Questions?

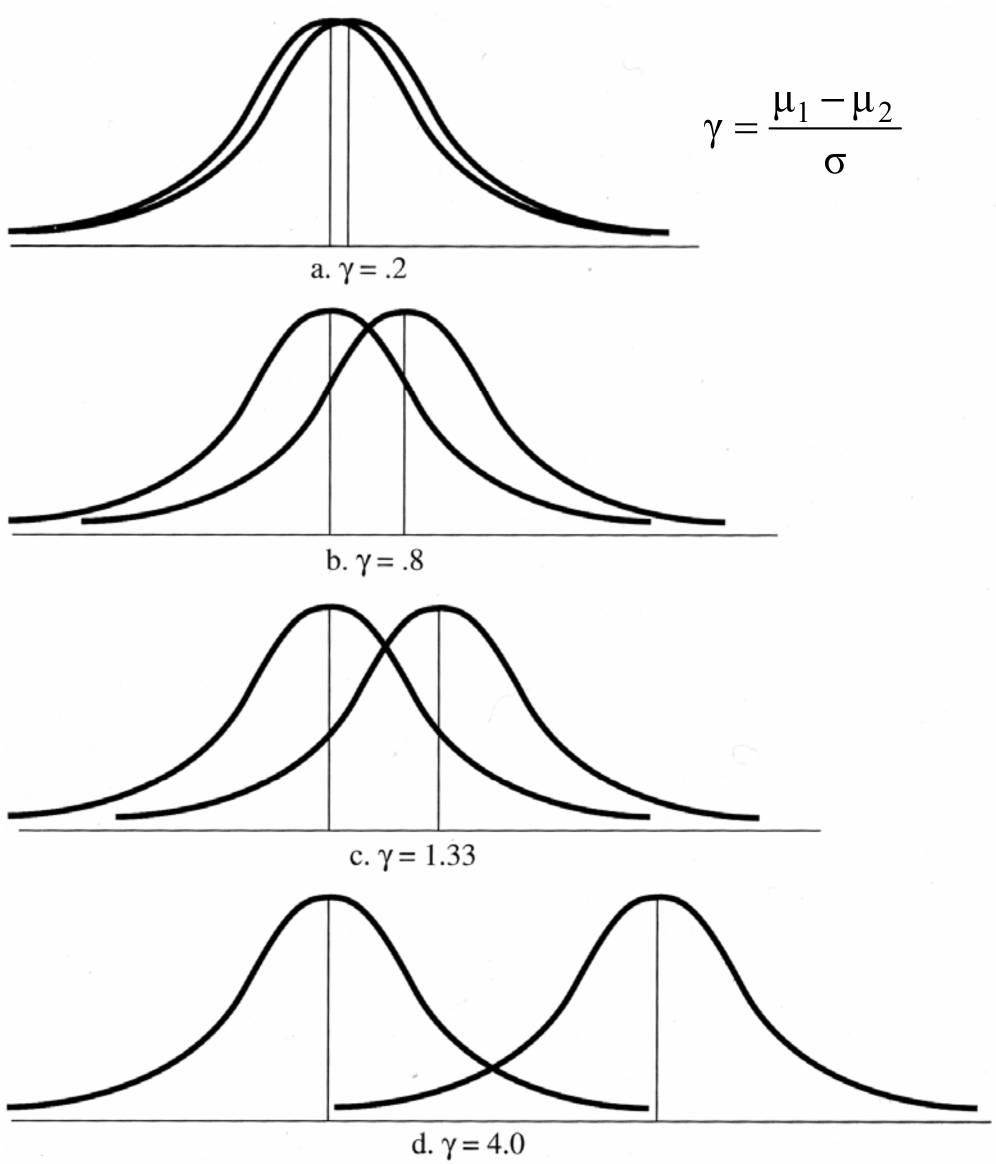
- Project

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

$$\gamma = \frac{\mu_1 - \mu_2}{\sigma}$$



From Explaining Psychological Statistic (Cohen)

t-test

- Formula

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

$$t = \frac{(\overline{X}_1 - \overline{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1{}^2 + s_2{}^2}{N}}}, \text{if } N = N_1 = N_2$$

μ_i population mean, 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

A	B
9	5
8	4
7	3
7	2
4	1

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	Actual Situation: Null Hypothesis is 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- β)
  - Computed effect size: $g = \frac{\overline{X}_1 - \overline{X}_2}{s_p}$ 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?

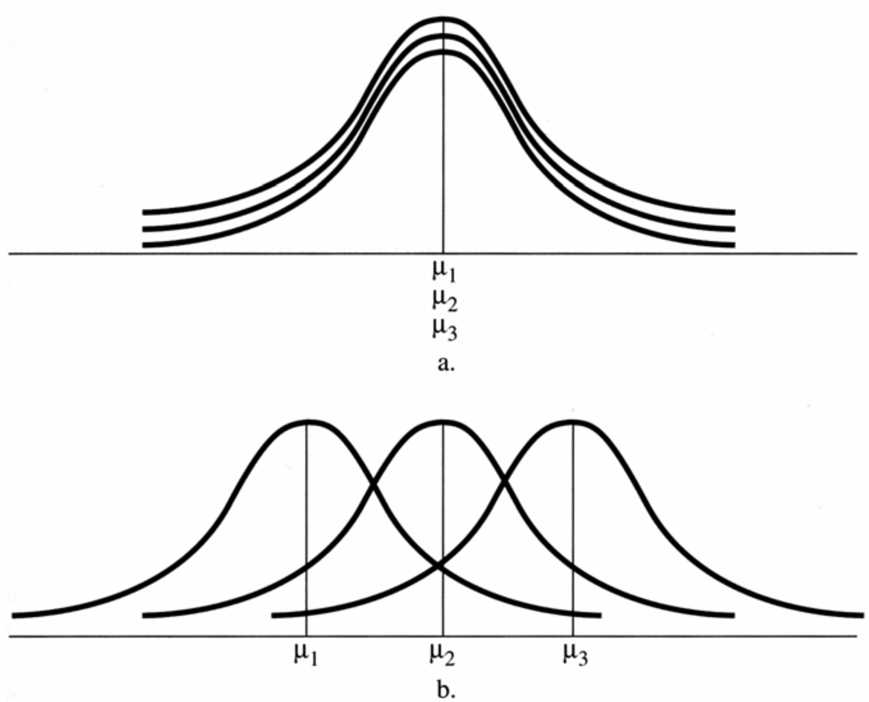
One-way Independent ANOVA

- 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

$$F = \frac{MS_{bg}}{MS_{wg}}, \quad \text{with} \begin{cases} MS_{bg} = \dfrac{SS_{bg}}{df_{bg}}, \quad SS_{bg} = \sum_{j=1}^{k} n_j (\overline{X}_j - \overline{X}_G)^2 \\ MS_{wg} = \dfrac{SS_{wg}}{df_{wg}}, \quad SS_{wg} = \sum (n_j - 1) s_j^2 \\ df_{bg} = k - 1 \\ df_{wg} = N - k \end{cases}$$

From Explaining Psychological Statistic (Cohen)

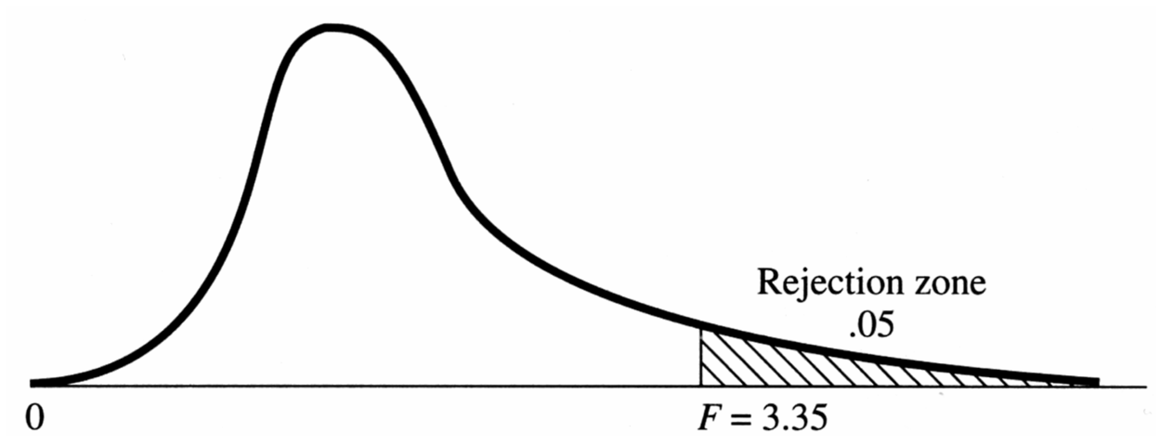
Interpretation



From Explaining Psychological Statistic (Cohen)

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

F distribution



From Explaining Psychological Statistic (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

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

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

ANOVA example

A	B	C
3	9	10
5	6	8
4	5	11
3	8	10
1	7	9
2	7	10
5	6	11
2	4	12
3	8	10
1	7	9

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*