Questions?

- Final
  - In class final on May 18th from 10:30 to 12:30
- Preliminary findings presentation
  - 04/24
- Paper review in class
  - Be ready to have a draft by May 1st
- Final presentation
  - 05/13

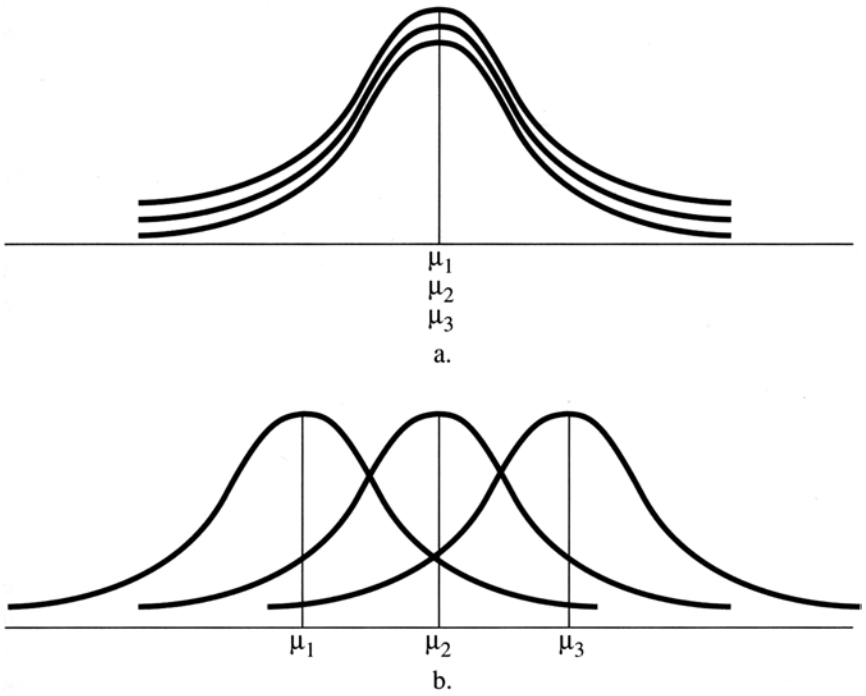
One-way Independent ANOVA

- 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

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

From Explaining Psychological Statistic (Cohen)

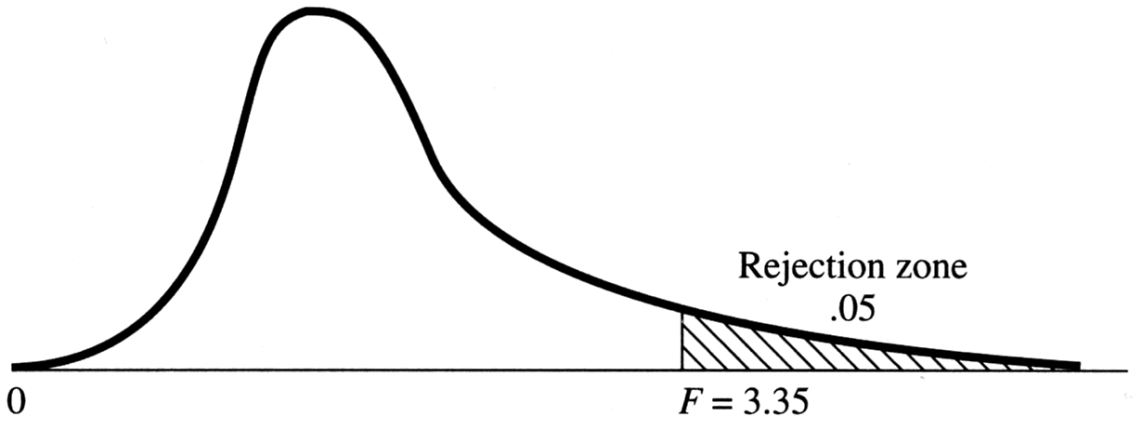
Interpretation



From Explaining Psychological Statistic (Cohen)

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

F distribution



From Explaining Psychological Statistic (Cohen)

Two-way ANOVA

- Setting
  - Full factorial design: *k* columns*, l* rows
  - For each *cell* (treatment) you gathered from a random samples
    - *Mean*
    - *Standard deviation*
- Null hypothesis
  - *F* ratios (row column and interaction) follow a *F* distribution
    - *Main effect: F_{col} and F_{row}*
    - *Interaction: F_{int}*

F ratios

$$F_{col} = \frac{MS_{col}}{MS_{cell}}, \quad \text{with} \begin{cases} MS_{col} = \dfrac{SS_{col}}{df_{col}}, \quad SS_{col} = n_{col} \displaystyle\sum_{j=1}^{k} (\overline{X}_j - \overline{X}_G)^2 \\ df_{col} = col\_count - 1 \end{cases}$$

$$F_{row} = \frac{MS_{row}}{MS_{cell}}, \quad \text{with} \begin{cases} MS_{row} = \dfrac{SS_{row}}{df_{row}}, \quad SS_{row} = n_{row} \displaystyle\sum_{j=1}^{k} (\overline{X}_j - \overline{X}_G)^2 \\ df_{col} = row\_count - 1 \end{cases}$$

$$F_{int} = \frac{MS_{int}}{MS_{cell}}, \quad \text{with} \begin{cases} MS_{bint} = \dfrac{SS_{int}}{df_{int}}, \quad SS_{int} = \underbrace{\left(\displaystyle\sum_{j=1}^{k} \frac{T_j^2}{n_j} - \frac{T^2}{N} \right)}_{SS_{Total}} - SS_{row} - SS_{col}, \\ df_{int} = df_{row} \times df_{col} \end{cases}$$

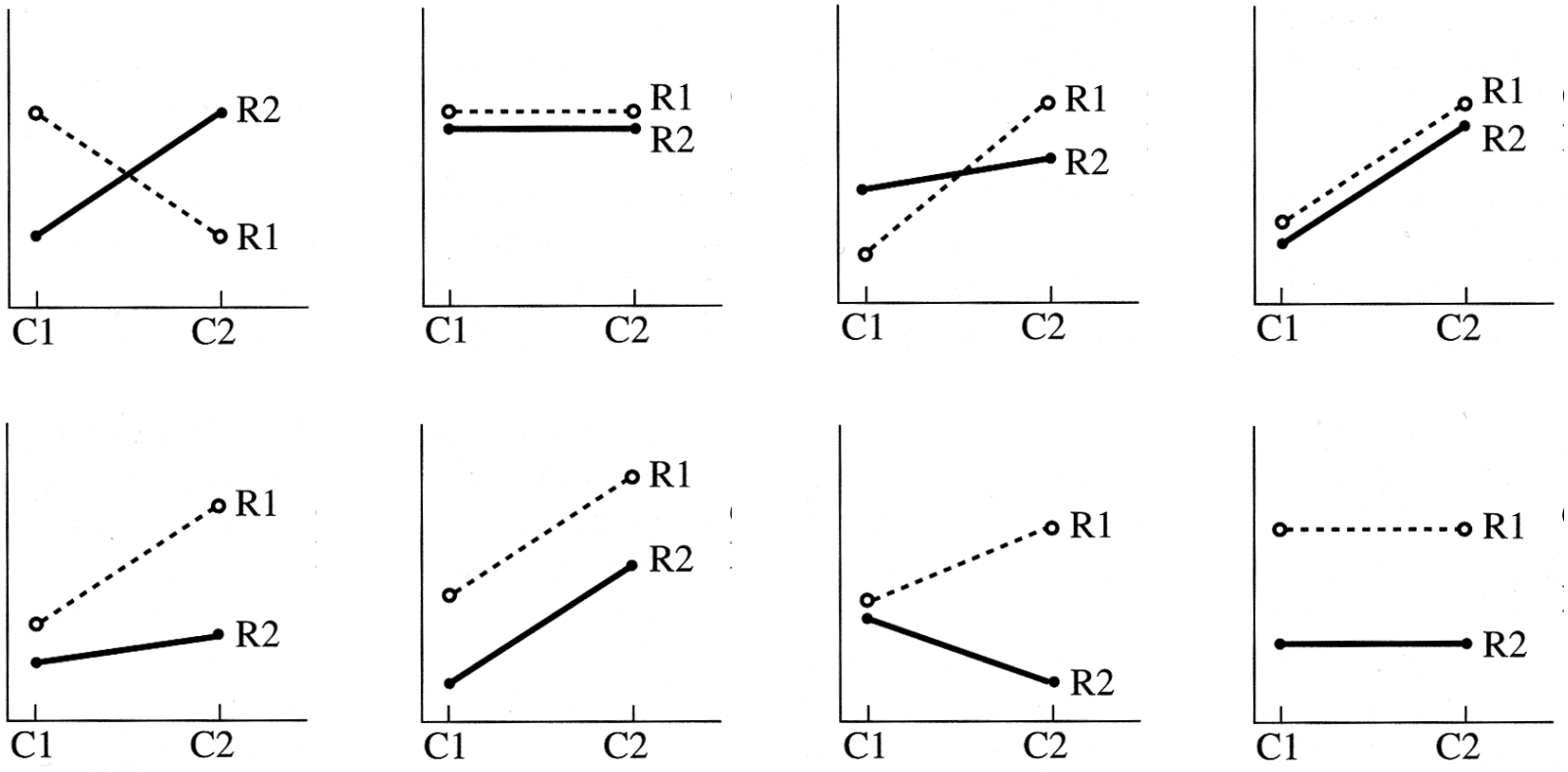
$$\text{and} \begin{cases} MS_{cell} = \dfrac{SS_{cell}}{cell\_count}, \quad SS_{cell} = \displaystyle\sum \sigma_j^2, \text{ assuming equal size cells} \\ df_{cell} = N_T - cell\_count \end{cases}$$

Interpretation (General Linear Model)

Score = Grand mean
+ Row effect
+ Column effect
+ Interaction effect
+ Error

Two-way ANOVA example

Interactions

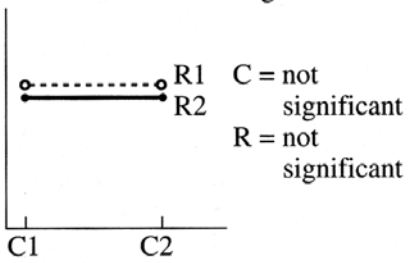


From Explaining Psychological Statistic (Cohen)

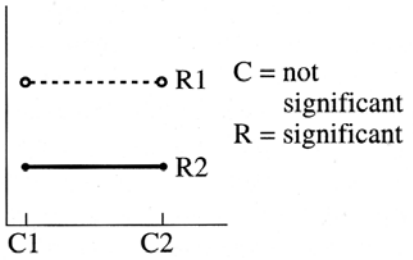
Interactions (Results)

C = Column means
R = Row means

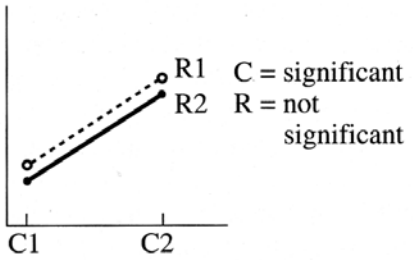
Interaction is not significant



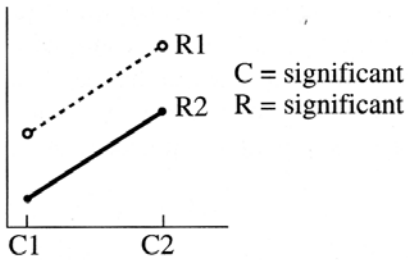
C = not significant
R = not significant



C = not significant
R = significant

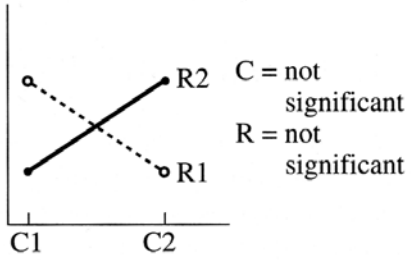


C = significant
R = not significant

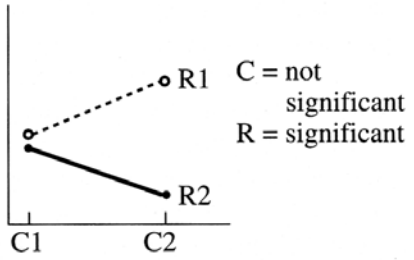


C = significant
R = significant

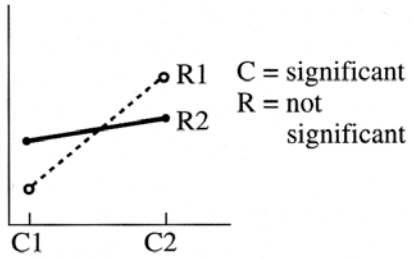
Interaction is significant



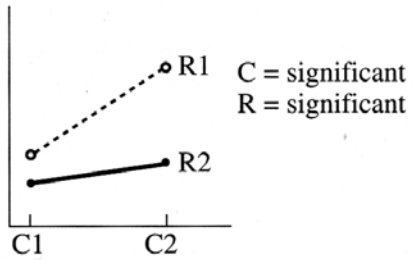
C = not significant
R = not significant



C = not significant
R = significant



C = significant
R = not significant



C = significant
R = significant

Interactions (Caveats)

- If the interaction is significant
  - Main effect must be interpreted with care
- If the interaction is not significant
  - Main effect can be interpreted with 2 separate ANOVAs

Other tests

- Repeated measure ANOVA
  - For within subject design
- Mixed Design ANOVA
  - For design which are both between and within subjects
- Multiple comparisons
  - Tukey and Bonferroni correction
- Nonparametric Statistics
  - Distribution-free tests
    - *non-ordinal scale*
    - *nominal scale*
    - *non-normal distribution*

Paper discussion