



POWER ANALYSIS

HOW TO CONSTRUCT A STUDY TO ADEQUATELY TO FIND AN
EXPECTED EFFECT

Presented By Georgetown Initiative for Open Science

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Link to OSF Page



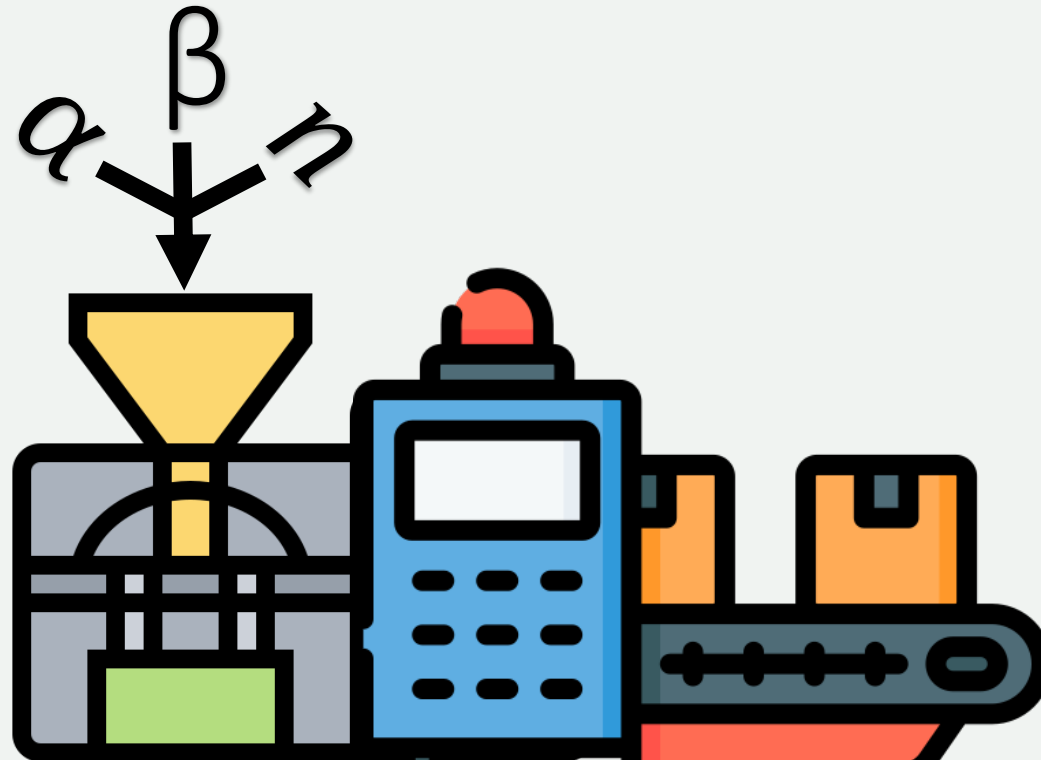
WHAT DO WE MEAN BY STATISTICAL POWER?

- How likely are we to accurately represent an expected statistically relationship given the n, p-value, and $1-\beta$ criterion.

TYPE 1 & TYPE 2 ERROR

		What you Find	
		Do Not Find Significance	Find Significance
What is True	There is No Difference (H0 Is True)	Accurate Assessment	Inaccurate Assessment TYPE 1 Error - α
	There is a Difference (H0 is False)	Inaccurate Assessment TYPE 2 Error - β	Accurate Assessment

THE STATISTICAL MACHINE



THE STATISTICAL MACHINE



THE STATISTICAL MACHINE



THE STATISTICAL MACHINE



THE INPUTS

- α
 - Determines the threshold for what you will consider a significant p-value (e.g. $p < .05$).
- $1-\beta$
 - Determines the likelihood of a false-negative effect.
- Sample Size
 - The size of your sample.
- Smallest Effect of Interest
 - The size of the statistical effect that you are setting out to find.

THE DIFFERENT TYPES OF TEST

(AS DEFINED BY G-POWER)

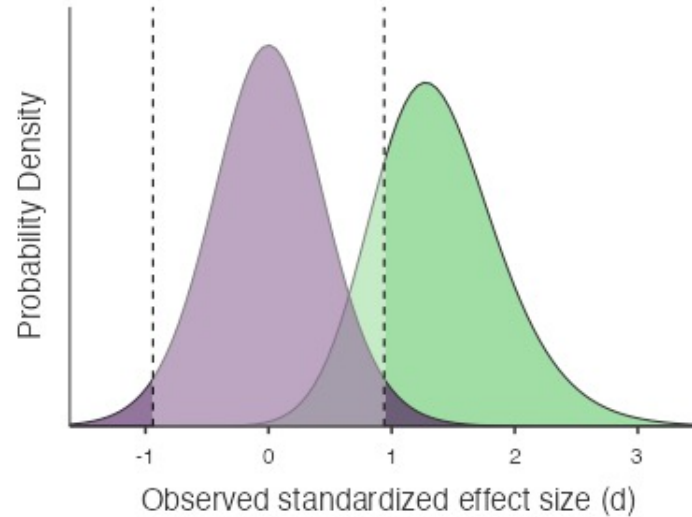
- A Priori
 - Sample Size
- Criterion
 - α
- Post Hoc
 - $1-\beta$
- Sensitivity Analysis
 - Minimum Statistical Effect

QUARK OF THIS RELATIONSHIP

- With a sufficiently sized study, you can find a significant effect.

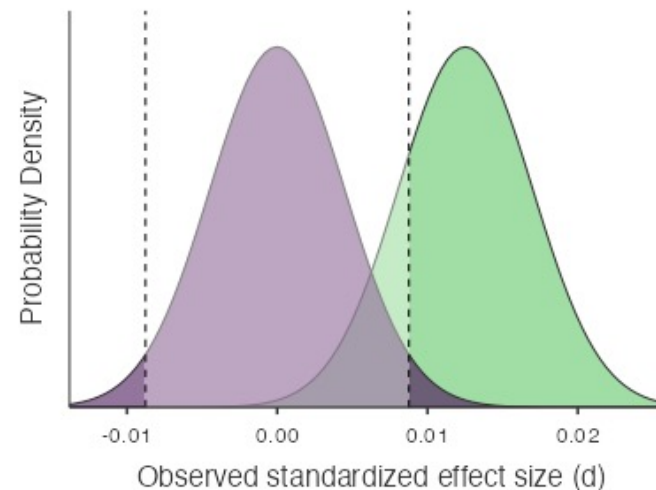
A Priori Power Analysis

Effect Size	User Defined			
	N_1	N_2	Power	α
1.32	10	10	0.800	0.0500



A Priori Power Analysis

Effect Size	User Defined			
	N_1	N_2	Power	α
0.0125	100000	100000	0.800	0.0500





BECAUSE OF THIS RELATIONSHIP, WHAT WE CARE MORE ABOUT IS THE MAGNITUDE OF THE EFFECT YOU ARE LOOKING TO FIND.

A FEW DIFFERENT WAYS WE CALCULATE MAGNITUDE OF EFFECT

- Cohen's D
 - T-Test
- R
 - Correlation
- R^2
 - Regression Model
- Odds Ratio
 - Logistic Regression
- Eta Squared
 - ANOVA
- χ^2
 - Chi-Squared Equivalency Test

COHEN'S D

- The standardized difference between two samples

$$Cohen's\ d = \frac{Mean_2 - Mean_1}{\sqrt{(SD_2^2 + SD_1^2)/2}}$$

- Useful for determining effects of t-tests or for binary independent variables.

PEARSON'S R

- The standardized relationship between two variables

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

- Useful for determining the relationship between for variables in a correlation and regression.

ODDS RATIO

- The standardized relationship likelihood between a variable and a categorical dependent variable

$$\text{Odds Ratio} = \text{Coefficient}^2$$

- Useful for determining the relationship for variables in a logistic regression.

HELPFUL SITE

<https://www.escal.site/>



Effect size converter

Convert between different effect sizes

By convention, Cohen's d of 0.2, 0.5, 0.8 are considered small, medium and large effect sizes respectively.

Cohen's d	0.500 
Pearson's correlation r	0.243 
R-squared	0.059 
Cohen's f	0.250 
Odds ratio (OR)	2.477 
Log odds ratio	0.907 
Area-under-curve (AUC)*	0.638 
Fisher's z (z')	0.247 

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Conversion formulae

All conversions assume equal-sample-size groups.

Cohen's d to Pearson's r ¹

$$r = \frac{d}{\sqrt{d^2 + 4}}$$

Cohen's d to Cohen's f ²

$$f = \frac{d}{2}$$

Cohen's d to *log odds ratio*³

$$\text{log odds ratio} = \frac{d\pi}{\sqrt{3}}$$

Cohen's d to *area-under-curve (auc)*¹

$$\text{auc} = \phi \frac{d}{\sqrt{2}}$$

ϕ : normal cumulative distribution function
R code: `pnorm(d/sqrt(2), 0, 1)`

Correlation r Fisher's z ⁴

$$z' = 0.5 * (\log(1 + r) - \log(1 - r))$$

References

1. Ruscio, J. (2008). A probability-based measure of effect size: Robustness to base rates and other factors. *Psychological Methods*, 13(1), 19-30. doi:10.1037/1082-989x.13.1.19
2. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.), Hillsdale, NJ: Erlbaum.
3. Sánchez-Meca, J., Marín-Martínez, F., & Chacón-MoscOSO, S. (2003). Effect-size indices for dichotomized outcomes in meta-analysis. *Psychological Methods*, 8(4), 448-467.
4. [Wikipedia: Fisher's z-transformation of r](#)
5. Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. Chichester, West Sussex, UK: Wiley.
6. Rosenthal, R. (1994). Parametric measures of effect size. In H. Cooper & L. V. Hedges (Eds.), *The Handbook of Research Synthesis*. New York, NY: Sage.

STANDARD CONVENTIONS OF DETERMINING POWER

- α
 - $p < .05$
- $1-\beta$
 - .80
- Smallest Effect of Interest
 - Depends on the expected effect. (e.g. $d = 3$)

OTHER RESOURCES

- Calculating Cohen's d from student's t in an OLS regression – Daniel Lakens
 - https://osf.io/ixgcd/?view_only=
- How To Run Additional tests in G*Power
 - <https://stats.oarc.ucla.edu/other/gpower/>
- Addition Power Analysis Workshop – Daniel Quintana
 - https://osf.io/uk5bp/?view_only=
- Way to Visualize Power
 - <https://rpsychologist.com/viz>

R PACKAGES FOR DETERMINING EFFECTS

- pwr
 - A simplified power analysis
- Effectsize
 - A more complex power analysis package, with extra functions for converting between effect sizes.

LIVE DEMONSTRATION OF G*POWER

- Look up G*Power on Google or go to this website.
 - <https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower>