power

Calculating post hoc power involves specific statistical formulas and software tools that incorporate the observed effect size, sample size, and significance level. Understanding the methodology is critical for accurate and meaningful estimation.

Step-by-Step Calculation Process

The typical procedure for calculating post hoc power includes the following steps:

- Determine the observed effect size from the study data (e.g., Cohen's d , odds ratio, correlation coefficient).
- Identify the sample size used in the test.
- Specify the significance level (α), commonly set at 0.05.
- Use statistical software or power analysis formulas to compute the achieved power.

Common Statistical Software and Tools

Several software packages facilitate post hoc power analysis, including:

- G*Power
- SPSS Power Analysis Modules
- R packages such as `pwr`
- Stata power commands

These tools allow researchers to input observed statistics and obtain power estimates efficiently.

Limitations and Criticisms of Post Hoc Power Analysis

Despite its widespread use, post hoc power analysis faces significant criticism regarding its interpretability and reliability. Researchers must be aware of these limitations when applying and reporting post hoc power results.

Dependence on Observed Effect Size

One major criticism is that post hoc power is calculated based on the observed effect size, which is a random variable subject to sampling variability. This dependence may lead to misleadingly high or low power estimates that do not reflect the true power of the study.

Redundancy with P-Values

Some statisticians argue that post hoc power analysis offers no additional information beyond the p-value obtained in hypothesis testing. Because power is inversely related to the p-value, reporting both may be redundant and potentially confusing.

Misinterpretation Risks

There is a risk that researchers misinterpret low post hoc power as proof that the study was inadequate, or that high power confirms the absence of effect, which may lead to erroneous conclusions. Proper understanding of the statistical context is essential to avoid these pitfalls.

Interpreting Results and Best Practices

Accurate interpretation of post hoc power analysis results requires a nuanced understanding of statistical principles and study context. Adherence to best practices enhances the utility and credibility of this method.

Guidelines for Interpretation

When interpreting post hoc power, consider the following:

- Recognize that power estimates are conditional on the observed effect size and sample size.
- Use post hoc power as one component of a broader statistical assessment, not as the sole criterion.
- Be cautious about drawing definitive conclusions solely from post hoc power results.

Recommendations for Researchers

To maximize the effectiveness of post hoc power analysis, researchers should:

1. Conduct a priori power analysis during study design to ensure adequate sample size.
2. Report post hoc power transparently alongside other statistical measures.
3. Use post hoc power as a diagnostic tool for understanding study limitations.
4. Supplement post hoc power with confidence intervals and effect size estimates for comprehensive interpretation.

Frequently Asked Questions

What is post hoc power analysis?

Post hoc power analysis is a statistical technique used to determine the power of a study after the data has been collected and analyzed, typically to assess the likelihood that the study could detect an effect of a certain size.

Why is post hoc power analysis considered controversial?

Post hoc power analysis is controversial because it often provides limited or misleading information; since it is calculated using the observed effect size, it can be biased and does not add value beyond the p-value and confidence intervals already reported.

When should post hoc power analysis be used?

Post hoc power analysis should be used cautiously, primarily for exploratory purposes or to understand the limitations of a study, but it is generally recommended to perform power analysis prior to data collection (a priori) for study planning.

How does post hoc power analysis differ from a priori power analysis?

A priori power analysis is conducted before data collection to determine the necessary sample size to detect an expected effect size, while post hoc power analysis is performed after data collection, using observed effect sizes to estimate the achieved power.

Can post hoc power analysis help interpret non-significant results?

While some researchers use post hoc power analysis to interpret non-significant results, it is often not helpful because low observed power may simply reflect the non-significant findings, making it a circular and uninformative approach.

What are better alternatives to post hoc power analysis?

Better alternatives include reporting confidence intervals, effect sizes, and conducting meta-analyses, which provide more meaningful insights into the precision and relevance of study findings than post hoc power calculations.

Is post hoc power analysis recommended in published research?

Most statistical guidelines and experts discourage the routine use of post hoc power analysis in published research due to its limitations and potential for misinterpretation.

How is post hoc power calculated?

Post hoc power is calculated by plugging the observed effect size, sample size, and significance level into power calculation formulas or software, but this calculation can be misleading because the observed effect size is a random variable.

Does a high post hoc power guarantee that study results are reliable?

No, a high post hoc power does not guarantee reliability of study results because it depends on observed data, which can be biased; reliability should be assessed through study design quality, replication, and other statistical measures.

Additional Resources

1. *Post Hoc Power Analysis in Behavioral Research*

This book offers a comprehensive overview of post hoc power analysis techniques specifically tailored for behavioral scientists. It explains the theoretical foundations and practical applications of power analysis after data collection. Readers will find detailed examples and step-by-step guides to correctly interpret post hoc power results and avoid common pitfalls.

2. *Statistical Power Analysis: Concepts and Applications*

Focusing on the concept of statistical power, this book covers both a priori and post hoc power analyses. It provides a thorough explanation of how power affects hypothesis testing and the interpretation of nonsignificant results. The text includes numerous examples from psychology and social sciences, emphasizing best practices for researchers.

3. *Applied Power Analysis for the Behavioral Sciences*

This practical guide introduces researchers to power analysis methods used in behavioral science studies, including post hoc analysis. It discusses when and how to perform power analyses after data collection to assess the likelihood of detecting true effects. The book is rich with software tutorials and real-world case studies.

4. *Understanding Post Hoc Power: Theory and Practice*

Dedicated entirely to post hoc power analysis, this book explores its theoretical underpinnings and practical limitations. It critically evaluates common misconceptions and advises on appropriate use in research reporting. The text also compares post hoc power analyses to alternative approaches such as confidence intervals and Bayesian methods.

5. *Power and Sample Size Calculations in Clinical Research*

While primarily focused on clinical trials, this book includes a significant section on post hoc

power analysis to interpret study findings. It guides researchers through calculations that can clarify nonsignificant outcomes and inform future research design. The book combines statistical theory with practical examples from medical research.

6. Post Hoc Power Analysis: Methods and Misconceptions

This book addresses the methodological challenges and common misunderstandings surrounding post hoc power analysis. It provides clear explanations of when post hoc power is informative and when it is misleading. The author offers alternative strategies to complement or replace post hoc power assessment in scientific studies.

7. Advanced Topics in Statistical Power Analysis

Targeted at advanced researchers and statisticians, this book delves into complex aspects of power analysis, including post hoc techniques. It covers recent developments, such as simulation-based power estimation and the use of effect size uncertainty. The book is ideal for those seeking a deep understanding of power analysis nuances.

8. Power Analysis in Research Design: A Guide for Social Scientists

This accessible guide helps social scientists integrate power analysis into all stages of research, with a component on post hoc analysis. It explains how to interpret power after data collection and use it to refine hypotheses and study designs. The book includes practical tips and examples from sociology, education, and psychology.

9. Interpreting Statistical Results: The Role of Post Hoc Power

This volume explores how post hoc power analysis fits into the broader context of statistical interpretation. It discusses the relationship between power, p-values, and confidence intervals, emphasizing careful communication of results. The book offers guidance on avoiding overreliance on post hoc power and using it judiciously in research reports.

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post hoc power analysis: Experimental Design and Data Analysis for Biologists Gerald Peter Quinn, Michael J. Keough, 2002-03-21 An essential textbook for any student or researcher in biology needing to design experiments, sample programs or analyse the resulting data. The text begins with a revision of estimation and hypothesis testing methods, covering both classical and Bayesian philosophies, before advancing to the analysis of linear and generalized linear models. Topics covered include linear and logistic regression, simple and complex ANOVA models (for factorial, nested, block, split-plot and repeated measures and covariance designs), and log-linear models. Multivariate techniques, including classification and ordination, are then introduced. Special emphasis is placed on checking assumptions, exploratory data analysis and presentation of results. The main analyses are illustrated with many examples from published papers and there is an extensive reference list to both the statistical and biological literature. The book is supported by a website that provides all data sets, questions for each chapter and links to software.

post hoc power analysis: *Applied Power Analysis for the Behavioral Sciences* Christopher L. Aberson, 2011-01-19 This practical guide on conducting power analyses using IBM SPSS was written for students and researchers with limited quantitative backgrounds. Readers will appreciate the coverage of topics that are not well described in competing books such as estimating effect sizes, power analyses for complex designs, detailed coverage of popular multiple regression and multi-factor ANOVA approaches, and power for multiple comparisons and simple effects. Practical issues such as how to increase power without increasing sample size, how to report findings, how to derive effect size expectations, and how to support null hypotheses, are also addressed. Unlike other texts, this book focuses on the statistical and methodological aspects of the analyses. Performing analyses using software applications rather than via complex hand calculations is demonstrated throughout. Ready-to-use IBM SPSS syntax for conducting analyses are included to perform calculations and power analyses at <http://www.psypress.com/applied-power-analysis>. Detailed annotations for each syntax protocol review the minor modifications necessary for researchers to adapt the syntax to their own analyses. As such, the text reviews both power analysis techniques and provides tools for conducting analyses. Numerous examples enhance accessibility by demonstrating specific issues that must be addressed at all stages of the power analysis and providing detailed interpretations of IBM SPSS output. Several examples address techniques for estimation of power and hand calculations as well. Chapter summaries and key statistics sections also aid in understanding the material. Chapter 1 reviews significance testing and introduces power. Chapters 2 through 9 cover power analysis strategies for a variety of common designs. Precision analysis for confidence intervals around mean difference, correlations, and effect sizes is the focus of chapter 10. The book concludes with a review of how to report power analyses, a review of freeware and commercial software for power analyses, and how to increase power without increasing sample size. Chapters focusing on simpler analyses such as t-tests present detailed formulae and calculation examples. Chapters focusing on more complex topics such as mixed model ANOVA/MANOVA present primarily computer-based analyses. Intended as a supplementary text for graduate-level research methods, experimental design, quasi-experimental methods, psychometrics, statistics, and/or advanced/multivariate statistics taught in the behavioral, social, biological, and medical sciences, researchers in these fields also appreciate this book's practical emphasis. A prerequisite of introductory statistics is recommended.

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post hoc power analysis: Statistical Power Analysis Brett Myors, Kevin R. Murphy, 2023-03-03 Statistical Power Analysis explains the key concepts in statistical power analysis and illustrates their

application in both tests of traditional null hypotheses (that treatments or interventions have no effect in the population) and in tests of the minimum-effect hypotheses (that the population effects of treatments or interventions are so small that they can be safely treated as unimportant). It provides readers with the tools to understand and perform power analyses for virtually all the statistical methods used in the social and behavioral sciences. Brett Myers and Kevin Murphy apply the latest approaches of power analysis to both null hypothesis and minimum-effect testing using the same basic unified model. This book starts with a review of the key concepts that underly statistical power. It goes on to show how to perform and interpret power analyses, and the ways to use them to diagnose and plan research. We discuss the uses of power analysis in correlation and regression, in the analysis of experimental data, and in multilevel studies. This edition includes new material and new power software. The programs used for power analysis in this book have been re-written in R, a language that is widely used and freely available. The authors include R codes for all programs, and we have also provided a web-based app that allows users who are not comfortable with R to perform a wide range of analyses using any computer or device that provides access to the web. Statistical Power Analysis helps readers design studies, diagnose existing studies, and understand why hypothesis tests come out the way they do. The fifth edition includes updates to all chapters to accommodate the most current scholarship, as well as recalculations of all examples. This book is intended for graduate students and faculty in the behavioral and social sciences; researchers in other fields will find the concepts and methods laid out here valuable and applicable to studies in many domains.

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post hoc power analysis: An Introduction to Statistical Concepts Richard G Lomax, Debbie L. Hahs-Vaughn, 2013-06-19 This comprehensive, flexible text is used in both one- and two-semester courses to review introductory through intermediate statistics. Instructors select the topics that are most appropriate for their course. Its conceptual approach helps students more easily understand the concepts and interpret SPSS and research results. Key concepts are simply stated and occasionally reintroduced and related to one another for reinforcement. Numerous examples demonstrate their relevance. This edition features more explanation to increase understanding of the concepts. Only crucial equations are included. In addition to updating throughout, the new edition features: New co-author, Debbie L. Hahs-Vaughn, the 2007 recipient of the University of Central Florida's College of Education Excellence in Graduate Teaching Award. A new chapter on logistic regression models for today's more complex methodologies. More on computing confidence intervals and conducting power analyses using G*Power. Many more SPSS screenshots to assist with understanding how to navigate SPSS and annotated SPSS output to assist in the interpretation of results. Extended sections on how to write-up statistical results in APA format. New learning tools including chapter-opening vignettes, outlines, and a list of key concepts, many more examples, tables, and figures, boxes, and chapter summaries. More tables of assumptions and the effects of their violation including how to test them in SPSS. 33% new conceptual, computational, and all new interpretative problems. A website that features PowerPoint slides, answers to the even-numbered problems, and test items for instructors, and for students the chapter outlines, key concepts, and datasets that can be used in SPSS and other packages, and more. Each chapter begins with an outline, a list of key concepts, and a vignette related to those concepts. Realistic examples from

education and the behavioral sciences illustrate those concepts. Each example examines the procedures and assumptions and provides instructions for how to run SPSS, including annotated output, and tips to develop an APA style write-up. Useful tables of assumptions and the effects of their violation are included, along with how to test assumptions in SPSS. 'Stop and Think' boxes provide helpful tips for better understanding the concepts. Each chapter includes computational, conceptual, and interpretive problems. The data sets used in the examples and problems are provided on the web. Answers to the odd-numbered problems are given in the book. The first five chapters review descriptive statistics including ways of representing data graphically, statistical measures, the normal distribution, and probability and sampling. The remainder of the text covers inferential statistics involving means, proportions, variances, and correlations, basic and advanced analysis of variance and regression models. Topics not dealt with in other texts such as robust methods, multiple comparison and nonparametric procedures, and advanced ANOVA and multiple and logistic regression models are also reviewed. Intended for one- or two-semester courses in statistics taught in education and/or the behavioral sciences at the graduate and/or advanced undergraduate level, knowledge of statistics is not a prerequisite. A rudimentary knowledge of algebra is required.

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of data, biased sampling designs, and more predictors than data points are pushing the limits of classical statistical analysis. This textbook provides a new tool for the statistical toolkit: data simulations. It shows that using simulation and data-generating models is an excellent way to validate statistical reasoning and to augment study design and statistical analysis with planning and visualization. Although data simulations are not new to professional statisticians, *Statistics by Simulation* makes the approach accessible to a broader audience, with examples from many fields. It introduces the reasoning behind data simulation and then shows how to apply it in planning experiments or observational studies, developing analytical workflows, deploying model diagnostics, and developing new indices and statistical methods.

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post hoc power analysis: *Quantitative Epidemiology* Xinguang Chen, 2022-02-22 This book is designed to train graduate students across disciplines within the fields of public health and medicine, with the goal of guiding them in the transition to independent researchers. It focuses on theories, principles, techniques, and methods essential for data processing and quantitative analysis to address medical, health, and behavioral challenges. Students will learn to access to existing data and process their own data, quantify the distribution of a medical or health problem to inform decision making; to identify influential factors of a disease/behavioral problem; and to support health promotion and disease prevention. Concepts, principles, methods and skills are demonstrated with SAS programs, figures and tables generated from real, publicly available data. In addition to various methods for introductory analysis, the following are featured, including 4-dimensional measurement of distribution and geographic mapping, multiple linear and logistic regression, Poisson regression, Cox regression, missing data imputing, and statistical power analysis.

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Multivariate techniques, including classification and ordination, are then introduced. Special emphasis is placed on checking assumptions, exploratory data analysis and presentation of results. The main analyses are illustrated with many examples from published papers and there is an extensive reference list to both the statistical and biological literature. The book is supported by a website that provides all data sets, questions for each chapter and links to software.

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post hoc power analysis: IBM SPSS for Intermediate Statistics Nancy L. Leech, Karen C. Barrett, George A. Morgan, 2012-03-29 Designed to help readers analyze and interpret research data using IBM SPSS, this user-friendly book shows readers how to choose the appropriate statistic based on the design, perform intermediate statistics, including multivariate statistics, interpret output, and write about the results. The book reviews research designs and how to assess the accuracy and reliability of data: whether data meet the assumptions of statistical tests; how to calculate and interpret effect sizes for intermediate statistics, including odds ratios for logistic and discriminant analyses; how to compute and interpret post-hoc power; and an overview of basic statistics for those who need a review. Unique chapters on multilevel linear modeling, multivariate analysis of variance (MANOVA), assessing reliability of data, and factor analysis are provided. SPSS syntax, along with the output, is included for those who prefer this format. The new edition features: IBM SPSS version 19; although the book can be used with most older and newer versions expanded discussion of assumptions and effect size measures in several chapters expanded discussion of multilevel modeling expansion of other useful SPSS functions in Appendix A examples that meet the new formatting guidelines in the 6th edition of the APA Publication Manual (2010) flowcharts and tables to help select the appropriate statistic and interpret statistical significance and effect sizes multiple realistic data sets available on the website used to solve the chapter problems password protected Instructor's Resource materials with PowerPoint slides, answers to interpretation questions and extra SPSS problems, and chapter outlines and study guides. IBM SPSS for Intermediate Statistics, Fourth Edition provides helpful teaching tools: all of the key SPSS windows needed to perform the analyses outputs with call-out boxes to highlight key points interpretation sections and questions to help students better understand and interpret the output extra problems using multiple realistic data sets for practice in conducting analyses using intermediate statistics helpful appendices on how to get started with SPSS, writing research questions, and review of basic statistics. An ideal supplement for courses in either intermediate/advanced statistics or research methods taught in departments of psychology, education, and other social and health sciences, this book is also appreciated by researchers in these areas looking for a handy reference for SPSS.

post hoc power analysis: IBM SPSS for Intermediate Statistics Karen C. Barrett, Nancy L. Leech, George A. Morgan, 2014-08-05 Designed to help readers analyze and interpret research data using IBM SPSS, this user-friendly book shows readers how to choose the appropriate statistic based on the design; perform intermediate statistics, including multivariate statistics; interpret output; and

write about the results. The book reviews research designs and how to assess the accuracy and reliability of data; how to determine whether data meet the assumptions of statistical tests; how to calculate and interpret effect sizes for intermediate statistics, including odds ratios for logistic analysis; how to compute and interpret post-hoc power; and an overview of basic statistics for those who need a review. Unique chapters on multilevel linear modeling; multivariate analysis of variance (MANOVA); assessing reliability of data; multiple imputation; mediation, moderation, and canonical correlation; and factor analysis are provided. SPSS syntax with output is included for those who prefer this format. The new edition features:

- IBM SPSS version 22; although the book can be used with most older and newer versions
- New discussion of intraclass correlations (Ch. 3)
- Expanded discussion of effect sizes that includes confidence intervals of effect sizes (ch.5)
- New information on part and partial correlations and how they are interpreted and a new discussion on backward elimination, another useful multiple regression method (Ch. 6)
- New chapter on how to use a variable as a mediator or a moderator (ch. 7)
- Revised chapter on multilevel and hierarchical linear modeling (ch. 12)
- A new chapter (ch. 13) on multiple imputation that demonstrates how to deal with missing data
- Updated web resources for instructors including PowerPoint slides and answers to interpretation questions and extra problems and for students, data sets, chapter outlines, and study guides.

IBM SPSS for Intermediate Statistics, Fifth Edition provides helpful teaching tools:

- all of the key SPSS windows needed to perform the analyses
- outputs with call-out boxes to highlight key points
- interpretation sections and questions to help students better understand and interpret the output
- extra problems with realistic data sets for practice using intermediate statistics
- Appendices on how to get started with SPSS, write research questions, and basic statistics.

An ideal supplement for courses in either intermediate/advanced statistics or research methods taught in departments of psychology, education, and other social, behavioral, and health sciences. This book is also appreciated by researchers in these areas looking for a handy reference for SPSS

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