Questions?

- Final
  - 30 min preparation (open book)
  - 30 min oral presentation
    - *15min to answer a specific question on a topic discussed in the class*
    - *15 min to present a paper (among 5 provided in advance)*

- Draft due this Thursday

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
Accept the null hypothesis	Correct decision	**Type II error**
Reject the null hypothesis	**Type I error**	Correct decision

- Design significance?
  - 3.00s versus 3.05s?

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*

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

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

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

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

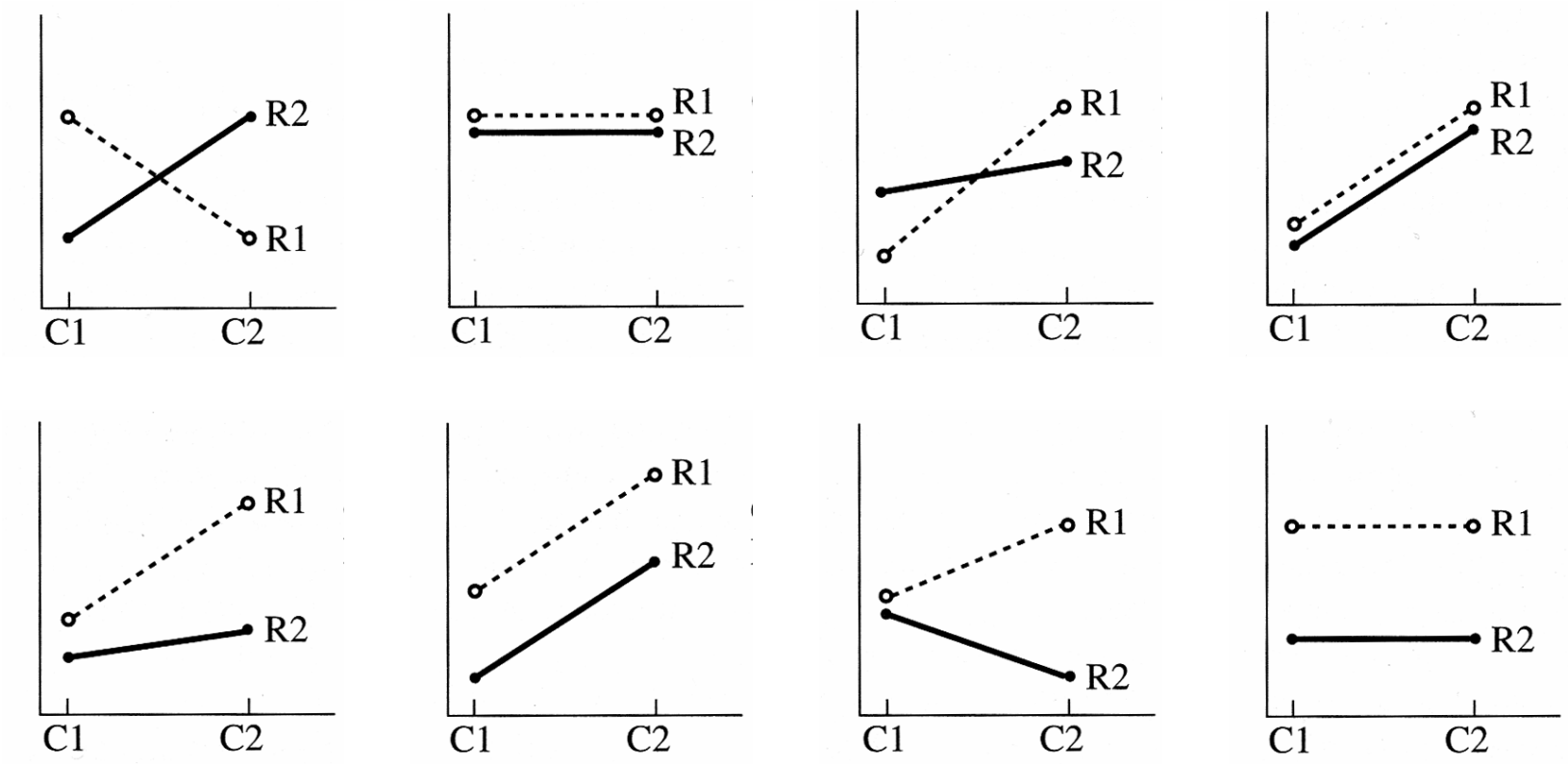
$$\text{and} \begin{cases} MS_{cell} = \dfrac{SS_{cell}}{cell\_count}, \quad SS_{cell} = \displaystyle\sum \sigma_j^2, \text{ assuming equal size cells} \\ df_{cell} = N_T - cell\_count \end{cases}$$

Interpretation (General Linear Model)

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

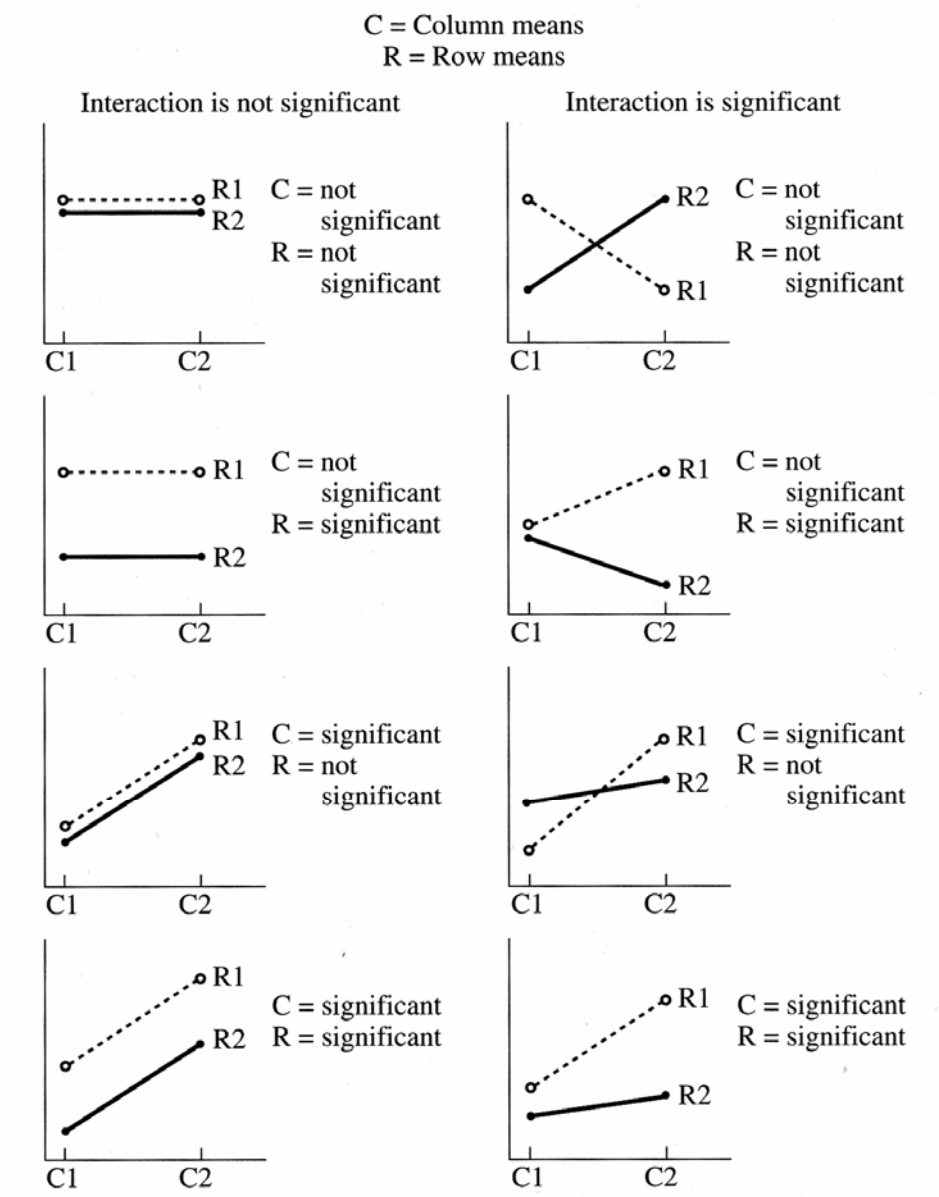
Two-way ANOVA example

Interactions



From Explaining Psychological Statistic (Cohen)

Interactions (Results)



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
- Nonparametric Statistics
  - Distribution-free tests
    - *non-ordinal scale*
    - *nominal scale*
    - *non-normal distribution*

Paper discussion