PREFACE

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

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 fourth edition of *Comprehending Behavioral Statistics* and the *Personal Trainer* CD to help you master statistics. Without question, this is the most powerful package ever created to help you learn statistics.

The first three 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 and 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 a given 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.

Personal Trainer CD

Comprehending Behavioral Statistics with the *Personal Trainer* CD 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* CD adds a whole new dimension to the *Comprehending Behavioral Statistics* pedagogy. The *Personal Trainer* CD, first available with the third edition of *Comprehending Behavioral Statistics*, has proven itself to be a versatile, potent learning-tool package. Students love it! It provides a level of interactivity and support not possible with any other statistics textbook.

The *Personal Trainer* CD has five main features:

- Lectlets—short, interactive audiovisual lectures. You'll hear Dr. Hurlburt talking to you about all the concepts in the course. He'll ask you questions. You'll 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—explorational and computational software. For example, ESTAT will present a scatterplot with a line drawn through it. You'll grab the line with the mouse and move it around until it best fits the scatterplot. That's your eyeball-estimation 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.

- Interactive algebra review—a quick interactive brush-up on the algebra concepts necessary for comprehending statistics.
- Supplementary Resources—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—interactive review of all the concepts in the textbook.

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

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

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 into your pocket or purse and use the *Personal Trainer* CD 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* CD provides interactivity not possible in the textbook alone, but the textbook remains a clear and complete exposition of the material.)

Eyeball-estimation

eyeball-estimation: predicting the approximate magnitude of a statistic

Eyeball-estimation techniques enable students 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 the eyeglass symbol shown here. 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 refining such awarenesses as the effects of outliers or 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 with much greater accuracy than do students taught by traditional methods (Hurlburt, 1993).

Progressive Cumulative Review

progressive cumulative review: gradual, incremental, comparative recap of previously learned concepts

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 my graduate students. The exercises were so effective that I started using them with sophomores more than 20 years ago. My sophomores' performance on cumulative exams now surpasses that of the graduate students I taught prior to using cumulative review exercises.

Lectlets

lectlet: a short, interactive audiovisual lecture

A lectlet (Hurlburt, 2001) is a short, interactive, computer-based, audiovisual lecture/discussion/demonstration (the term is by analogy to "applet"—a short computer program). You'll hear me introduce and explain 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:

- Some students learn better by hearing than they do by reading.
- Because the media 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 easily be rewound and replayed, as often as desired, and the 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 same message (the transcript has been found very useful by many non–special-needs students as well).
- Lectlets solve problems for instructors. The class pace 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 complements *Comprehending Behavioral Statistics*, but either can be used without the other.

ESTAT is the computer software designed to accompany *Comprehending Behavioral Statistics*. ESTAT (for ESTimating STATistics) is available in Windows and Apple Macintosh formats on the *Personal Trainer* CD. *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 numeric 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 textbook 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. 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. *Comprehending Behavioral Statistics* also supports students who are using SPSS by providing detailed instruction for its use (SPSS 12.0 Student Version) and annotated SPSS printouts at the end of each chapter. Look for the SPSS logo in the margin of each chapter's Connections section.

Resources

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), thus reducing the book's manufacturing cost. That cost savings is what makes it possible to provide the *Personal Trainer* CD to you for free.
- They make the book more focused for the 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

The *Personal Trainer* CD 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 electronic review of the concepts covered in that chapter as well as a multiple-choice quiz on the chapter. Like ESTAT and the lectlets, QuizMaster asks questions and provides immediate feedback in an almost game-like atmosphere.

Light-hearted but Not Lightweight

I have several times referred to the materials in *Comprehending Behavioral Statistics* and the *Personal Trainer* CD 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 easily choose which of its innovations to use. Every student has the *Personal Trainer* CD and can use it on any Apple 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 on the *Personal Trainer* CD. (*Comprehending Behavioral Statistics* can be used with or without computer software.)
- Student Study Guide by Paul C. Koch of St. Ambrose University includes ESTAT-like exercises for students without access to computers and quiz questions.
- Instructor's Manual (250 pages, including a test bank with 1100 items).
- ExamView® computerized test bank (1100 items for Windows or Macintosh).
- JoinIn™ on TurningPoint® lets you pose book-specific questions and display students' answers seamlessly within the Microsoft PowerPoint slides of your own lecture.
- Electronic Transparency CD-ROM provides many of the figures and tables in this text loaded into Microsoft® PowerPoint®.

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 in 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," flagged with the international information symbol  , 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

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

The second edition had a set of "info notes" in the margins that gave the student information about where things could be found; for example, "When σ is known, use Equation (7.2)." Students were uniformly enthusiastic about these notes, so the third and fourth editions expand their functions and have perhaps seven times as many. They allow communication with the student outside the flow of the main exposition and thus have substantial pedagogical value. They allow 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.

Effect Sizes, Power Analysis, and Practical Significance

Comprehending Behavioral Statistics gives a clear, thorough presentation of practical significance, including discussions of power and effect sizes throughout the textbook. In fact, my main motivation for writing this book in the first place (in about 1990) was to provide a vivid, comprehensible, visualizable presentation of effect sizes. I created the eyeball-estimation techniques that are used throughout this book 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.

Responding to the same issues, the American Psychological Association 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 *Publication Manual of the American Psychological Association* (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. Thus, this textbook incorporates the Task Force recommendations not just at the reporting level but also at the comprehension level.

Connection to the Web

Click a button in the Resources section of the *Personal Trainer* CD and you'll go to a website 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.

Help for Old Friends (What's New in the Fourth Edition)

The fourth edition is the result of a process I call "precision-guided edition." As you know, a precision-guided munition or "smart-bomb" is a self-guided weapon designed to have maximum effect directly on small, specific targets while minimizing collateral damage. I applied the same logic to the creation of this edition. I asked three classrooms of students to keep a pad of textbook-line report forms with them while they used the third edition of *Comprehending Behavioral Statistics*. Their task was to mark on these forms the exact line they were reading whenever they experienced any difficulty whatsoever. If they had to reread a sentence, or were distracted, or stumbled for whatever reason, they were to mark the line they were reading on the form.

Students provided exquisitely specific feedback in this way. If several students marked the same line, then it was my job to figure out why this line presented difficulties and fix it. Students didn't necessarily have to know *why* they had difficulties (although many students provided valuable suggestions); they simply had to report *where* they had difficulty. Nearly always when students pointed to a specific line, I could discern that the problem was and remedy it. Sometimes this involved merely substituting a single word for an original word that had an unintended double meaning; sometimes it involved altering material a page or so earlier so that the targeted line would have a clearer reference; sometimes it required reworking an entire passage. In all cases, this process aimed improvements directly at places the students found troublesome with little collateral damage. The third edition of *Comprehending Behavioral Statistics* was widely praised for its clear readability; the fourth edition should be clearer still.

The only structural change is that the exercises in all chapters have been streamlined. Included in the fourth edition of the textbook are the basic exercises and the cumulative review exercises. The other exercise sets from the third edition (Extending Your Comprehension, From the Journals, and Computer Explorations) are included in Resources on the *Personal Trainer* CD.

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