JVIB News & Features

Statistical Sidebar

MANOVA (Multivariate Analysis of Variance): An Expanded Form of the ANOVA (Analysis of Variance)

Robert Wall Emerson

In this issue of the *Journal of Visual Impairment & Blindness (JVIB)*, the article entitled "Evaluation of the Effectiveness of a Tablet Computer Application (App) in Helping Students with Visual Impairments Solve Mathematics Problems," by Beal and Rosenblum, uses a statistical test referred to as a MANOVA (Multivariate Analysis of Variance). The discussion included in this issue's Statistical Sidebar will build on the information included in one from the March-April 2017 issue of *JVIB* in which ANOVA (Analysis of Variance) tests and *t*-tests were examined. At its heart, the MANOVA is an expanded form of the ANOVA. Both tests use means from groups of scores in a dataset and the spread (or variance) among those scores to see whether the differences in mean group scores are statistically meaningful. The key difference in going from the ANOVA to the MANOVA is that in the ANOVA test there is only one dependent variable (the measure that an experimenter is assessing to see if it is different when other variables change), and the MANOVA has two or more dependent measures rolled into the same statistical test. This situation often occurs when a researcher has two or more related dependent measures and wants to obtain an overall statistical result on the set of dependent measures instead of conducting a series of ANOVA tests on each one.

When a researcher is using a MANOVA, the data must satisfy certain conditions. Typically, the dependent variables should not be too tightly correlated. If the dependent measures are too closely aligned, the power of the test can be reduced. However, the dependent measures are often related, since that relationship is generally what leads a researcher to use a MANOVA in the first place. More importantly, however, is the fact that the variance of scores in each group being assessed should be comparable and the data need to be normally distributed. If some groups have a large spread in their scores and other groups have very small spreads, the results of the test might be misleading. When a researcher reports the results of a MANOVA (or ANOVA), he or she can also report tests designed to show whether these assumptions in the data are satisfied. For example, Box's *M* can indicate whether the sample size is too small by showing whether the covariance in different groups of data is significantly different (it should be noted that such difference is not desirable).

Although this sidebar is only touching the surface of the complicated topic of ANOVAs and MANOVAs, these concepts might be easier to understand by reading a bit of the article. The first sentence of the Results section reads,

> A least-squares MANOVA with mathematics level (1, 2, 3) and literacy medium

(braille, print) as between-subjects factors and unit type (app[lication] or paper) as a within-subject factor was conducted with the dependent measure changing based on what was analyzed (such as the number of problems solved correctly or the number of problems for which the teacher provided no help).

Although this sentence seems like quite a mouthful, it does describe clearly the intent of the authors' analytical approach. The authors employed a "least squares" approach instead of a "mean squares" approach. Using mean squares or least squares are two ways of approaching most group-based statistical testing. Within the mathematics of MANOVA, ANOVA, regression tests, and others, there are points where individual scores or differences between scores or both are squared and added in different ways. The *mean squares* approach takes the average of squared values at a given point in the calculation while the *least squares* approach takes the smallest squared value.

Of more importance to the reader of this article is the laying out of the variables used in this MANOVA analysis. The authors indicate in the sentence listed above that they used two between-subjects factors and one within-subjects factor. *Between subjects* means that the factor varied across participants. If height is being used as a predicting or independent variable in a study, for example, it would generally be considered to be a between-subjects factor, since each participant would be of a different height. In this study, each participant was assigned mathematics units in one of three different levels of difficulty, and each participant also accessed the schoolwork in question in either print or braille. The within-subjects factor was different for each participant because each participant completed both paper-based and app-based units within the study. Each of these three independent variables were entered into the MANOVA so the authors could observe their impact on the outcome measures or dependent variables. And, since this study used outcome measures such as "number of problems solved" or "number of problems for which the teacher provided no help," which are different but related items, the authors decided to put them into the same statistical analysis in order to account for the relatedness of the outcome measures. And thus, a MANOVA analysis is born.

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