Overview of Session

- Comparing two group means (Last Week)
- Comparing more than two group means
  - Analysis of Variance assess if any differences
  - Planned and post hoc test
  - Other Analysis of Variance (ANOVA) designs

Comparing Two Groups

- Designs
  - Existing groups
  - Experiments
- Graphic representation of scores & means
- Statistical significance assessed with t test
- Focus is on the difference between the means
Comparing Several Group Means

- Graphic display
- Approach uses ratio of two variances
- Ratio for test of variance for two groups
- Ratio for test of means for several groups

Ratio of Two Variances For Two Groups

- Populations with the same variance
- Ratio of variances is F distributed
  - Degrees of freedom are
    - $n_1 - 1$ for numerator
    - $n_2 - 1$ for denominator
- Used to test for equality of variance
  - Under the null hypothesis the ratio is F distributed
  - An extreme F score indicates that they are not equal

Testing For Equality of Several Means

- Estimates of population variance
  - Estimate using the group means
  - Estimate using variation around group mean
- When null hypothesis is true
  - Ratio of estimates is F distributed
  - The ratios are close to one.
- When null is not true
  - The ratio is large
  - Null hypothesis of equal means is rejected
**Computation of F Ratio**

- $MS_{Between}$ is estimate of variance using means.
- $MS_{Within}$ is estimate of variance using deviations for groups means.
- The test statistic $F$ is their ratio:

\[
F = \frac{MS_{Between}}{MS_{Within}}
\]

**Test Statistic for ANOVA**

- $H_0$: $\mu_1 = \mu_2 = \cdots = \mu_k$.
- $H_1$: These means are not all equal.
- Test Statistic: $F = \frac{MS(\text{treatment})}{MS(\text{error})}$

\[
SS(\text{total}) = \sum (x_{ij} - \bar{T})
\]
\[
SS(\text{treatment}) = n_1 (\bar{T}_1 - \bar{T}) + n_2 (\bar{T}_2 - \bar{T}) + \cdots + n_k (\bar{T}_k - \bar{T})
\]
\[
SS(\text{error}) = SS(\text{total}) - SS(\text{treatment})
\]
\[
MS(\text{treatment}) = \frac{SS(\text{treatment})}{k-1}
\]
\[
MS(\text{error}) = \frac{SS(\text{error})}{N-k}
\]

**Assumption of One-Way Analysis of Variance**

- Observations are independent or errors are independent.
- Scores within groups are normally distributed.
- All groups have the same variance.
Which Means Are Different From Each Other

- A significant ANOVA only means the group means are not all equal
- Other tests need to be run to find out which means are different from each other
  - Planned Comparisons (1 for each degree of freedom)
  - Post hoc tests
    - Tukey’s Honest Significant Difference for all pairs
    - Bonferroni used in lab.

Multiple Factor Designs

- Two factor designs
  - Effects:
    - Main effect for factor 1
    - Main effect for factor 2
    - Interaction of factor 1 and factor 2
  - Example
    - Factor 1: Treatment (Drug or Placebo)
    - Factor 2: Gender (Male or Female)
    - Treatment X Gender Interaction
- Three or four factors

Multiple Measurement Occasions

- Within Factor Designs
  - One factor
  - Two or more factors
- Mixed Designs
  - One or more between factors
  - One or more within factors