Chapter 19
Conducting All-Possible-Subsets for MANOVA and Factorial MANOVA: No Longer a Weekend Project

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ABSTRACT
Multivariate techniques are increasingly popular as researchers attempt to accurately model a complex world. MANOVA is a multivariate technique used to investigate the dimensions along which groups differ, and how these dimensions may be used to predict group membership. A concern in a MANOVA analysis is to determine if a smaller subset of variables may be used in the classification functions without any loss of explanatory power when precision of parameter estimates or parsimony needs to be addressed. One way to address these concerns is with all possible subsets. However, not all common statistical packages easily facilitate this analysis and the analysis can be a weekend project. As such, the purpose of this chapter is to examine and demonstrate R and SPSS solutions to conduct an all-possible-subsets MANOVA, including all-possible-subsets factorial MANOVA.

INTRODUCTION
When designing research studies, theory guides the variables that are included in a model and provides the foundation for research questions. Researchers then determine data collection and analysis methods based on the research questions (Huberty & Morris, 1989; Pedhazur, 1997). Multivariate methods consider

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a set of variables simultaneously, instead of in isolation and are extensions of the more popularly used univariate methods (Bray & Maxwell, 1985; Tabachnick & Fidell, 2013; Zientek & Thompson, 2009). In the 1970s, some researchers predicted multivariate statistics methods would become the dominant analysis in the near future (Finn, 1974; Tatsuoka, 1973). Since that prediction, the use of multivariate methods has grown in the area of contemporary psychology research (Tabachnick & Fidell, 2013) and in educational psychology research (see Elmore & Woehlke, 1998; Onwuegbuzie, 2002; Zientek, Capraro, & Capraro, 2008).

When conducting MANOVAs, initial model selection is important. However, when a number of variables are included in the model, parsimony may need to be addressed (Huberty & Olejnik, 2006; Thompson, 2006). A parsimonious model is a simpler model with the most explanatory power. The parsimony is related to a parsimonious interpretation of multiple outcome variables (see Huberty & Morris, 1989). Fortunately, the evolution of computer technology has increased the ability to address parsimony with methods once considered superior but difficult to conduct. However, Grimm and Yarnold (1995) cautioned researchers that having the ability to conduct multivariate methods that were once complex does not mean that they should haphazardly including many measures “to see what pops out as important” (p. 3). Variable inclusion should be a thoughtful process. The purpose of the current paper is to investigate and demonstrate two sets of statistical software that conduct a MANOVA and a factorial MANOVA with an all-possible-subset analysis. Huberty and Olejnik (2006) referred to this analysis as a weekend project because of the complexity and length of time that was required to complete the analysis. In the case of a single grouping variable, these packages are a viable alternative to problematic stepwise descriptive discriminant analyses (DDAs; cf. Huberty, 1994; Thompson, 1995).

MANOVA

Multivariate analyses are conducted when a researcher has a desire to consider group differences among several dependent variables simultaneously. A MANOVA is an extension of analysis of variance (ANOVA) in that, instead of examining if a variable depends on group membership, several theorized variables are examined simultaneously to determine if those variables depend on group membership (i.e., independent variable). For a MANOVA, consideration is given to the interrelations among variables (Huberty & Morris, 1989). According to Huberty and Morris (1989), “The basic MANOVA question is, Are there any overall (interaction, main) effects present?” (p. 304), then other research questions follow. These questions relate to “(a) determining outcome variable subsets that account for group separation; (b) determining the relative contribution to group separation of the outcome variables in the final subset; and (c) identifying underlying constructs associated with the obtained MANOVA results” (Huberty & Morris, 1989, p. 304).

When researchers decide to conduct a MANOVA, dependent variables are theoretically or empirically related and ideally both (Weinfurt, 1995). Univariate ANOVAs are appropriate when a case can be made that outcome variables are conceptually independent. Conducting a MANOVA is not a license to conduct multiple ANOVAs and then interpret the univariate results. The research purpose is the basis for the type of analyses to conduct (Huberty & Morris, 1989). Once an argument for a MANOVA is made, result interpretations should be based on the multivariate findings because MANOVA (a) helps control for Type I error and (b) takes into account the pattern covariation among the dependent variables. As noted by Thompson (1991), a reason for conducting MANOVAs that is more important than controlling
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