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# Review of Michael N. Mitchell’s Stata for the Behavioral Sciences

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**Abstract.** In this article, I review *Stata for the Behavioral Sciences* by Michael N. Mitchell (2015 [Stata Press]).

**Keywords:** gn0069, book review, behavioral sciences, ANOVA, analysis of variance, experimental design

## 1 Introduction

You know that warm comfortable feeling you get when you return home after a long absence? That is the feeling I got while reading Michael N. Mitchell’s *Stata for the Behavioral Sciences*. The feeling was due to the familiarity of the material on analysis of variance (ANOVA) and experimental design covered in the book. Reading this book took me back to my student days when I struggled with ANOVA problem sets and class research projects. The familiar material is one reason I thoroughly enjoyed reading Mitchell’s book. The other reason I enjoyed it so much is Mitchell’s clear writing style and copious, detailed examples.

As you can tell from the previous paragraph, the subject matter of this book primarily covers ANOVA and experimental design. Some may think that this definition of methods for the behavioral sciences is a bit narrow, but it is consistent with the way the topic was taught back in the day. Interestingly, before Stata 11, many social and behavioral researchers felt that Stata was difficult to use for ANOVA and experimental design. This was not because Stata could not do these types of analyses but because Stata lacked easy-to-use postestimation convenience commands for ANOVA. This began to change when Stata 11 introduced factor variables and the `margins` command. Then, Stata 12 followed with the `contrast` and `marginsplot` commands, which put Stata on a par with other statistical packages used in the behavioral sciences.

Before I get into the meat of this review, I need to deal with a couple of details. First, in the spirit of full disclosure, I want to say that Michael Mitchell was the person who hired me to work in the Statistical Consulting Group at the University of California–Los Angeles (UCLA) in 1999. In fact, the first assignment Michael gave me was to learn Stata. We worked closely for many years before Michael left UCLA to pursue other endeavors.

Second, I need to address the elephant in the room, namely, the title of the book—*Stata for the Behavioral Sciences*. Does this title mean that the book will be of interest only to researchers in the behavioral sciences? No, of course not. Many disciplines

other than the behavioral sciences use ANOVA methods. Beyond that, any researcher that uses categorical predictors with more than two groups will find useful material in this book. Finally, anyone wanting more details on topics such as factor variables and the `margins`, `contrast`, or `marginsplot` command will find this book a treasure trove of information.

## 2 Content

After a preface in which Mitchell provides his motivation for writing the book and describes his background as a statistical consultant at UCLA, the text is divided into 23 chapters, which, in turn, are collected into 5 sections. I will resist the temptation to present in-depth reviews of each of the 23 chapters; that would be rather long and repetitive. I do not use the word “repetitive” as a criticism. Rather, it is part of the nature of ANOVA analyses; that is, similar tasks are performed for each of the different ANOVA designs.

So rather than providing in-depth coverage of each of the chapters, I will review each of the five sections and highlight material that readers may find most useful—like a tour guide on a seven-countries-in-six-days grand tour. Or, in this case, 23 chapters in 5 sections.

### 2.1 Warming up (chapters 1–3)

The first stop on our tour is a section titled “Warming up”, and like a warm-up before a long run, it is intended to ease you into ANOVA and experimental design before getting into more substantial material.

The book does not start with a formal tutorial on Stata but rather lists several reasons why one would want to use Stata. This is followed by a chapter on how to summarize and describe ANOVA-type datasets. Finally, there is a chapter on inferential statistics covering single-sample and two-sample hypothesis tests of means and proportions. No big highlights in this section. Remember, it is just a warm-up.

### 2.2 Between-subjects ANOVA models (chapters 4–11)

The next stop on our tour delves into between-subjects designs. With between-subject models, the observations in each group or cell are independent of the observations in the other groups or cells. Introductory statistics courses often label these designs using terms like “one-way ANOVA”, “two-way ANOVA”, or “factorial ANOVA”. These introductory courses will also usually include material on analysis of covariance (that is, ANOVA designs that include a continuous predictor).

A long time ago, back in my student days, textbooks such as Winer's *Statistical Principles in Experimental Design* (1962) or Kirk's *Experimental Design: Procedures for the Behavioral Sciences* (1968) devoted many pages to manual computational formulas

for various ANOVA designs. Back then, we thought that computing the omnibus ANOVA was the hardest part of the analysis. Today, all of that computational drudgery is taken care of using the `anova` command. We now realize the real work comes after the `anova` command when we address specific hypotheses about group differences or work on the decomposition of complex interactions. In some respects, the `anova` command itself becomes almost the least interesting part of the data analysis.

This is where Mitchell's detailed explanations of the inner workings of `margins`, `contrast`, and `marginsplot` come into play. Through numerous examples, he shows how you can estimate the group means, test contrasts among the group means, or decompose interactions into simple effects and simple main effects.

I wish to highlight two chapters in this section. The first is chapter 10, "Supercharge your analysis of variance (via regression)". Here Mitchell demonstrates that by using regression to do ANOVA, one can analyze complex survey data, use robust standard errors to compensate for heterogeneity, and do full robust regression (using the `rreg` command); he even dips into quantile regression. Early on as a student, I learned that ANOVA and regression were two sides of the same coin. They each estimate the same underlying model but present their results differently. Sadly, many students today do not know that there is any connection between ANOVA and regression. Mitchell makes this connection clear.

Another highlight of this section is chapter 11 on power analysis. Here Mitchell details the complexities of the `power` command. This is a topic that many of the older ANOVA books either gloss over to some degree or discuss with almost illegible power graphs.

## 2.3 Repeated measures and longitudinal designs (chapters 12–13)

The third stop on our tour delves into repeated measures and longitudinal designs. If the previous section was concerned with between-subject designs, then this section deals with within-subject designs. In the past, these designs might have gone by various names, such as "randomized block design" for one-way within-subject design or "randomized block factorial" when there are two or more crossed within-subject factors. If there is a mixture of between- and within-subject factors, the model might be called a "split-plot factorial". Traditional statistics packages dealt with these designs by having the data in wide form, incorporating both multivariate and univariate estimation. The biggest downside to this approach is that if a subject is missing even one of the repeated measures, then all the data for that subject have to be discarded.

Instead of using `anova` to analyze repeated-measures designs, Mitchell has chosen an alternative approach of analyzing the data using linear mixed models (using the `mixed` command). This approach is becoming more common. You may even encounter the term "repeated-measures mixed models" for these types of analyses in the literature.

These mixed models use data in the long form and are much more tolerant of missing observations. They allow one to use all the available data for each subject. Ad-

ditionally, the mixed-models approach allows for a greater variety of within-subject covariance structures. Traditional repeated-measures ANOVA allowed only for unstructured and compound symmetry (exchangeable) covariance structures, while mixed models allow for `independent`, autoregressive (`ar #`), moving-average (`ma #`), `banded`, Toeplitz (`toeplitz`), or `exponential` structures in addition to `unstructured` and `exchangeable`.

One complication for the mixed-model approach is that it uses large-sample maximum likelihood estimation. The large-sample approach is evident from the  $z$  and chi-squared statistics displayed in the results. Much of behavioral sciences research has relatively small sample sizes. Thus the  $p$ -values associated with  $z$  and chi-squared statistics are biased downward.

Small-sample mixed models were an issue with Stata before version 14, which introduced the `dfmethod` option. The term “dfmethod” stands for the degrees of freedom method, that is, the method used to approximate the denominator degrees of freedom that are necessary to obtain  $p$ -values for  $t$  and  $F$ . Stata 14 provides five different methods for estimating denominator degrees of freedom: `residual`, `repeated`, `anova`, Satterthwaite (`satterthwaite`), and Kenward–Rogers (`krogers`). Unsurprisingly, not all statisticians approve of this approach for dealing with small samples in mixed models. Mitchell provides an example of a small-sample repeated measures using the `repeated` method with `dfmethod` in `mixed`.

## 2.4 Regression models (chapters 14–19)

The next stop on the tour examines traditional regression analyses. Earlier, in chapter 10, Mitchell described how to supercharge ANOVA models using regression. In this section, he details traditional regression analysis using continuous predictors. Highlights of this section include presenting regression results, tools for model building, regression diagnostics, and power analysis for regression. The discussion on regression in this section is very good, but it is not as extensive as that found in Mitchell's (2012) earlier book, *Interpreting and Visualizing Regression Models Using Stata*.

## 2.5 Stata overview (chapters 20–23)

Our final stop on this tour is the section titled “Stata overview”, which will probably not be of great interest to most experienced Stata users. The sights here will appeal mainly to the neophyte Stata user, but even an experienced user may find some gems. After a generic review of Stata's estimation commands, Mitchell moves on to postestimation commands, with a section highlighting features of the `margins` command. Also, do not miss the gallery of `marginsplot` graphs covering a number of common scenarios.

Next comes a short side trip through some data management commands, including how to read data into Stata and a review of the `reshape` command. Reshaping is frequently called upon when analyzing repeated-measures ANOVA data. I should mention that Mitchell (2010) has also authored *Data Management Using Stata: A Practical Handbook*, which provides more extensive coverage of data management in Stata.

The tour ends with 41 common SPSS commands. Mitchell gives the Stata equivalent for each SPSS command along with a worked example. This material is specifically designed to help users who are moving from SPSS to Stata. SPSS is widely taught and used in the social and behavioral sciences. Many of these users do not know the advantages of using Stata and how it can facilitate the analysis of complex experimental designs.

### 3 Strengths and weaknesses

I have already alluded to one of the strengths of this book, namely, the numerous, clearly described examples. These examples lead you through progressively more complex designs. Mitchell presents many easy-to-understand data analysis scenarios. These are similar to the questions that in my experience, researchers do ask. Each scenario comes with its own dataset, which Mitchell describes and then analyzes.

Another strength is that the inclusion of topics not typically found in ANOVA books, such as power and regression, sets this book apart from other ANOVA books that I have used.

When it comes to weaknesses, I can identify only minor improvements or omissions. I am sure that most of what I consider omissions came after careful consideration about the length of the book. No single book can include all the information on this extensive topic. But here are some areas that could be improved if space were not an issue.

Exercises or problem sets would be a nice addition if one wanted to use the book as a text for a first course in ANOVA.

Classical ANOVA books, such as Kirk (1968) and Winer (1962), cover many more ANOVA designs than Mitchell does. There are a multitude of nested designs, lattice designs, Latin square designs, Graeco-Latin square designs, designs with group-interaction confounding, treatment-interaction confounding, etc. These designs came primarily out of agricultural research and, even back in my student days, were not very common in behavioral sciences. However, it could be useful to see examples of a couple of these more esoteric designs in the book.

I would have liked more examples of repeated-measures designs with small samples to highlight the different `dfmethod` options. The only example in the book uses the `repeated` option. And even though I prefer using linear mixed models for repeated measures, it would have been informative to see how the results compare with analyzing the same data using the `anova` command.

## 4 Conclusion

Back in his UCLA days, Mitchell used to describe stat packages as statistical tool boxes. The more tools you know how to use well, the faster and easier the process of analyzing data becomes. While *Stata for the Behavioral Sciences* does not break any new methodological or statistical ground, it does provide solid coverage on useful ANOVA tools that may not be well known to everyone. The material in the book is accessible to beginners, yet it still can provide useful information for many advanced users. I wish that this book had been available years ago because I would have gladly recommended it to some of our Stat Consulting clients. And just maybe, reading this book may tempt some of the SPSS users to give Stata a try.

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Phil Ender is a psychologist who took too many statistics courses. He taught statistics and research methods courses for UCLA's Graduate School of Education and Information Studies. He also worked for 15 years as a consultant for the UCLA Statistical Consulting Group. He retired from UCLA in 2015.