

# *Comprehending Behavioral Statistics 3e*

Russell T. Hurlburt  
Wadsworth Publishing

## Preface

Statistical reasoning is one of the modern educated person's fundamental skills: scientific, economic, political, and everyday decisions almost always rest on a statistical foundation. This textbook provides an honest comprehension of this important material, making statistical concepts readily accessible without sacrificing statistical correctness.

Your instructor has selected the third edition of *Comprehending Behavioral Statistics* and the *Personal Trainer* to help you master statistics. Without question, this is the most powerful package ever created to help you learn statistics.

The first two editions of *Comprehending Behavioral Statistics* have earned a loyal following among students and instructors for their clear writing, visual focus (twice as many illustrations as most textbooks), and accuracy, and especially for two innovations not found in any other textbook: eyeball estimation and progressive cumulative review.

- Eyeball-estimation techniques enable you to predict, without the use of a calculator or statistical tables, the approximate magnitude of statistics. Then computation confirms your eyeball-estimate. Eyeball estimation brings students in contact with their data and visually demonstrates the connections between data and statistics. It's quick, useful, and besides that, it's fun.
- Progressive cumulative review gives you the chance to exercise one of the most important skills in statistics, determining what statistical procedure is appropriate for this situation. In most texts, students already know what procedure to apply by the chapter they happen to be in. Progressive cumulative review gives you practice in that discrimination.

**NEW!** The *Personal Trainer* CD adds a whole new dimension to the *Comprehending Behavioral Statistics* pedagogy. The *Personal Trainer* CD is easy to operate. There's nothing to install. Simply stick the CD in your computer's CD drive (Windows or Macintosh) and the *Personal Trainer* takes off automatically. That means you can slip the CD in your pocket or purse and use the *Personal Trainer* in your campus computer center, public library, or friend's house -- wherever and whenever it's convenient. (By the way, the textbook is complete by itself, without the CD. The *Personal Trainer* provides interactivity not possible in the textbook alone, but the textbook remains a clear and complete exposition of the material.)

**i** Whether to use statistical reasoning is not an option. Your only choice is how well.

**i** CBS with the *Personal Trainer* is like a Ferrari with a turbocharger. The Ferrari itself is a beautiful, high performance machine, but when the turbo kicks in, hold on!

The *Personal Trainer* has five main features:

- Lectlets are short, interactive, audio/visual lectures. You hear Dr. Hurlburt talking to you about all the concepts in the course. He'll ask you questions. You type your responses on the computer screen, and he'll provide immediate feedback. It's like having your instructor make house calls at any hour of the day or night.
- ESTAT is explorational and computational software. For example, ESTAT will present a scatterplot with a line drawn through it. You grab the line with the mouse and move it around until it best fits the scatterplot. That's your eyeball-estimate of the regression line. Then ESTAT will give you immediate feedback on how well you did. It's a potent learning device that masquerades as a game.
- An interactive algebra review provides a quick interactive brush-up on the algebra concepts necessary for comprehending statistics.
- Supplementary Resources provide amplifications of the material in the textbook. These Resources are seamless (same author, same notation, same look and feel) extensions that can be read on the computer screen or printed if desired.
- QuizMaster provides interactive review of all the concepts in the textbook.



The *Personal Trainer* is integrated effortlessly with the textbook. This logo appears in the textbook margin with an invitation such as “Click **Lectlet 2A** on the *Personal Trainer* CD for an audio/visual discussion of Sections 2.1 through 2.4.”

None of the features found in the *Personal Trainer* are available in any other textbook. All are described more completely below.

### **Eyeball-estimation**

**Eyeball-estimation:**  
predicting the  
approximate  
magnitude of a  
statistic

Eyeball-estimation techniques enable you to predict, without the use of a calculator or statistical tables, the approximate magnitude of statistics. Sections of the text that present eyeball-estimation skills are flagged with an eyeglass symbol.

Eyeball-estimation is not a substitute for accurate computation; *Comprehending Behavioral Statistics* is thorough in its treatment of computation skills. Students benefit from eyeball-estimation, however, for these reasons:

- Students who eyeball-estimate are actively involved. They inspect the data and decide for themselves the approximate magnitude of a reasonable answer.

- Eyeball-estimation cultivates genuine understanding of statistical concepts. The ability to make an educated guess is better evidence of comprehension than is the ability to compute a result.
- Following eyeball-estimation, computation has an element of excitement because it provides immediate feedback on the accuracy of the estimate.
- Eyeball-estimation is quick. A beginning student can eyeball-estimate a standard deviation in about 15 seconds. Computation would take the same student about 15 minutes. A class hour is ample time for eyeball-estimation and discussion of more than a dozen standard deviations. Students remain actively involved throughout the discussion because they provide the eyeball-estimations in each case.
- Eyeball-estimation engages students regardless of their level of mathematical sophistication. With eyeball-estimation, a classroom discussion of the standard deviation is comprehensible to inexperienced students, who can practice fundamentals such as locating an inflection point and estimating its distance from the mean. The same discussion is challenging for mathematically sophisticated students, who can practice (for example) refining their awareness of the effects of skew on the standard deviation.
- Eyeball-estimation is a valuable skill. It enables students to spot mistakes immediately. Students trained in eyeball-estimation techniques estimate far more accurately than do students taught by traditional methods.

### Progressive Cumulative Review

Students of statistics who do well on quizzes and midterm exams may nonetheless perform poorly on a cumulative final. Why? Because traditional statistics textbooks fail to incorporate practice in one of the most important skills: the ability to discriminate between procedures. The student who uses a typical text knows that all the problems in the  $t$  test chapter require  $t$ , all the problems in the ANOVA chapter require ANOVA, and so on. The student therefore gets no practice in deciding which test to use.

*Comprehending Behavioral Statistics* remedies this omission by including progressive cumulative review exercises. In each chapter, cumulative review exercises present, in random order, problems of the types found in that and previous chapters. Rather than compute, you'll be asked to state which null hypothesis is appropriate and to describe the characteristics of the appropriate statistical test.

Cumulative review exercises are progressive in that the complexity of required discriminations increases gradually with each successive chapter. In Chapter 10, for example, you'll discriminate among three easy options: finding the area under a normal distribution, creating a confidence interval, or testing a hypothesis. The

task becomes slightly more complex in Chapter 11, where you must also discriminate between testing a hypothesis about the mean of one group or the means of two groups. This step-by-step pattern of slightly increasing complexity continues throughout the text. By the end of the course, you'll have become proficient in making complex discriminations.

I began developing cumulative review exercises for use with my graduate students. The exercises were so effective that I started using them with sophomores more than ten years ago. My sophomores' performance on cumulative exams now surpasses that of the graduate students I taught prior to using cumulative review exercises.

## Lectlets

**NEW!** A lectlet (Hurlburt, 2001) is a short, interactive, computer-based, audio/visual lecture/discussion/demonstration (the term is by analogy to “applet” -- a short computer program). You'll hear Dr. Hurlburt introducing and explaining the concepts in the textbook and see (synchronized to the audio) graphs, figures, equations, and so on displayed on the computer screen. Each lectlet begins with a series of interactive review questions; you'll type brief answers and then click a button for immediate feedback. Here are five reasons that lectlets are effective learning tools:

**lectlet:**  
short, interactive,  
audio/visual  
lecture

- Some students learn by hearing better than they do by reading.
- Because the mediums are different, the lectlets' approach to the subject matter is somewhat different from the textbook's, which in turn is somewhat different from the instructor's classroom. The convergence promotes genuine learning.
- Lectlets solve problems for students. Students use the lectlets in a variety of ways, some before coming to class as a way of preparing for understanding in the classroom, some after class as a way of consolidating what they learned or clearing up what was fuzzy, some when they miss a class for illness or extracurricular activity, some for review before exams.
- Lectlets solve problems for students with special needs. Students with learning disabilities, hearing difficulties, or for whom English is a second language, benefit from the multiple media approach. The lectlets can be easily rewound and replayed, as often as desired, and volume personally controlled. The lectlets have a word-for-word transcript available at the click of a button, so students can both hear and see the exact same message (the transcript has been found very useful by many non-special-needs students as well).
- Lectlets solve problems for instructors as well. The class does not need to be slowed down for students who need additional repetition. Now the instructor can say, “Listen to Dr. Hurlburt's explanation of this concept in Lectlet 5B. Replay it as often as you need. Then if you still don't understand it, come back and talk to me.”

## ESTAT Computer Simulation Package

ESTAT is the computer software designed to accompany *Comprehending Behavioral Statistics*. ESTAT (for ESTimating STATistics) is available in Windows and Apple Macintosh formats. *Comprehending Behavioral Statistics* can be used independently of computer software. Students who use ESTAT, however, will benefit from its innovations: eyeball-estimation exercises, and the most user-friendly computational package available.

ESTAT provides practice in eyeball-estimation by generating and displaying data, inviting you to eyeball-estimate a statistic, and then providing immediate feedback on the accuracy of your estimate. For example, in one of the standard deviation exercises, sdest, ESTAT displays a histogram and asks you to eyeball-estimate the standard deviation. When you click a button, the actual standard deviation appears in both graphic and numerical form. Another click and ESTAT produces a new histogram from a randomly generated infinite series of data sets. Context-sensitive help is always available via a click, as is a step-by-step tutorial.

Compared with typical homework, ESTAT exercises are more efficient and cultivate better comprehension. Students who use a traditional text to do standard deviation homework spend one to three hours calculating the standard deviations of about three distributions, perhaps six if they also use a workbook. They compute their answers and check the results in the back of the book, spending almost no time developing comprehension of the relationship between those standard deviations and their distributions.

By contrast, students who use the ESTAT sdest standard deviation laboratory, with its infinite stream of Monte Carlo histograms, spend about a minute on each cycle of observation, estimation, and feedback. In less than half an hour, students can encounter more than 15 distributions, and all of that time is spent developing comprehension of the relationship between those standard deviations and their distributions. Plenty of homework time remains for computation, which is now based on a solid conceptual foundation.

For those who do not have access to computers, ESTAT-like exercises are also included in the Study Guide.

ESTAT also includes a statistical computational package that is the most user friendly available. ESTAT provides all relevant statistics automatically, freeing the student from the need to figure out how to ask the computer to display any statistic. For instance, if the data consist of three or more groups, ESTAT automatically displays an ANOVA. If the data consist of two groups, ESTAT automatically displays the independent-sample  $t$ ; if the groups have equal numbers of observations, ESTAT also automatically displays the dependent-sample  $t$ , the correlation coefficient, and the regression equation.

Because statistics are displayed automatically, ESTAT elicits a decision process that is the reverse of the process required by other programs. Typical programs require you to decide which statistic to request from among many that might be available. With ESTAT, you decide which statistics to use from among a few that are automatically displayed.

As a result, ESTAT's computational package dispels anxiety for the beginning student whose grasp of statistical concepts is not yet secure. Typical computational packages escalate anxiety because any complexity of the computer interface drastically compounds the student's insecurity. Nothing is more discouraging than the failure to elicit an appropriate result from the computer, particularly when the student does not know whether to attribute that failure to unfamiliarity with the interface or to unfamiliarity with the statistics themselves. By contrast, students can immediately interact successfully with ESTAT. Its interface actively facilitates every task and elicits in students the desire to explore and master statistical concepts.

## Resources

**NEW!** A Resource is a portable document (actually, a .pdf file) designed to be displayed on a computer screen (or printed if desired). The *Comprehending Behavioral Statistics* Resources are prepared in the same way as the rest of *Comprehending Behavioral Statistics* (same author, same editorial process, same compositor, and so on), so they have the same look and feel as the textbook. They are designed to be seamlessly integrated with the textbook -- or omitted without loss of continuity.

- They make the book shorter (about 70 pages in all), reducing the book's manufacturing cost. That cost savings is what makes it possible to provide the *Personal Trainer* to you for free.
- They make the book more focused for the more introductory student by removing the distraction of having to step over more advanced material.
- They allow coverage at several different levels. For example, consider two-way ANOVA. The textbook itself provides a "consumer's point of view" on this topic -- how to interpret two-way ANOVA. A Resource on the CD seamlessly (same author, same notation, same look and feel) extends this coverage to include computational details.

## Interactive Algebra Review and QuizMaster

**NEW!** The *Personal Trainer* provides an interactive review of the basic concepts in algebra necessary for comprehending statistics. The student who "has math anxiety" can spend an hour with this tool and refocus the required algebra skills, including summation notation. Each chapter also has a QuizMaster, an interactive review of the concepts covered in that chapter as well as multiple-choice quiz

over the chapter. Like ESTAT and the lectlets, QuizMaster asks questions and provides immediate feedback in an almost game-like atmosphere.

### **Light-hearted but not Light Weight**

I have several times referred to the materials in *Comprehending Behavioral Statistics* and the *Personal Trainer* as being “fun” or “game-like,” and that is indeed how students find them. However, I wish to emphasize that there is absolutely no sacrifice of comprehension for fun. The light-hearted approach of *Comprehending Behavioral Statistics* does not compromise depth of comprehension. High quality teaching and learning can be inherently fun, and these materials demonstrate that. But you will not find cartoons or condescension. Learning statistics is important, important enough to enjoy it while you do it.

### **Instructor's Flexibility in Using the Text**

*Comprehending Behavioral Statistics* is organized so that the instructor may choose which of its innovations to use. Every student has the *Personal Trainer* CD, and can use it on any Macintosh or Windows machine. All its materials are just a click away; the instructor can easily orchestrate which materials to recommend, or can leave the choice up to the individual student.

A complete set of ancillary materials is available and includes these items:

- ESTAT eyeball-estimation and computation computer program, available in Windows or Apple Macintosh formats.
- (*Comprehending Behavioral Statistics* can be used with or without computer software.)
- Student Study Guide (including ESTAT-like exercises for students without access to computers).
- Instructor's Manual (250 pages, including a test bank with 1100 items).
- Computerized test bank (1100 items for DOS or Macintosh)

### **Organization for the Convenience of Students**

*Comprehending Behavioral Statistics* incorporates numerous features that enhance the student's learning and convenience:

- There are more than 400 accurately drawn figures (two to three times more than most textbooks).
- End-of-chapter exercises are graduated from simple to complex and include examples from journals.

- Definitions of statistical terms and symbols are given both in the margins of pages where they initially appear and in the Glossary at the back of the book.
- Most frequently used formulas and tables are reproduced on the inside covers.
- "Info notes" give useful comments and cross-reference information.
- Statistical tables have colored edges for easy accessibility (Appendix A).
- A reference review of basic arithmetic is included (Appendix B).
- All statistical formulas are listed together for ready reference (Appendix C).
- Results of exercise subcomputations, not just final results, are given in the answers to exercises (Appendix D).

### Info notes

**NEW!** The second edition had a set of “info notes” in the margin of the textbook that gave the student information about where things could be found, for example, “When  $\mu$  is known, use Equation (7.2).” Students were uniformly enthusiastic about these notes, so the third edition expands their functions and has about seven times as many.

**i** This is an info note. There are over 350 in the textbook.

These info notes now grab attention and focus the student on some aspect of the main text. They allow communication with the student outside the flow of the main exposition, and thus have substantial pedagogical value. They help the student to double back or look ahead, to review and consolidate, to remember or emphasize, to focus on the main point of a long paragraph, and so on. Furthermore, the info notes provide a flexible review guide.

### The Task Force on Statistical Inference

The American Psychological Association recently convened a task force to study the use of statistics in the psychology literature. Perhaps the most discussed outcome of this study was the recommendation that journal editors require the reports of effect sizes and power analyses (Wilkinson, 1999). The Fifth Edition of the APA *Publication Manual* (2001) adopted most of the Task Force’s recommendations. I am in wholehearted agreement with these recommendations, most of which were already incorporated in the first (1994) and/or second (1998) editions of this textbook.

When I began writing this book in 1990, my main motivation was to solve through education the same issues that motivated the Task Force. I wanted to create a way for students (and thence professionals) to gain a better understanding of their data and their statistics. I created the eyeball-estimation techniques because they help students get intimately, concretely, and skillfully acquainted

with (among other things) effect sizes and statistical power. My reasoning was this: If students gain a clear understanding of effect sizes and power, they will naturally report those measures in any later publications.

Thus this textbook incorporates the Task Force recommendations not just at the reporting level but at the comprehension level. There is thus little new in this regard in this edition -- most was already incorporated in earlier.

### Connection to the Web

Click a button in the Resources section of the *Personal Trainer* and you'll go a web site that provides updates, additional Resources, and so on. Included is an Errata section. We have worked hard to make *Comprehending Behavioral Statistics* error free, but in a project of this size, errors may occur. We will keep an up-to-the minute list of corrections here.

### **NEW!** Help for Old Friends (What's New in the Third Edition)

Here are the main changes in the third edition:

- The *Personal Trainer* CD is new. ESTAT was available as a separate ancillary in previous editions. The lectlets are entirely new.
- Heuristic formulas are emphasized. The second edition provided discussions of both heuristic and computational formulas for the standard deviation, ANOVA, correlation coefficient, and regression slope. The third edition puts the computational formulas in optional boxes in the textbook, and moves the discussion of those formulas to Resources on the *Personal Trainer*.
- Dependent-sample tests and statistical power are placed in separate chapters. The second edition positioned dependent-sample  $t$  tests and statistical power both in Chapter 12. The third edition divides those into separate chapters (Chapter 12: Dependent-sample Tests and Chapter 13: Statistical Power. That change moves the second edition's Chapter 13 (ANOVA) to Chapter 14 in the third edition.
- Textbook coverage of more advanced ANOVA topics is lightened, with deeper coverage included on the *Personal Trainer* CD. Chapter 14 in the second edition discussed the rationale and computation for *a priori* tests, *post hoc* tests, and repeated-measures ANOVA, and Chapter 15 discussed the rationale and computation of two-way ANOVA. The third edition combines the rationales for all four of those topics into one chapter (Chapter 15), and moves the computation for all four tests to Resources on the *Personal Trainer*. Thus the third-edition textbook coverage of these four topics is "consumer oriented," a discussion of how to interpret these tests. This organization makes the textbook coverage of these four topics less demanding, and therefore easier to assign in time-pressured situations.

- There are more info notes. The second edition included approximately 50 “info notes,” marginal tips that provided cross references throughout the textbook. This concept is substantially expanded in the third edition, which includes about 350 info notes in the margin that help keep the student focused on the main points of the material.