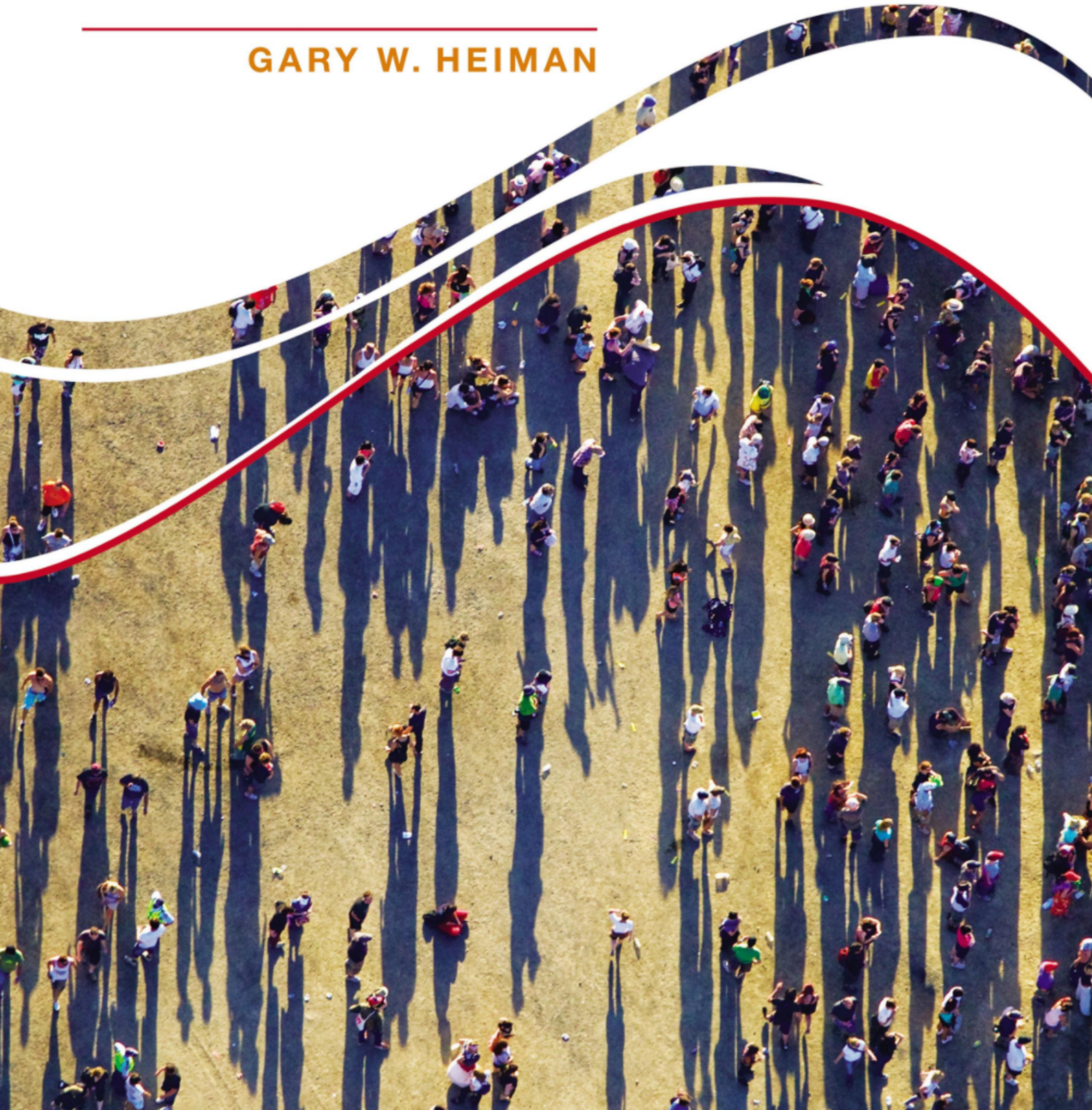
SEVENTH EDITION

Basic Statistics for the BEHAVIORAL SCIENCES

GARY W. HEIMAN



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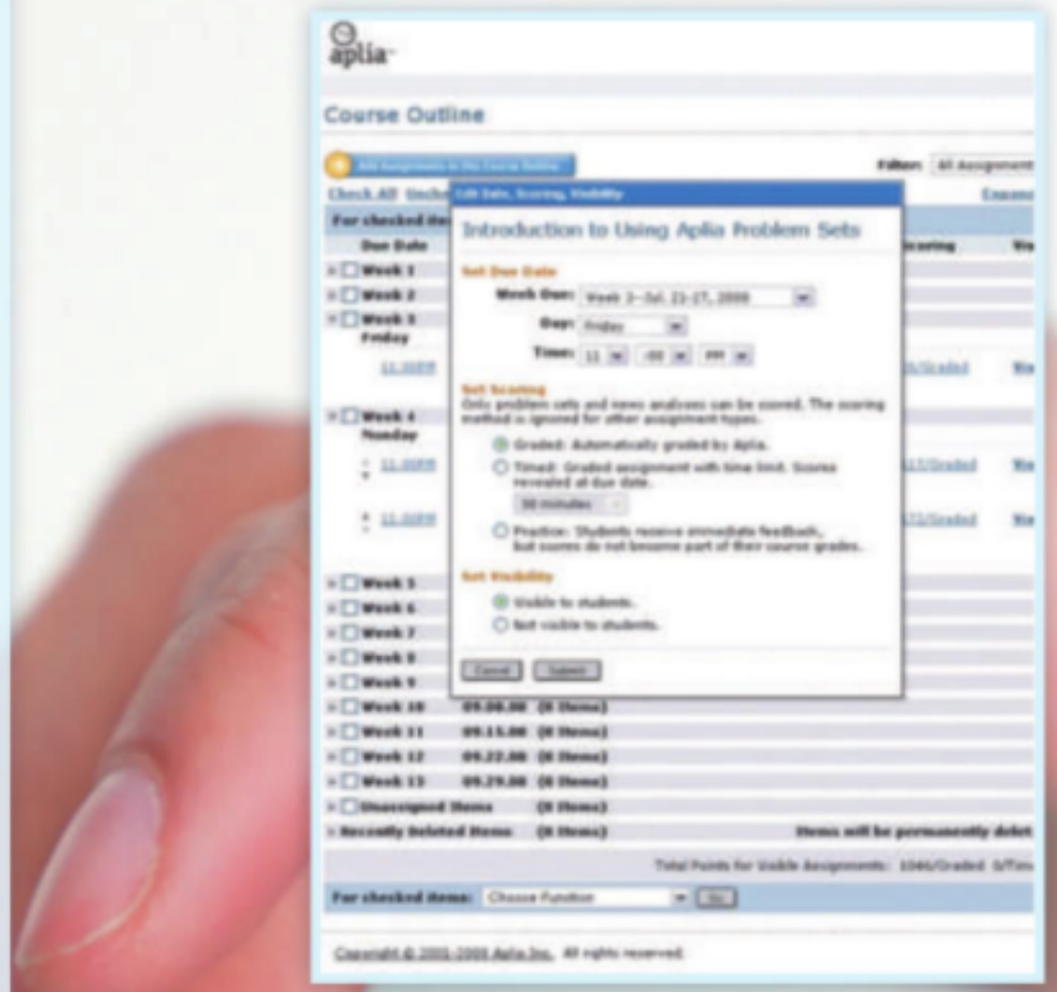

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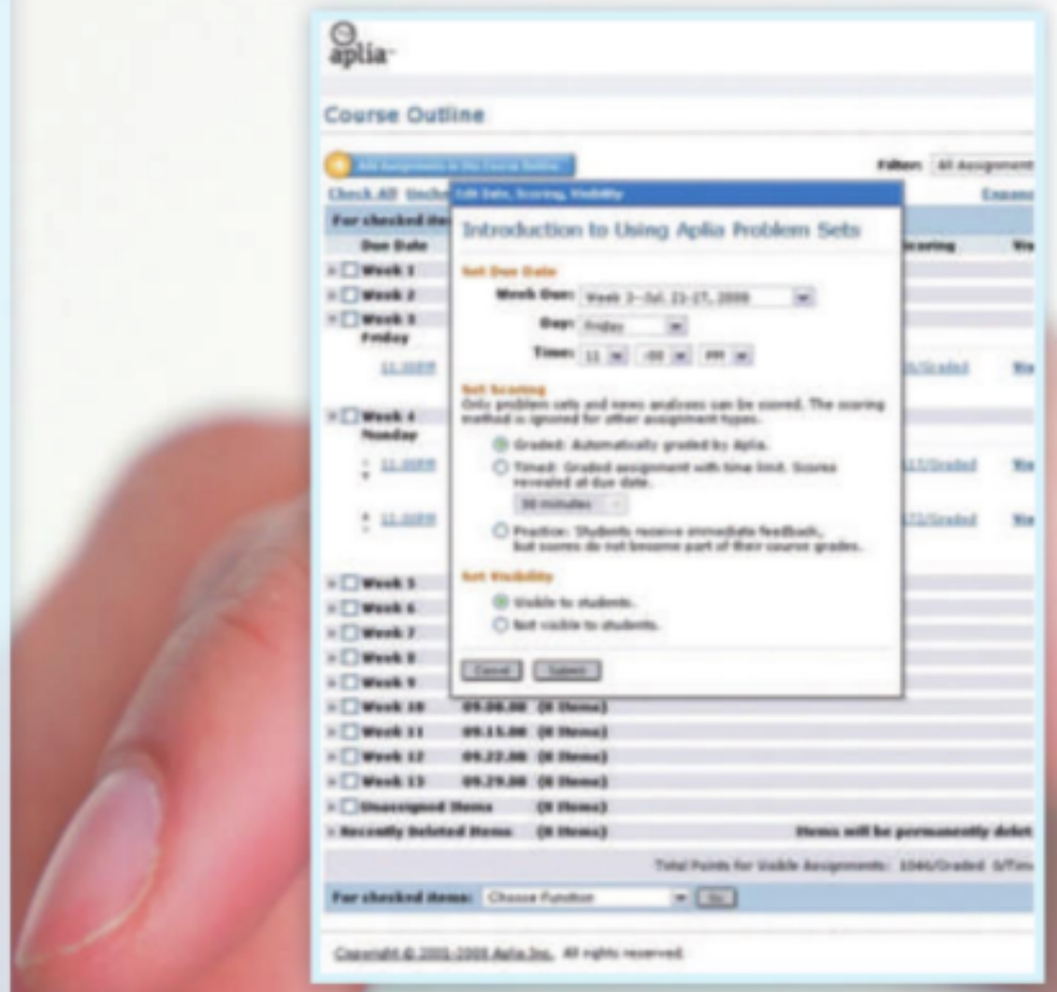

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Selecting a Descriptive Statistical Procedure

Type of Data	Individual Scores	Central Tendency	Variability	Correlation Coefficient
Nominal	frequency, rel. frequency, or percentile (Chapter 3)	Mode (Chapter 4)	Range (Chapter 5)	ϕ or C (Chapter 15)
Ordinal	frequency, rel. frequency, or percentile (Chapter 3)	Median (Chapter 4)	Range (Chapter 5)	Spearman r_S (Chapter 7)
Interval or ratio (skewed distribution)	frequency, rel. frequency, or percentile (Chapter 3)	Median (Chapter 4)	Range (Chapter 5)	Convert to ranks, compute Spearman r_S (Chapter 7)
Interval or ratio (normally distributed)	frequency, rel. frequency, percentile, or z-score (Chapters 3 and 6)	Mean (Chapter 4)	Standard deviation or variance (Chapter 5)	Pearson r (Chapter 7) and regression (Chapter 8)

Summary of Identifying an Experiment's Components

Researcher's Activity		Role of Variable		Name of Variable		Amounts of Variable Present		Compute Statistics?
Researcher manipulates variable	→	Variable influences a behavior	→	Independent variable	→	Conditions (Levels)	→	No
Researcher measures variable	→	Variable measures behavior that is influenced	→	Dependent Variable	→	Scores (Data)	→	Yes

Selecting an Inferential Statistical Procedure

Type of Design	Parametric Test	Nonparametric Test
One sample (when σ_X is known)	*z*-test (Chapter 10)	none
One sample (when σ_X is not known)	One-sample *t*-test (Chapter 11)	none
Two independent samples	Independent-samples *t*-test (Chapter 12)	Mann-Whitney *U*, or one-way chi square (Chapter 15)
Two related samples	Related-samples *t*-test (Chapter 12)	Wilcoxon *T* test (Chapter 15)
Three or more independent samples (one factor)	Between-subjects ANOVA (Chapter 13)	Kruskal-Wallis *H* or one-way chi square (Chapter 15)
Three or more related samples (one factor)	Within-subjects ANOVA (Appendix A)	Friedman χ^2 (Chapter 15)
Two factors (independent samples)	Two-way, between-subjects ANOVA (Chapter 14)	Two-way chi square (Chapter 15)

Basic Statistics for the Behavioral Sciences

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SEVENTH EDITION

Gary W. Heiman

Buffalo State College, Professor Emeritus

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For my wife Karen, the love of my life

BRIEF CONTENTS

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PREFACE TO THE INSTRUCTOR

The purpose of this textbook is to actively *teach* statistics. I work very hard at presenting every topic in a patient and logical manner that avoids confusion, anticipates student questions, engages students, and even includes a little humor to make a point memorable (although it may elicit a groan or two). I concentrate on showing students the *logic* of statistics so that, when we simplify the jargon and boil down the principles to concrete ideas, statistics really do make sense. Therefore, for this edition I performed a page-by-page revision of the entire book, using my knowledge of teaching statistics and responses to structured reviews from users and nonusers of the previous edition. The goal was to provide the clearest presentation that I can, that best teaches the material in ways that can be easily understood.

I have also responded to two trends that impact the teaching of statistics: the prevalence of students with poor math skills and high math anxiety and the availability of computer programs like SPSS. Together, these have led some instructors to deemphasize "computing" formulas, spending more time on conceptual explanations involving "defining" formulas. However, many instructors are unwilling to dispense entirely with computing formulas. Therefore, I have revised a number of chapters to first present a more complete verbal explanation of the defining formulas for a statistic and then to describe how we arrive at the computing formula in a math-friendly manner.

However, the text does not pander to student weaknesses regarding mathematics. On the one hand, the book is geared toward students who may not be proficient in math and who grudgingly learn statistics. On the other hand, I fully expect that students ultimately will be capable of performing and understanding these statistical procedures as they are found in modern research—as "junior" researchers. The tone is always, "At first this may *appear* difficult, but you can do it."

Each procedure is introduced using a simple study with easily understood goals. The focus is that research examines relationships and that statistics are for describing and inferring such relationships. Therefore, procedures are introduced in terms of how they accomplish this, and examples are worked through in a step-by-step manner. The most difficult concepts are presented in small chunks that span different chapters, so they are less overwhelming when fully revealed. Throughout, I do not forget that, from the student's perspective, everything about this course is new and often very strange and a little scary. My goals are to dispel the myth that statistics are incomprehensible, to give students the opportunity to successfully and easily learn statistics, and to have it be an engaging (and possibly fun) experience.

MAJOR CHANGES IN THE SEVENTH EDITION

Although there are numerous changes in this edition, the most notable are:

1. Two new review sections were added: The ***Halfway Review*** follows Chapter 8 and reviews descriptive statistics. This helps to prepare students for inferential procedures, especially by reminding them about *z*-scores and sampling distributions. The ***Second-Half Review*** follows Chapter 15 and focuses on selecting inferential procedures and their subroutines and on interpreting the answers. This helps students to take the macro view of the material by organizing and integrating all inferential procedures at one time.
2. To show the similarity between inferential procedures, all discussions were rephrased to be a consistent choice between two explanations for a study's outcome: (a) the sample data were produced by, and represent, a relationship between the variables that operates in nature; or (b) the relationship does not operate in nature, but by chance, the sample data give the *appearance* of such a relationship.
3. These major changes in content were made: Discussion of estimating the median was deleted from Chapter 4; discussion of the variance of Y around Y' was deleted from Chapter 8; formulas for the Mann-Whitney, Wilcoxon, Kruskall-Wallis, and Friedman tests were moved from Chapter 15 to Appendix A. In Chapter 15 is now a brief description of each procedure's use. The other tests for ranks were deleted.
4. The SPSS manual in Appendix B was revised. This guide for computing all procedures discussed in the text was revised (with new screen captures) for the new SPSS version 20. The section, *Using the SPSS Appendix*, appears at the conclusion of many chapters to integrate the appendix and each chapter. The book is organized, however, so that instructors may easily include or exclude discussions of SPSS.

CHAPTER CONTENT AND REVISIONS

Chapter 1 serves as a brief preface for the student and reviews basic math and graphing techniques. Much of this is material that instructors often present at the first class meeting, but having it in a chapter helps reinforce and legitimize the information. To help orient students and to address their math anxiety, I added a new *What Is the Purpose of a Statistics Course?* and *But Thinking About Numbers Is Hard!*

Chapter 2 introduces the terminology and goals of statistics while integrating them with the purpose and logic of behavioral research. The description of experiments was revised, adding a new section to help students spot the independent and dependent variables in a design. Also, discussions that touch on research methods were shortened.

Chapter 3 presents simple, relative, and cumulative frequency, as well as percentile. Grouped distributions are briefly discussed, with additional information in Appendix A. I revised the discussion of treating the normal curve as a solid figure for finding area and relative frequency.

Chapter 4 introduces measures of central tendency but focuses on the characteristics of the mean. The discussion of the median was revised, removing the procedure for estimating it. I also simplified transformations and the mean, and I revised how to envision a relationship in the population.

Chapter 5 introduces the concept of variability, using small data sets and then large distributions. The chapter was reordered to present conceptual explanations and defining formulas for the variance and standard deviation for the sample, for the population, and for estimating the population. Then computing formulas are discussed, with examples.

Chapter 6 deals with *z*-scores by first discussing relative standing, which leads to *z*-scores and *z*-distributions. Then using *z*-scores to obtain area under the curve and relative frequency is presented. The discussion then transitions to sampling distributions and computing *z*-scores for sample means, to set up for later inferential procedures. (Instructions for using linear interpolation with statistical tables are presented in Appendix A.)

Chapter 7 presents correlation coefficients in general, explaining how they convey the type and strength of a relationship. Then an expanded discussion explains the Pearson *r* using the *z*-score formula, with examples. The computing formula (which reduces rounding error) is explained, with a complete example. The Spearman coefficient, with an example, is then presented.

Chapter 8 presents linear regression, explaining its logic with an expanded discussion of how the slope and *Y*-intercept summarize a relationship. When discussing prediction errors, the focus is now on only the standard error of the estimate. The chapter concludes with a revised explanation of the proportion of variance accounted for as it applies to correlation and regression.

Halfway Review is a new mini-chapter located between Chapters 8 and 9. It briefly reviews the major points from all previous chapters, especially in terms of the concepts needed to learn upcoming inferential procedures.

Chapter 9 begins inferential statistics by explaining probability and how it is used in behavioral research, but without the confusing aspects of the terminology, hypotheses, and conclusions of significance testing. Instead, probability is linked to random sampling, representativeness, and sampling error which leads to computing the probability of sample means. Then I discuss using probability to make decisions about the representativeness of sample means, along with the mechanics of setting up and using a sampling distribution. These later sections now more clearly formalize the steps involved in all subsequent procedures.

Chapter 10 presents statistical hypothesis testing using the *z*-test. This includes the terminology and symbols, the interpretation of significant and nonsignificant results, Type I and Type II errors, and an introduction to power. A major revision involved the probability of Type I errors and reporting $p < .05$, with added help for remembering when to use < or >.

Chapter 11 presents the one-sample *t*-test and the confidence interval for a population mean. Major revisions here involved the logic of the one-sample *t*-test, its similarity to the *z*-test, using variance to compute the standard error of the mean, and understanding the formula for the confidence interval. Then, because of similarities to the *t*-test, significance tests of the Pearson and Spearman correlation coefficients are also discussed. The chapter ends with a revised discussion of how to design a powerful study.

Chapter 12 covers the independent- and the dependent-samples *t*-tests and versions of the confidence interval used with each. The chapter ends with using Cohen's *d* or the squared point-biserial correlation to measure effect size. The latter includes a revised discussion of how the proportion of variance accounted for is a measure of effect size in experiments, with new examples.

Chapter 13 introduces the one-way, between-subjects ANOVA. The discussion of experiment-wise error and the conceptual underpinnings of ANOVA were revised and simplified. Post hoc tests for equal and unequal *n*s, eta squared, and interpreting