

CHAPTER 8

POWER & EFFECT SIZE

FOR EDUC/PSY 6600

“Cohen (1994): “Next, I have learned and taught that the primary product of research inquiry is one or more measures of effect size, not p values.” (p. 1310).

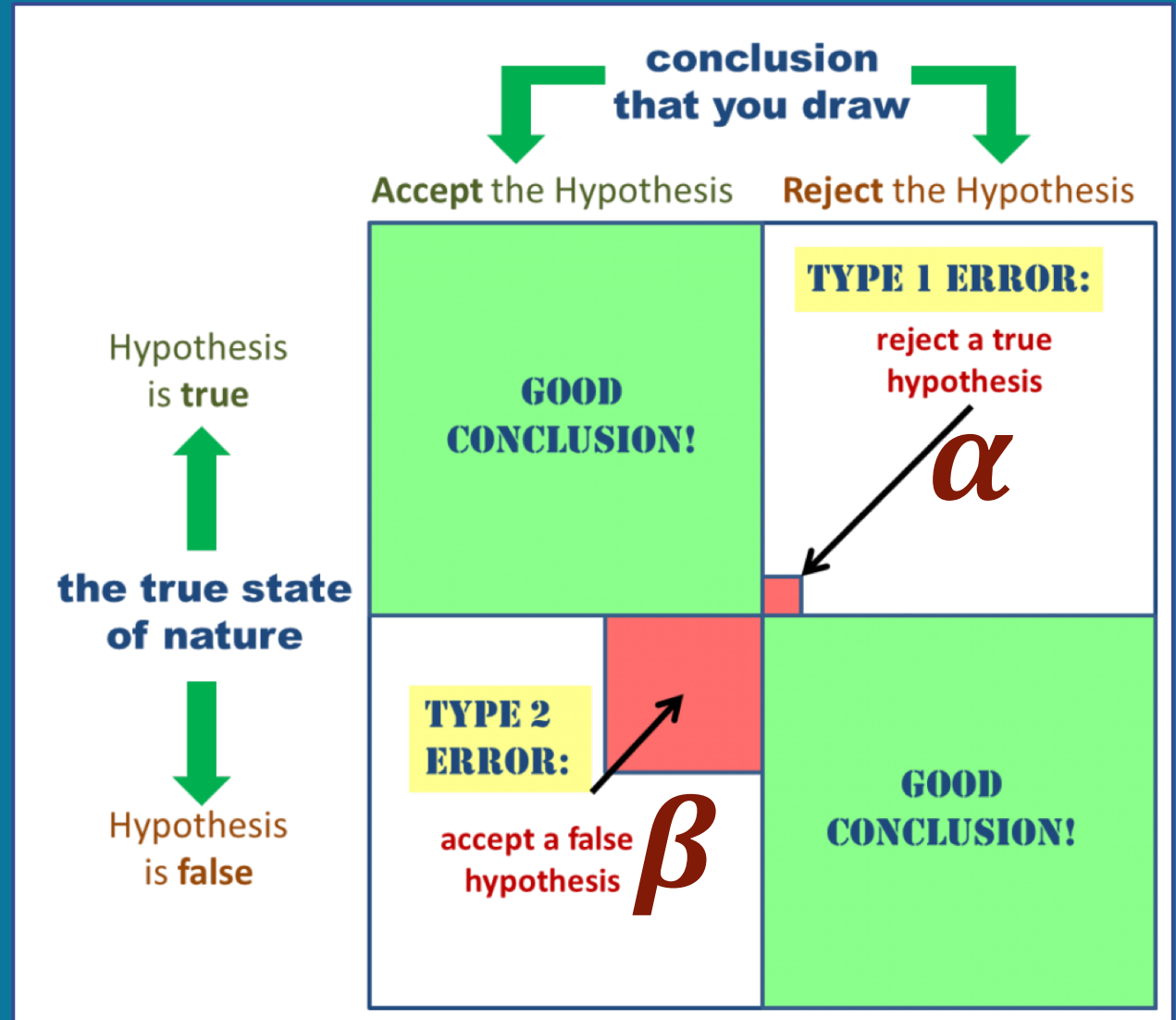
Abelson (1995): “However, as social scientists move gradually away from reliance on single studies and obsession with null hypothesis testing, effect size measures will become more and more popular” (p. 47).

”

Types of Errors

When we conduct a hypothesis test, we either reject or fail to reject the Null Hypothesis.

Our decision usually causes four outcomes:



Types of Errors

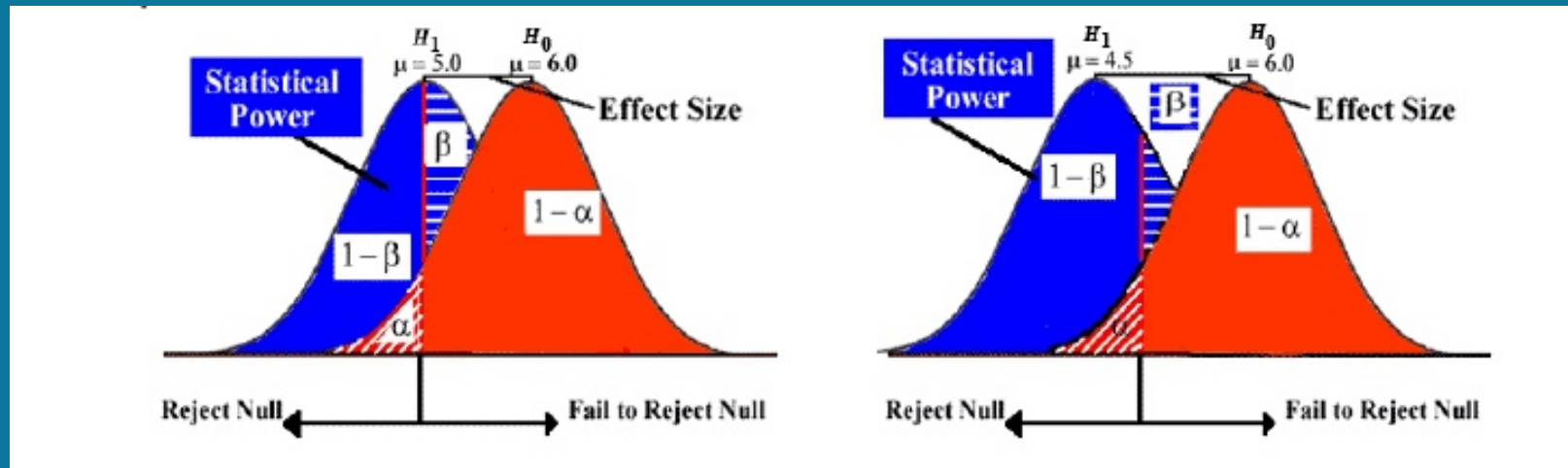
$$\underline{\text{Power} = 1 - \beta}$$

“the probability of
correctly rejecting
a false null hypothesis.”

Effect Sizes

$$\text{Cohen's } d = \frac{\bar{X}_1 - \bar{X}_2}{s_p} \text{ or } t \sqrt{\frac{n_1 + n_2}{n_1 n_2}}$$

$$\eta^2 = r_{pb}^2 = \frac{t^2}{t^2 + (n_1 + n_2 - 2)}$$



Effect Sizes

$$\text{Cohen's } d = \frac{\bar{X}_1 - \bar{X}_2}{s_p} \text{ or } t \sqrt{\frac{n_1 + n_2}{n_1 n_2}}$$

Cohen's d	Interpretation
.2	Small
.5	Moderate
.8	Large

Effect Sizes

$$\eta^2 = r_{pb}^2 = \frac{t^2}{t^2 + (n_1 + n_2 - 2)}$$

η^2 (eta squared) and r_{pb}^2

- **association** between grouping variable (IV) and continuous DV
- Ranges from 0 to 1
- With only 2 groups, results are same

What affects power?

1. Sample Size

- Larger sample = more power

2. Effect Size

- Larger Effect size = more power

3. Alpha Level

- Higher Alphas = more power

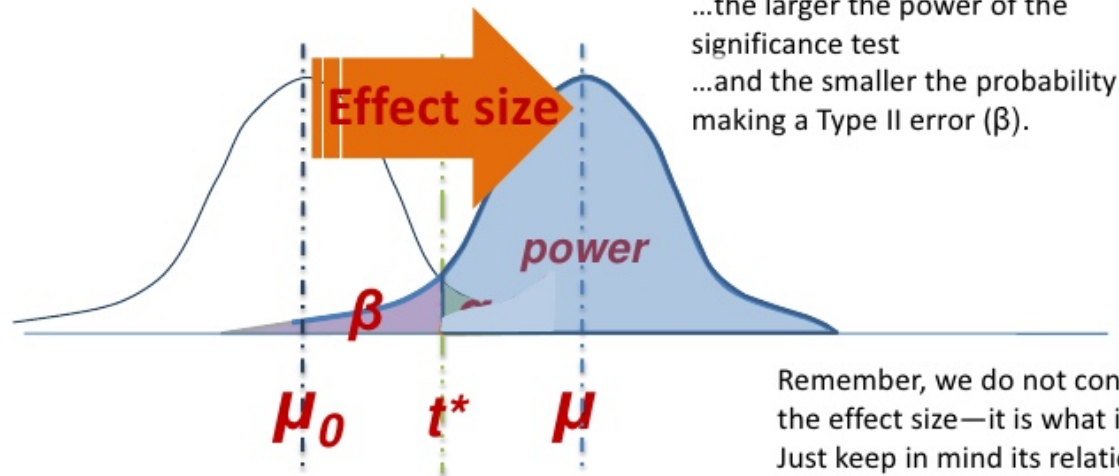
4. Directionality

- One tail = more power

Types of errors and their probabilities

- How does effect size relate to power and β ?

The larger the effect size...
...the larger the power of the
significance test
...and the smaller the probability of
making a Type II error (β).



Remember, we do not control
the effect size—it is what it is.
Just keep in mind its relation
to both power and β .

Power Analysis

- Non-centrality parameter is calculated by:

$$\delta = \frac{d}{\sigma \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

- Since it's assumed that the...
 - Variances are same in 2 groups
 - N 's are same in 2 groups
- ...and since σ is often assumed to be 1...
- ...the equation is simplified...

δ	ONE-TAILED TEST (α)			
	.05	.025	.01	.005
	TWO-TAILED TEST (α)			
	.10	.05	.02	.01
0.5	.14	.08	.03	.02
0.6	.16	.09	.04	.02
0.7	.18	.11	.05	.03
0.8	.21	.13	.06	.04
0.9	.23	.15	.08	.05
1.0	.26	.17	.09	.06
1.1	.29	.20	.11	.07
1.2	.33	.22	.13	.08
1.3	.37	.26	.15	.10
1.4	.40	.29	.18	.12
1.5	.44	.32	.20	.14
1.6	.48	.36	.23	.16
1.7	.52	.40	.27	.19
1.8	.56	.44	.30	.22
1.9	.60	.48	.33	.25
2.0	.64	.52	.37	.28
2.1	.68	.56	.41	.32
2.2	.71	.60	.45	.35
2.3	.74	.63	.49	.39
2.4	.77	.67	.53	.43
2.5	.80	.71	.57	.47
2.6	.83	.74	.61	.51
2.7	.85	.77	.65	.55
2.8	.88	.80	.68	.59
2.9	.90	.83	.72	.63

When $n_1 = n_2$

$$\delta = \mathbf{d} \sqrt{\frac{n_k}{2}}$$

$$n_k = 2 \left(\frac{\delta}{\mathbf{d}} \right)^2$$

When $n_1 \neq n_2$

$$\frac{2}{\frac{1}{n_1} + \frac{1}{n_2}} = \frac{2n_1n_2}{n_1 + n_2}$$

$$\delta = \mathbf{d} \sqrt{\frac{n_h}{2}}$$

FORMULA SHEET

$$\begin{array}{l}
 \delta = \text{"EXPECTED T OR Z" (population parameters)} \\
 \left. \begin{array}{l}
 \text{1 group: } \delta = \frac{\mu}{\sigma} \sqrt{n} \xrightarrow{d = \frac{\mu}{\sigma}} \delta = d \sqrt{n} \\
 \text{2 groups: } \delta \xrightarrow{\text{equal } n's} \frac{\mu_1 - \mu_2}{\sigma} \sqrt{\frac{n}{2}} \xrightarrow{d = \frac{\mu_1 - \mu_2}{\sigma}} \delta = d \sqrt{\frac{n}{2}}
 \end{array} \right\} \begin{array}{l}
 \xleftrightarrow{\text{est. } d = g \left(1 - \frac{3}{4 df - 1} \right)} \\
 \\
 \end{array} \left\{ \begin{array}{l}
 g = \text{"effect size" (sample statistics)} \\
 \\
 g = \frac{\bar{X}_1 - \bar{X}_2}{s_p} \left\{ \begin{array}{l}
 = t \sqrt{\frac{2}{n}} \quad \xleftarrow{n_1 = n_2} \\
 = t \sqrt{\frac{n_1 + n_2}{n_1 n_2}} \quad \xleftarrow{n_1 \neq n_2}
 \end{array} \right.
 \end{array} \right.
 \end{array}$$

G-POWER

Download at: <http://www.gpower.hhu.de/>

G*Power 3.1.9.2

File Edit View Tests Calculator Help

Central and noncentral distributions Protocol of power analyses

Test family: t tests

Statistical test: Correlation: Point biserial model

Type of power analysis: A priori: Compute required sample size - given α , power, and effect size

Input Parameters

Determine =>

Tail(s): One

Effect size $|p|$: 0.3

α err prob: 0.05

Power ($1 - \beta$ err prob): 0.95

Output Parameters

Noncentrality parameter δ : ?

Critical t: ?

Df: ?

Total sample size: ?

Actual power: ?

X-Y plot for a range of values

Calculate

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CHAP 8: SECTION A

- **d** is just the number of standard deviations that separate two **population** means
- **g** is the number of standard deviations (based on pooling the sample variances and taking the square-root) separating the **sample** means.
- connection between a calculated t and delta;
 - large t 's are *usually* associated with large deltas
 - small t 's *usually* with small deltas.
 - Of course, the **alternate hypothesis distribution** shows that t can occasionally come out very differently from delta

CHAP 8: SECTION B

An estimate of **power**
is only as good as
the estimate of **effect size** upon which it is based

...BUT determining the effect size is usually
the purpose (or should be) of the experiment.