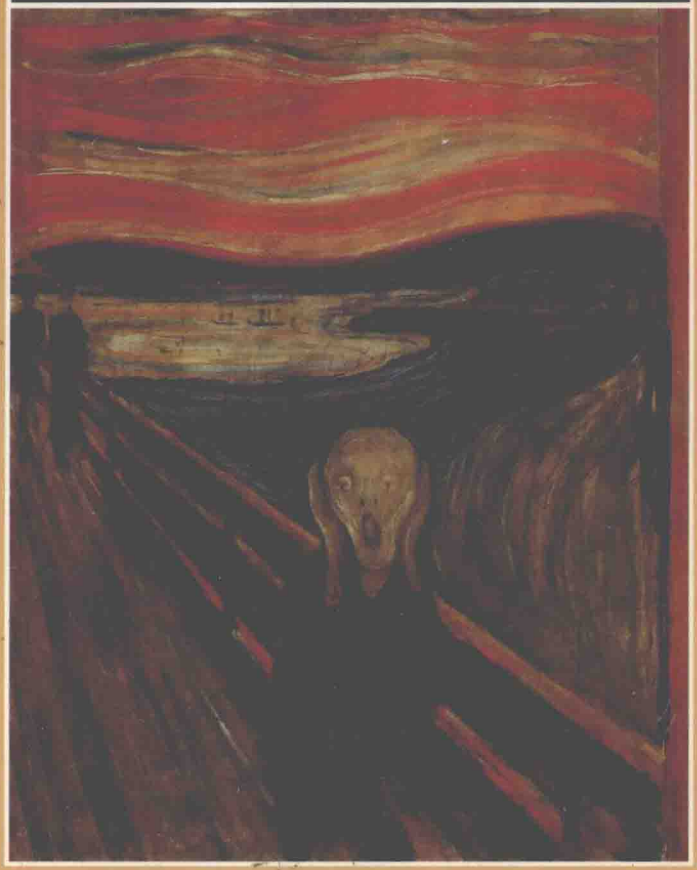
STATISTICS FOR THE TERRIFIED

SECOND EDITION



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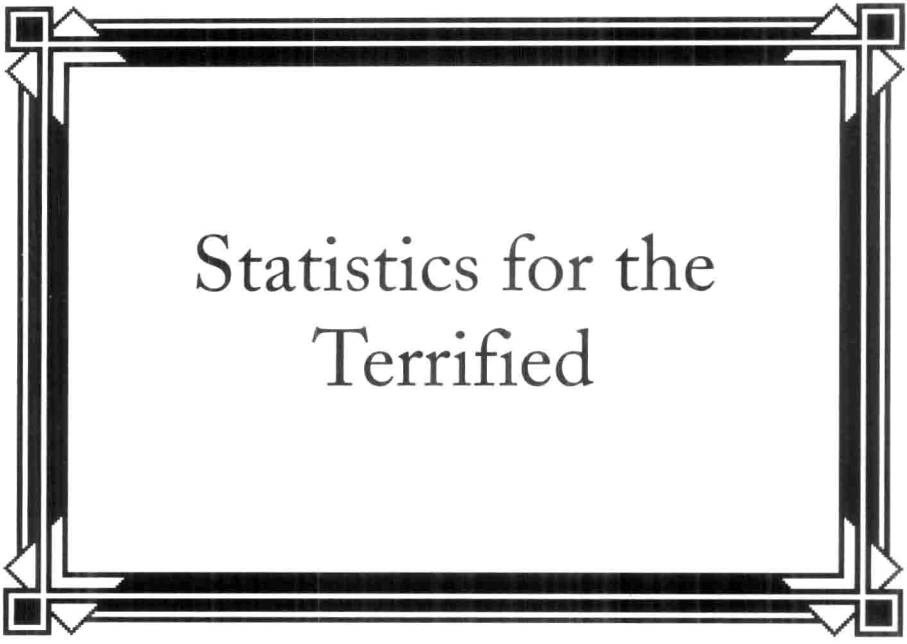

Statistics for the Terrified

Second Edition

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Dedication

Jerry Kranzler, friend and colleague, is the primary author of this book. He developed the ideas in it, through working with generations of students. Nearly all of them began Jerry's statistics class wishing they were anywhere but in a stats class; nearly all of them ended their work feeling glad about the course, proud of their progress, and amazed at how Jerry had done it. As Jerry's co-author, and in his absence, I take the liberty of dedicating this second edition to him. Jerry, thank you for your friendship, your wisdom, your humor, and your love of learning. We miss you.

Preface

A book like this, one that has grown over so many years, has made friends with a lot of people. And I want to acknowledge those people, to say "thank you" for their nudges and pats-on-the-back and occasional less friendly, but equally useful bits of information.

When I've read other books, especially textbooks, I've tended to skip over all that "front stuff." I expect most readers will do the same thing here. But if you've gotten this far, maybe you're different; if so, please accept my thanks in advance for reading this. The people whom I shall be acknowledging really do deserve your notice and appreciation.

First on the list of folks to thank, of course, must be all the students. I can't list names and won't even try to pick out a representative few; they know who they are. They made this book, it's about them and for them, and if it weren't for them, you wouldn't be reading any of this.

Jerry Kranzler, though a coauthor, needs to be recognized here. Jerry died shortly after the first edition of *Terrified* was published, but his sense and spirit live on in every page of the new edition. Jerry did the greater part of the work for this book; his vision began it and his experience gave it form and structure.

Fellow faculty in the DABCS (I won't spell it out, but isn't "Department of ABCs" a great acronym within a College of Education?) at the University of Oregon have been enormously encouraging. Suzie Prichard, secretary and good friend, made even bad days bearable by her encouragement and sense of

humor. And friends and colleagues in that other world, outside of academia, have been patient and understanding when I've grumped and whined over a difficult passage. Thank you, thank you all.

Then there are the good folks at Prentice Hall: editorial staff, reviewers, and probably others that I don't even know about. Anita Castro, who has steered me through the revision process with unfailing good humor, and Randy Pettit, Production Editor, whose email comments cheered my days. And the reviewers: Sandra A. McIntire, Rollins College; and Eugene R. Gilden, Linfield College, who will never know how useful they have been. And, finally, Sarah Streett of Colorado State University, who patiently sorted through the entire manuscript and corrected errors that I never even knew were possible!

Words are poor things for expressing sincere feelings, and these paragraphs are woefully inadequate to express my gratitude. I hope that all of the people I've mentioned, especially those who couldn't be named specifically, will understand how much their support has really meant.

—Janet Moursund

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Introduction

"You haven't told me yet," said Lady Nuttal, "what it is your fiancé does for a living."

"He's a statistician," replied Lamia, with an annoying sense of being on the defensive.

Lady Nuttal was obviously taken aback. It had not occurred to her that statisticians entered into normal social relationships. The species, she would have surmised, was perpetuated in some collateral manner, like mules.

"But Aunt Sara, it's a very interesting profession," said Lamia warmly. "I don't doubt it," said her aunt, who obviously doubted it very much. "To express anything important in mere figures is so plainly impossible that there must be endless scope for well-paid advice on how to do it. But don't you think that life with a statistician would be rather, shall we say, humdrum?"

Lamia was silent. She felt reluctant to discuss the surprising depth of emotional possibility which she had discovered below Edward's numerical veneer.

"It's not the figures themselves," she said finally, "it's what you do with them that matters."

—K. A. C. Manderville, *The Undoing of Lamia Gurdleneck*[1]

[1]In the first edition, we confessed that we did not know the origin of this quotation, and asked for help in finding it. Thanks to Dr. Keith Baggerly of the Rice University Statistics Department, we can now share with you the following information: The quote first appeared as an introductory blurb for volume II of "The Advance Theory of Statistics" by Maurice Kendall and Alan Stuart. Many statisticians really liked the quote, and tried to track down the book to find out more about the mysterious statistician fiancé, but to no avail. The mystery was solved in 1992, with the

Another statistics book! There are so many statistics books on the market now that it seems strange even to me that there be another one. However, as a teacher of statistics, I have been dissatisfied with available books because they seem aimed at students who whizzed right through college algebra and considered taking math as a major just for the sheer joy of it. Most of my students in counseling and education programs are not like that. Many of them would respond with a hearty "true" to many of the following self-test statements. I invite you to test yourself, to see if you too fit the pattern.

1. I have never been very good at math.
2. When my teacher tried to teach me long division in the fourth grade, I seriously considered dropping out of school.
3. When we got to extracting square roots, thoughts of suicide flashed through my mind.
4. Word problems! My head felt like a solid block of wood when I was asked to solve problems like, "If it takes Mr. Jones 3 hours to mow a lawn and Mr. Smith 2 hours to mow the same lawn, how long will it take if they mow it together?"
5. Although I never dropped out of school, I became a quantitative dropout soon after my first algebra course.
6. I avoided courses like chemistry and physics because they required math.
7. I decided early that there were some careers I could not pursue because I was poor in math.
8. When I take a test that includes math problems, I get so upset that my mind goes blank and I forget all the material I studied.
9. Sometimes I wonder if I am a little stupid.
10. I feel nervous just thinking about taking a statistics course.

Did you answer "true" to many of these items? If so, this book may be helpful to you. When writing it, I made some negative and some positive assumptions about you:

1. You are studying statistics only because it is a requirement in your major area of study.
2. You are terrified (or at least somewhat anxious) about math and are sure you cannot pass a course in statistics.
3. It has been a long time since you last studied math, and what little you knew then has long since been forgotten.

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appearance of an article in *Chance* by Fortney, et al. entitled "The Undoing of Maurice Kendall." In short, note that one of the main characters in the quote is the aunt, Lady Sara Nuttal, the author is K. A. C. Manderville, and be aware that Alan Stuart and Maurice Kendall were both very fond of anagrams (Roman lettering, so u's can be written as v's).

4. But with a little instruction and a lot of hard work on your part, you can learn statistics. If you can stay calm while baking a cake or reading your bank statement, there is hope for you.
5. You may never learn to love statistics, but you can change your self-concept. When you finish your statistics course you will be able to say, truthfully, "I am the kind of person who can learn statistics! I'm not stupid."

In this book, I will attempt to help you to achieve two important objectives: (1) to understand and compute some basic statistics, and (2) to deal with math anxiety and avoidance responses that interfere with your learning.

Here is some advice that I think you will find useful as we move along: (1) Because the use of statistics requires you to work with numbers, you should consider buying a calculator. Make sure that the calculator has at least one memory and that it can take square roots (almost all calculators can do this). Before you go out and invest in such a machine, though, check out your personal computer—many desktop and laptop computers come equipped with calculator software that will easily handle the problems in this book. (2) Try to form a support group of fellow statistics students. Exchange telephone numbers and times when you can be reached. Talk about what you are studying and offer to help others (you may learn best by teaching others). When you are stuck with a problem that you can't solve, don't hesitate to ask others for their help. Very likely they have some of the same feelings and difficulties you do. Not everyone gets stuck on the same topics, so even you may be helpful to someone else.

If you are one of the "terrified" for whom this book is intended, there are two appendixes at the end of the book that may be helpful to you. Appendix K, "Overcoming Math Anxiety," will give you some general tools and techniques for dealing with the uncomfortable feelings that many students experience when they find themselves dealing with numbers. And Appendix B provides a review of some of the basic math concepts that you may have once known, but that have gotten rusty through disuse. It also gives some sample problems that will allow you to test your ability to use those concepts. I know that reading an appendix before you even get to the first chapter of a book may seem pretty weird (and probably not politically correct), but I think these may help you to get off to a running start and will be well worth your time and trouble. Of course, if you don't have problems with math, and already know all the basics, you won't learn anything new; but, even so, "Shucks, I know all this" is a great way to begin a statistics class. Especially if you think it may be terrifying!

1

Middleness and Variability

The field of statistics is concerned with methods of organizing, summarizing, and interpreting data. "Data" means information: Any collection of information is a collection of data. For statisticians, though, "data" generally means numerical information. Statistics really amounts to a collection of techniques for dealing with sets of numbers: organizing them, summarizing them, figuring out what they mean. This chapter will focus on the "summarizing" part. It will present methods of finding a number that describes a group of numbers.

We often ask questions such as, "What is the average IQ of this class?" or "How much money does the average football player make?" When we ask such questions, we are really asking for a single number that will represent all of the different IQ scores, or player salaries, or whatever. Many people are not aware that there is more than one "average." In this chapter, you will find three methods for computing an average: the mean, the median, and the mode.

Just one number, though, can be misleading. Sets of data not only have a middle, but they have a spread: The numbers in the data set cluster more or less tightly around the middle. The second kind of summarizing technique is finding a number that describes that spread.

Before presenting measures of middleness and spread, however, I need to digress a bit and discuss symbolizing data.

SYMBOLIZING DATA

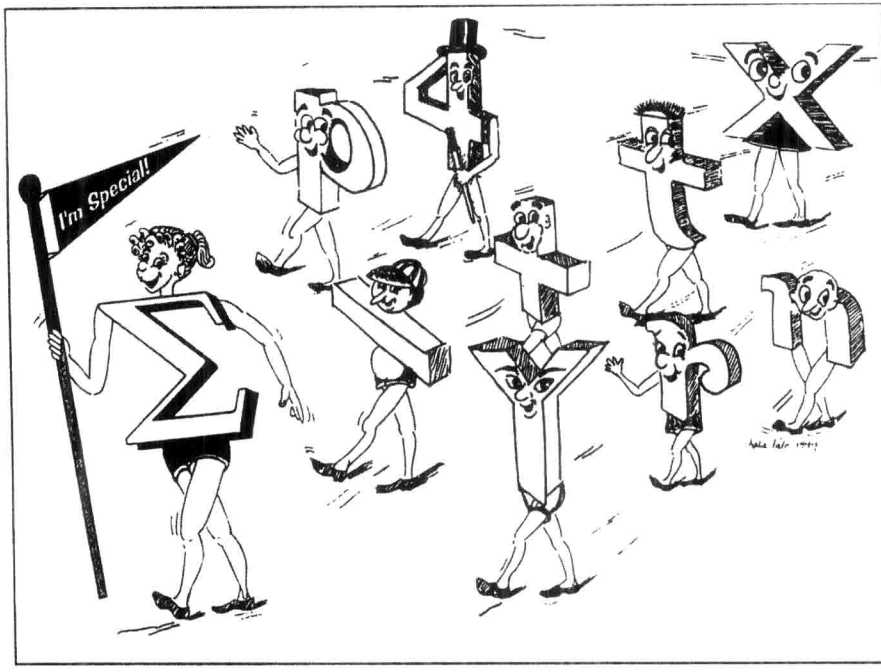
If you have read, or even looked at, any statistics books, you have probably noticed the use of many symbols unfamiliar to you. These symbols are shorthand ways of referring to numbers, or to manipulations that we use on numbers. A common example is the small "2" that we put high and to the right (that position is called "superscript," by the way, just as the low-and-to-the-right position is a "subscript") of a number to indicate that the number is to be squared—multiplied by itself. It's certainly simpler to write "$5^2 = 25$" than to write "5 times itself is equal to 25." And, as we shall see, other sorts of procedures that can be symbolized quite easily would require lots and lots of words if we had to write them out.

Learning to read statistics material is somewhat analogous to learning to read music or a foreign language: impossible at first, difficult for a while, but relatively easy after some effort. One thing to remember, though: Since symbols are a way of condensing information, a paragraph that is full of mathematical symbols has much more information in it than an ordinary paragraph in a history book or a newspaper article. Don't be surprised if it takes you three or four times longer to get through a page in a statistics book (even this one!) than to get through a page in a nonnumerical book. In fact, one of the challenges for the beginning statistics student is learning to slow down. Force yourself to adjust your reading speed to the density of the information on the page, and you'll find that things get much easier.

Variables

Those of us who are interested in education or the behavioral sciences are concerned mostly with characteristics of people, such as ability, achievement, interests, and personality. When you study people, one of the first things you will notice is that people vary considerably on almost every characteristic. Some people are much brighter than others; some learn more than others in the same amount of time; some are more emotional, or more grumpy, or more talkative than others. In statistics, we call such characteristics *variables.*

It is conventional to designate variables by capital letters near the end of the alphabet. For example, the intelligence test scores earned by a group of five students could be designated with the capital letter X, and achievement test scores earned by the same students could be represented by a Y. The first student's intelligence test score would be X_1; the third student's achievement test score would be Y_3. With X and Y as your two variables, you could ask, "What is the average score on the X variable?" or "Is there any relationship between X and Y?"



The Summation Sign

You will also be introduced to quite a few Greek letters, especially sigma, designated by Σ. The Greek uppercase letter sigma (Σ) directs you to sum (add up) whatever comes after it. If years in school are represented by the letter X, then ΣX directs you to add up all the X scores:

Example

Years in School (X)
5
3
4
6
8
$\Sigma X = 26$

Similarly, if achievement test scores are represented by the letter Y, and the test scores are 82, 71, 69, 50, and 22, then $\Sigma Y = 82 + 71 + 69 + 50 + 22 = 294$. You will find more information about working with the summation sign in Appendix B, "Basic Math Review."

Parentheses

Strange as it may seem, parentheses are an important mathematical symbol. They serve as a kind of recipe, telling us in what order to do things. In a complicated set of cooking directions, it can be important to know whether to add the sugar before you beat the egg whites or afterward; in the same way, it's important to know whether to square a set of numbers before or after you add them together.

The parentheses rule is simple: Work from the inside out. Carry out whatever operations are inside the innermost set of parentheses, and then whatever is inside the next set, and so on. For example, $(((x(x + y)) - 32)/y)^2$ means to (1) add x and y together; (2) multiply the sum by x; (3) subtract 32; (4) divide by y; and finally (5) square your answer. The parentheses are important because doing the operations in a different order will give you a different result. Try it. Let $x = 2$ and $y = 5$, and see what happens when you change the order of operations!

THE MEAN

The *mean* is the most often used measure of central tendency *(central tendency* is a fancy statistical term that means, roughly, "middleness"). The mean is an old acquaintance of yours: the arithmetic average. You obtain the mean by adding up all the scores and dividing by the number of scores. Remember?

Different statistics texts use different symbols to designate the mean. Some use a bar over the letter symbolizing the variable: a group's mean score on variable X would be symbolized $\bar{X}$. Others (this book included) use a capital M, with a subscript indicating the referred-to variable: The mean score on variable X is M_X. If the amount of time needed to thread a needle is designated by Y, then the mean time needed by the people in the Busy Bee Sewing Circle to thread their needles would be M_Y[1].

[1]By convention, M_x and M_y are used to designate the mean of a sample, that is, a finite set of something—test scores, people, wallpaper colors, what have you. Sometimes we want to refer to the mean of a less definite, often infinite set: all the fifth-graders in the United States, for example, or the scores that all those fifth-graders would get if they all were given the same achievement test. A large, inclusive group like this is called a *population*, and its mean is symbolized by the Greek letter μ (pronounced "mew," like a kitten). Values having to do with populations are called parameters and are usually symbolized using lowercase Greek letters; for sample values (called *statistics*), we use the normal English-language alphabet.

To be technically correct, we would have to define a *population* as the collection of all the things that fit the population definition and a *sample* as some specified number of things selected out of that population. You'll see why that's important when we talk about inferential statistics in Chapter 6. For now, though, just assume that we are working with samples—relatively small groups of things in which each individual member can be measured or categorized in some way.