ANALYSIS OF VARIANCE (ANOVA)

Introduction to ANOVAs

What is an ANOVA?

ANOVA is a technique that allows comparisons of group means, in order to draw inferences about an absence/presence of statistically significant differences between population means. It is similar to a t-test (as it compares means between groups), but an ANOVA can compare two or *more* group means.

- Essentially, an ANOVA tests the null hypothesis that means for all groups are identical (no statistically significant difference)
- A statistically significant ANOVA indicates that not all means are identical (*at least one* differs)
    - An ANOVA alone does not indicate *which* mean is different
    - More than one group mean can be different
- ANOVA is currently the most used statistical technique in psychology research (multiple regression a close second)

Why can't we use multiple t-tests to compare means?

- The more *t*-tests you run, the more likely you are to make a Type I error (rejecting the null hypothesis when you shouldn't).
- When all assumptions have been met, ANOVA is more powerful than *t*-tests (when comparing more than two groups)

Error rate: The chance of making an error in any given test. Alpha level is usually .05 (i.e., $p > .05$). This means, there is a 5% chance of making an error.

Familywise error rate: Is calculated based on the total number of tests that we make. If we run multiple t-tests, our familywise error rate is going to be calculated using (to the power of) a higher number, thus increasing the probability of making at least one Type I error.

Decisionwise alpha level: is an alpha level that can be set (usually .05) for each comparison.

Lastly, ANOVAs are labelled based on the number of IVs (factors) it includes.
For example:

- For one IV = One-Way ANOVA
- For two IVs = Two-Way ANOVA
- For three IVs = Three-Way ANOVA, etc

One-Way Independent Measures ANOVA/ One-Way Between-Groups ANOVA

Sample questions that could be answered using a One-Way ANOVA:

1. Which treatment is most effective for depression?
    a. CBT, meditation, combination of these two
2. Does loneliness vary by attachment style?
    a. Secure, anxious pre-occupied, fearful-avoidant, dismissive-avoidant
3. Is number of days of exercise influenced by geographical location?

4. Victoria, New South Wales, Queensland, South Australia

In an ANOVA, we are seeking to find how much variability is accounted for in the data, and whether or not our model accounts for more variability than chance.

$$(SS_T) = (SS_M) + (SS_R)$$

Total Sum of Squares (SS_T): Total variability between scores (between the different groups of the IV in the model)
Model Sum of Squares (SS_M): Variability between group means (in our model).

- This is the explained variance (how much variability is accounted for by the IV)

Residual Sum of Squares (SS_R): Residual variability

- This is the unexplained variance (due to chance)

To determine whether the group means are statistically different, we compare the amount of variability explained by the model and the residual. This is done using the F-ratio.

- When the treatment (or groups) have no effect/no significant difference, then we can say that the differences between the model and the residual are entirely due to chance. When the F ratio is small <1, the test is non-significant, and differences are due to chance.
- A larger F ratio = differences between treatments are greater than chance; treatment has a statistically significant effect

Formula for the F ratio:

$$F - \text{ratio} = \frac{\text{MSmodel}}{\text{MSresidual}}$$

In order to get a larger *F* value, the numerator needs to be larger than the denominator. If the numerator is zero, or a very small number, the *F* ratio will be small, and the p value will be .05.

What does the F ratio actually tell us?

If the F is large, this is telling us that the variability attributable to the model is greater than the variability that occurs simply due to chance (i.e., error).
There are two ways to obtain a large F ratio:

1. If MSmodel is already large: means large differences in group means, i.e., will have a large numerator
2. If MSresidual is small: very little variability within groups, i.e., will have a small denominator

If the F ratio is larger than the critical value for our set alpha level (usually .05), it tells us that 1 or more group means are statistically significant from each other

Assumptions for the One-Way ANOVA:

1. Independence of observations
    a. All observations within each sample must be independent
    b. There is no work around for this assumption, if it is violated you cannot run the ANOVA
2. Interval or ratio data
    a. Interval (such as temperature), ratio (such as height or weight)