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).

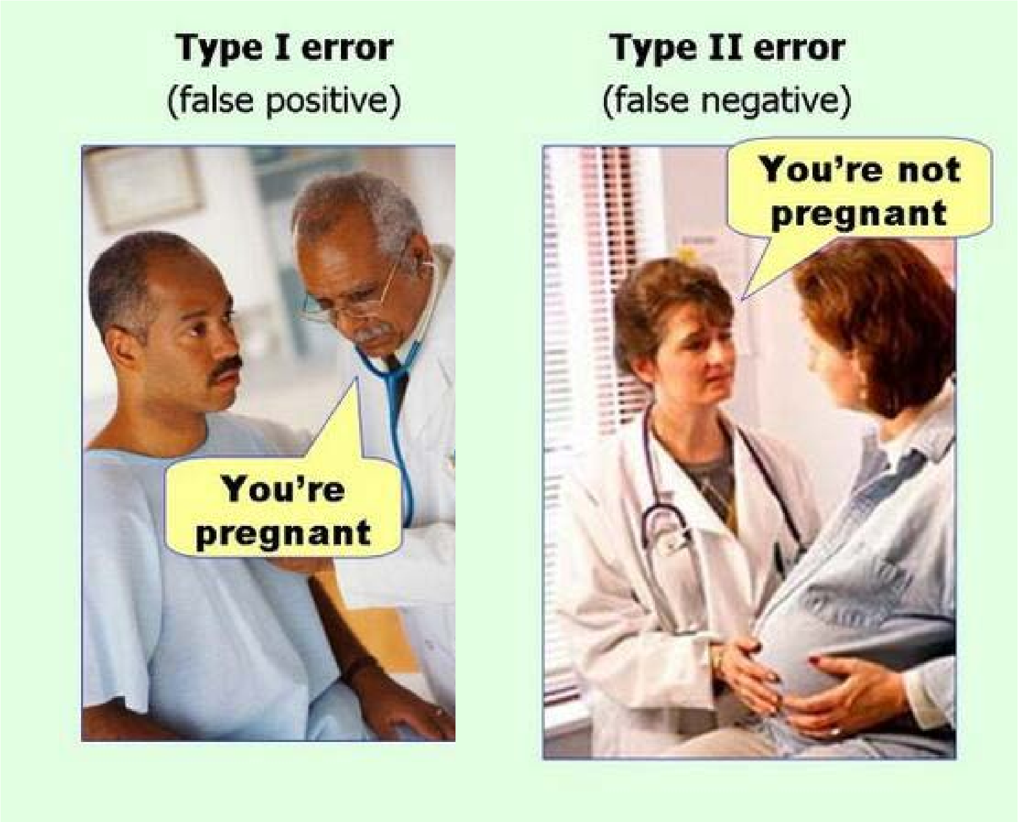
COHEN CHAP 8. POWER & EFFECT SIZE

For EDUC/PSY 6600

TYPES OF ERRORS

When we conduct a hypothesis test, we wither reject or fail to regect the Null Hypothesis. Our decision usually causes four outcomes:

		REALITY	
		NULL HYPOTHESIS	
		TRUE	FALSE
STUDY FINDINGS	TRUE		Type II error (β) 'False negative'
	FALSE	Type I error (α) 'False positive'	

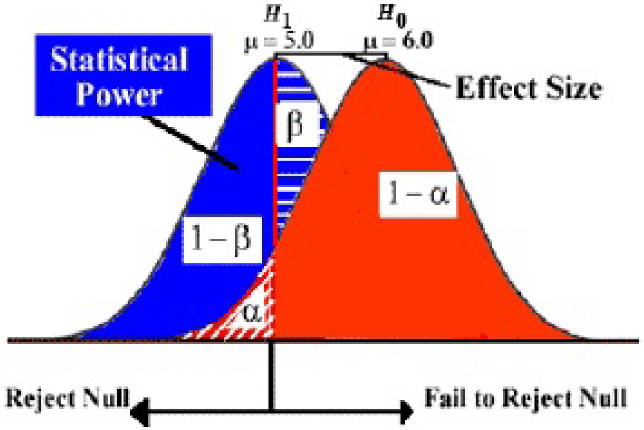


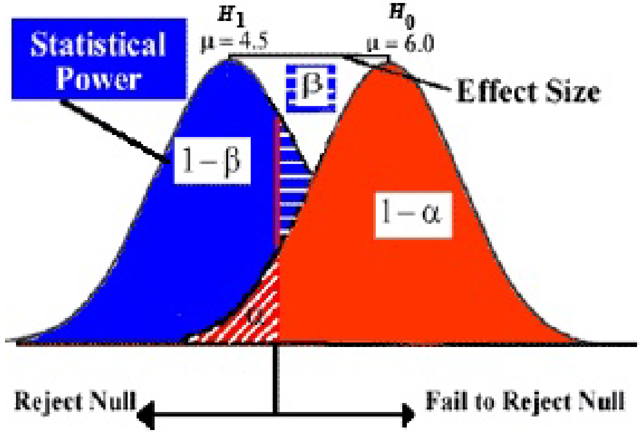
<u>Power = 1 – β</u>

"the probability of correctly rejecting a falsely rejecting a false null hypothesis."

EFFECT SIZE

- Cohen's d:
  - Small: 0.2
  - Medium: 0.5
  - Large: 0.8





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

- η^2 and r^2_{pb}: association between grouping variable (IV) and continuous DV
  - Ranges from 0 to 1
  - With only 2 groups, results are same

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

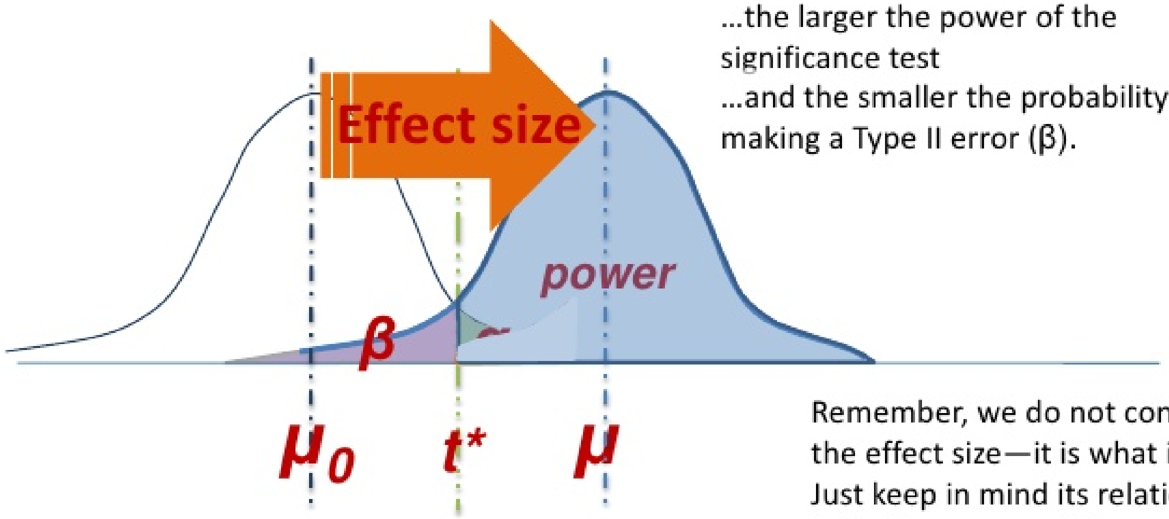
WHAT AFFECTS POWER?

1. Sample Size
   - Larger sample = more power
2. Effect Size
   - Larger Effect size = more power
3. Alpha Level
   - Higher Alphs = 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
- *ns* are same in 2 groups

…and since σ is often assumed to be 1…

…the equation is simplified…

	One-Tailed Test (α)			
	.05	.025	.01	.005
	Two-Tailed Test (α)			
δ	.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

POWER ANALYSIS

When $n_1 = n_2$

Post hoc

- δ → Power via Table A.3
- n = # cases in any one group

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

a priori

- n per group necessary for specified power

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

When $n_1 \neq n_2$

Post hoc

- Conservative approach: use smaller n in previous formulae
  - Ineffective if ns vastly different or small
- Liberal approach: compute harmonic (not arithmetic) mean: $\bar{n}_h = \dfrac{2}{\dfrac{1}{n_1} + \dfrac{1}{n_2}} = \dfrac{2n_1 n_2}{n_1 + n_2}$
- Then, $\delta = \mathbf{d}\sqrt{\dfrac{\bar{n}_h}{2}}$

a priori

- Always plan for **equal** n's
- Never throw out data just to make your n's equal!

G-POWER

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