

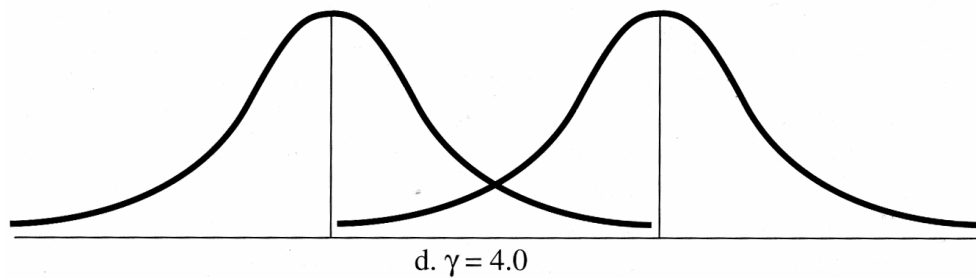
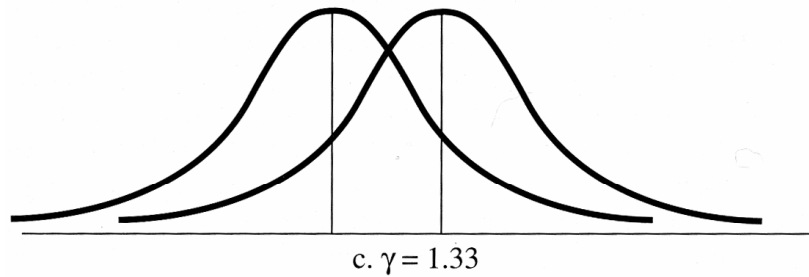
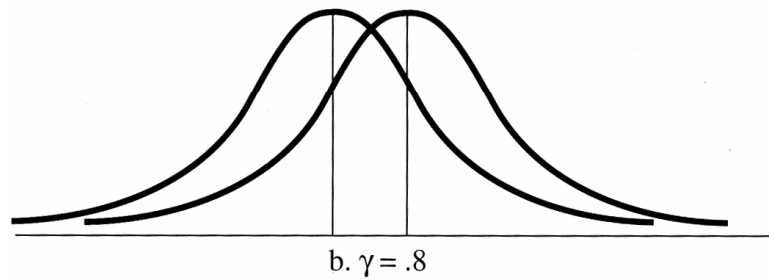
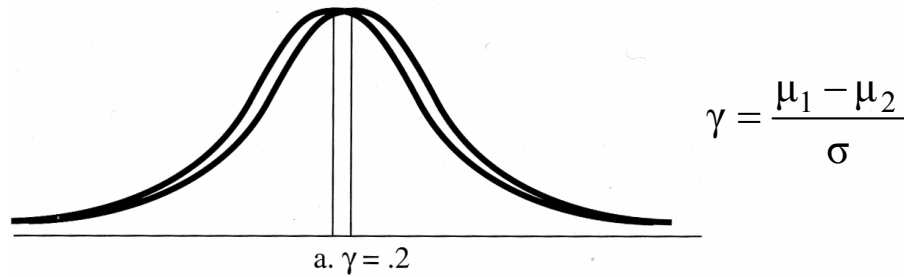
Questions?

- Project
- Homework

t-Test for two independent sample means

- Setting
 - Two different treatments: (pen versus mouse)
 - For each treatment you gathered from a random samples
 - *Mean*
 - *Standard deviation*
- Null hypothesis
 - The difference of the means follows a normal distribution

t-test interpretation



From Explaining Psychological Statistics (Cohen)

***t*-test**

- **Formula**

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{s_p^2 \left(\frac{1}{N_1} + \frac{1}{N_2} \right)}}, \text{ with } \begin{cases} s_p = \sqrt{\frac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{N_1 + N_2 - 2}} \\ df = N_1 + N_2 - 2 \end{cases}$$
$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2 + s_2^2}{N}}}, \text{ if } N = N_1 = N_2$$

μ_i population mean, $\bar{X}_i$ estimated population mean, s_i estimated population standard deviation

- **Assumptions**

- Independent Random Sampling
- Normal Distribution
- Homogeneity of Variance (same variance for the 2 populations)

***t*-test example**

Statistical significance

- Statistical significance
 - Comparing to the null hypothesis: “There is no effect”
 - Type I errors are the most disruptive

Researcher's Decision	Actual Situation: Null Hypothesis is	
	True	False
Fail to reject the null hypothesis	Correct decision	Type II error
Reject the null hypothesis	Type I error	Correct decision

- Design significance?
 - 3.00s versus 3.05s?

Power

- Symbols:

- Type II error rate: β
- Power: $(1 - \beta)$

- Computed effect size: $g = \frac{\bar{X}_1 - \bar{X}_2}{s_p}$ with $s_p = \sqrt{\frac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{N_1 + N_2 - 2}}$

- Expected t value (alternative hypothesis distribution): $\delta = \sqrt{\frac{N}{2}}\gamma$
 - δ can be found in table
 - g is an estimator for γ

- Usage

- The null hypothesis cannot be rejected: is it a type II error?
- How many subjects do I need?

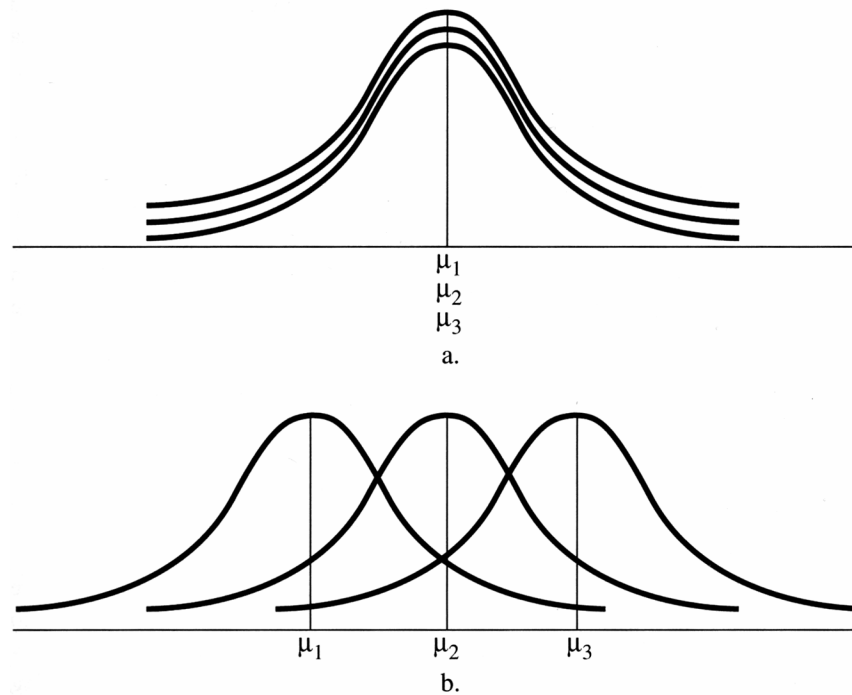
One-way Independent ANOVA

- Setting
 - k different treatments: (pen versus mouse, versus TrackPoint)
 - For each treatment you gathered from a random samples
 - *Mean*
 - *Standard deviation*
- Null hypothesis
 - The F ratio follows a F distribution

$$F = \frac{MS_{bg}}{MS_{wg}}, \quad \text{with} \left\{ \begin{array}{l} MS_{bg} = \frac{SS_{bg}}{df_{bg}}, \quad SS_{bg} = \sum_{j=1}^k n_j (\bar{X}_j - \bar{X}_G)^2 \\ MS_{wg} = \frac{SS_{wg}}{df_{wg}}, \quad SS_{wg} = \sum (n_j - 1) s_j^2 \\ df_{bg} = k - 1 \\ df_{wg} = N - k \end{array} \right.$$

From Explaining Psychological Statistic (Cohen)

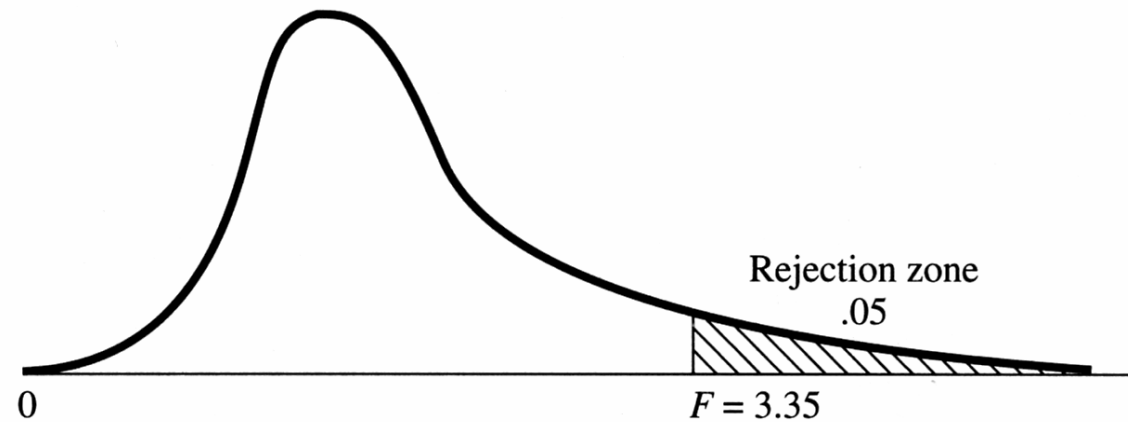
Interpretation



From Explaining Psychological Statistics (Cohen)

$$F = \frac{\text{treatment effect} + \text{error variance}}{\text{error variance}}$$

F distribution



From Explaining Psychological Statistics (Cohen)

- Degree of freedom

Number of scores that are free to vary after one or more parameters have been found for a distribution

ANOVA

- Alternative computation method

$$F = \frac{MS_{bg}}{MS_{wg}}, \text{ with } \begin{cases} MS_{bg} = \frac{SS_{bg}}{df_{bg}}, & SS_{bg} = \sum_{j=1}^k \frac{T_j^2}{n_j} - \frac{T^2}{N} \\ MS_{wg} = \frac{SS_{wg}}{df_{wg}}, & SS_{wg} = \sum X^2 - \sum_{j=1}^k \frac{T_j^2}{n_j} \\ df_{bg} = k - 1 \\ df_{wg} = N - k \end{cases}$$

- Assumptions
 - Independent Random Sampling
 - Normal Distributions
 - Homogeneity of variance

ANOVA example

Multiple comparison

- Dangers
 - Alpha inflation
- Tests
 - Post hoc comparison
 - *Fisher's Protected t-Test*
 - *Tuckey's HSD Test*
 - *Scheffé Test*
 - A priori comparison
 - *Orthogonal Contrasts*
 - *Bonferroni's t-Test*