Chapter 10: Factorial Analysis of Variance (ANOVA)

I. Overview

a. Factorial ANOVA is used when you have at least two categorical independent variables and one continuous (i.e., intervally scaled) dependent variable.

b. As with a one-way ANOVA, factorial ANOVA simply partitions the variance in the dependent variables into different parts.
   i. The part that is attributed to random sampling error.
   ii. The part that is associated to which group one belongs to on each independent variable.
   iii. The part that is attributable to the interaction between the independent variables.

c. There are several purposes of a factorial ANOVA.
   i. One is to determine whether there is a statistically significant difference between the means of the groups of *each* independent variable on the dependent variable.
      1. e.g., Do the standardized reading test scores of students differ depending on their gender (independent variable #1) and which of four high schools in the study students attend (independent variable #2)?
   ii. Another is to determine whether there is a statistically significant interaction between the independent variables on the dependent variable.
      1. e.g., Does the relationship between gender and reading test score depend on which school the student attends?
         a. If boys have higher test scores than girls in one school but girls have higher test scores in another, that is an interaction effect.
   iii. A third purpose is to examine whether there are difference between group means on the dependent variable when controlling for other variables (i.e., statistical controls).
      1. This can be other categorical, independent variables
      2. It can also be covariates which can be interval or categorical variables
      3. Examining the effect of one independent variable on the dependent variable while controlling for the effects of covariates and other independent variables is referred to as examining the *partial* effects or the *controlled* effects.

II. Main Effects and Interaction Effects

a. In a factorial ANOVA, there are both main effects and interaction effects to examine.

b. Main effects are whether there are statistically significant differences between the groups on each independent variable, when controlling for the other variables in the model.
   i. For example, the test for whether boys and girls differ in their reading test scores is test of main effects.
   ii. Similarly, the test of whether students in the four different schools differ in their reading test scores is a test of main effects.
   iii. Each of these main effects tests is controlling for the variance in the dependent variable that is attributable to the other variables and the interaction effects in the model.

1. E.g., if there is a main effect for gender, that means that boys and girls differ in their test scores even after controlling for any differences in test scores by school and for the interaction of school x gender.

c. Interaction effects refer to situations where the association between one independent variable and the dependent variable differs according to the second independent variable.
    i. E.g., If the difference between boys and girls test scores is not consistent across different schools.
    ii. Interaction effects are also known as *moderator* effects, or just *moderation.*

d. Interpreting main and interaction effects: A small controversy
    i. If there is a significant interaction effect, how should one interpret the main effects?
        1. E.g., if I find that girls in School A have much higher reading scores than boys in that school, this will probably produce a main effect for gender, with girls having higher average test scores overall. But if the boys and girls in schools B, C, and D do not differ in their test scores, does it still make sense to say that girls have higher average scores than boys overall?
        2. Some researchers say main effects are meaningless in the presence of a significant interaction. Others say, report all of the effects.

III. Covariates and Analysis of Covariance

a. Sometimes, researchers want to know whether groups differ on a dependent variable *after* controlling for some other variable. So they add one or more covariates to their model.
    i. E.g., You may want to know whether boys and girls differ in their reading test scores after you control for their grade level and level of parental education.

b. When including a covariate, the analysis becomes an Analysis of Covariance (ANCOVA).

c. Unlike the independent variables in an ANOVA, which must be categorical variables, covariates can be intervally scaled variables.

IV. Simple Effects

a. Allows researchers to compare specific cells in an interaction to see whether they differ significantly.
    i. e.g., If I find a statistically significant interaction between gender and school on standardized reading test scores, I may want to know whether the difference between girls and boys in School A is statistically significant. In this situation, I would perform a test of simple effects.

V. Effect Size

a. As with one-way ANOVA, in a factorial ANOVA eta-squared is the effect size measure that is most often used.

b. Because there are multiple effects in a factorial ANOVA (i.e., multiple independent variables and at least one interaction, plus covariates if used), the eta-squared statistics are actually *partial* eta-squared.
    i. This means that the eta-squared is the percentage of variance in the dependent variable that is explained by another variable (independent, covariate, or interaction) after controlling for the effects of all of the other variables in the model.

VI. Summary

a. Factorial ANOVA is an extension of the one-way ANOVA discussed in Chapter 10.

b. By including multiple independent variables, we can examine the main effects of each independent variable while controlling for the other independent variables in the model.

c. Multiple independent variables also allow the researcher to examine interaction effects.

d. The addition of a covariate in the ANOVA turns it into an ANCOVA and allows researchers to examine interaction and main effects while controlling for one or more additional variables.