Introduction

In this lecture, tips are given on how to choose the correct statistic for a particular experimental design. Also discussed are how to calculate results with chi-square tests, the *t-test* for correlated groups, and the analysis of variance formula.

The Correlated-Groups *t*-test (or the *t*-test for Two Related Samples)

As seen in Module 6, the *t*-test examines differences in designs that have one independent variable, two treatment groups, and a dependent variable that is measured by an interval or ratio scale (Bluman, 1998). Questions to ask are: 1) are we using a directional or nondirectional hypothesis (, thus, a one-tailed or a two-tailed test), 2) what is our significance level, and 3) how many degrees of freedom do we have? In *within-subjects designs* or *repeated-measures designs*, subjects serve as their own controls. Thus, this design lowers the need for subjects and reduces variance and error by removing individual differences. This design is also effective when demonstrating changes over time, such as learning or development (Gravetter & Wallnau, 2008). This *t* statistic is also used for between-subjects designs that use *matched groups*. The critical values of *t* are listed in Table B-2 (Jackson, 2011, p. 337).

The *t*-test for related samples involves calculating *difference scores* ($_D$)between the subjects' scores in treatments 1 and 2 (in a within-subjects design) or between each pair of subjects' scores (in a matched-subjects design).

The formula is:

$$M_D = \sum_D / n$$, where n = number of $_D$ scores (Nolan & Heinzen, 2011).

Once the mean for difference scores is calculated, the *t* statistic can be calculated:

$$t = (M_D - \mu_D) / {}^{S}M_D, \text{ where } {}^{S}M_D = \sqrt{s^2} / n$$

It is assumed that $\mu_D = 0$.

Hypothesis Testing, Confidence Intervals, and Effect Size for the Correlated-Groups *t*-test and the Matched Design

The four steps for hypothesis testing are the same as those seen previously. In step 3, sample variance must be calculated since population variance is unknown:

$$s^2 = SS / (n - 1)$$

Cohen's *d* for repeated-measures designs is:

$$d = M_D / s$$ (Jackson, 2011).

Variance (r^2) is calculated the same way as shown previously.

The Analysis of Variance Test

The analysis of variance (ANOVA) test examines mean differences among two or more treatment groups (Bluman, 1998). The *one-way* ANOVA is used in two cases: 1) a *one-way between-subjects analysis of variance* is used when there is one independent variable with multiple independent groups, and 2) a *one-way repeated measures analysis of variance* is used when there is one independent variable with multiple matched groups (or a within-subjects design). The *two-way* ANOVA is used for factorial designs (two or more independent variables), whether the design uses independent groups, matched groups, or a combination of the two (a *mixed* design). In addition, the data should be measured by interval or ratio scales. Additional criteria are that the variances of the groups' populations are roughly equal (or *homogeneous*) and that the populations are normally distributed. However, the test is fairly robust,meaning that meaningful results may be obtained even if some of the criteria are unmet (Myers & Hansen, 2006).

Instead of using ANOVA, one could simply calculate a series of *t*-tests, but that is more cumbersome and, more importantly, increases the chance of committing a type I error. ANOVA examines mean differences indirectly by calculating differences in variance, a statistic called the *F ratio* (Bluman, 1998). The numerator of the F ratio calculates *between-groups variance*, actual differences caused by the independent variable plus random chance fluctuations caused by error. The denominator of the F ratio calculates *within-groups variance*, which is error caused by random chance fluctuations among the subjects. Thus, the F ratio is an attempt to factor out random chance error; what is left over should reflect the impact of the independent variable on subjects' behavior.

Following is an example of working through the ANOVA formulas. The student is encouraged to follow each step outlined in Jackson's text. One-way, between-subjects ANOVA is calculated as follows: Examine Table 20.1 (p. 299) to see the hypothetical raw data, means, and the grand mean for this particular study involving one independent variable and three treatment groups. Next, SS_{Total} is calculated in Table 20.2 (p. 302), and the denominator of the F ratio, *within-groups variability*, is calculated in Table 20.3 (p. 303). The denominator, MS_W, is the *meansquarewithingroups*. It is calculated by dividing SS_W, or *sum of squares for within-groups variability*, by df_W, or *degrees of freedom for within-groups variability*.