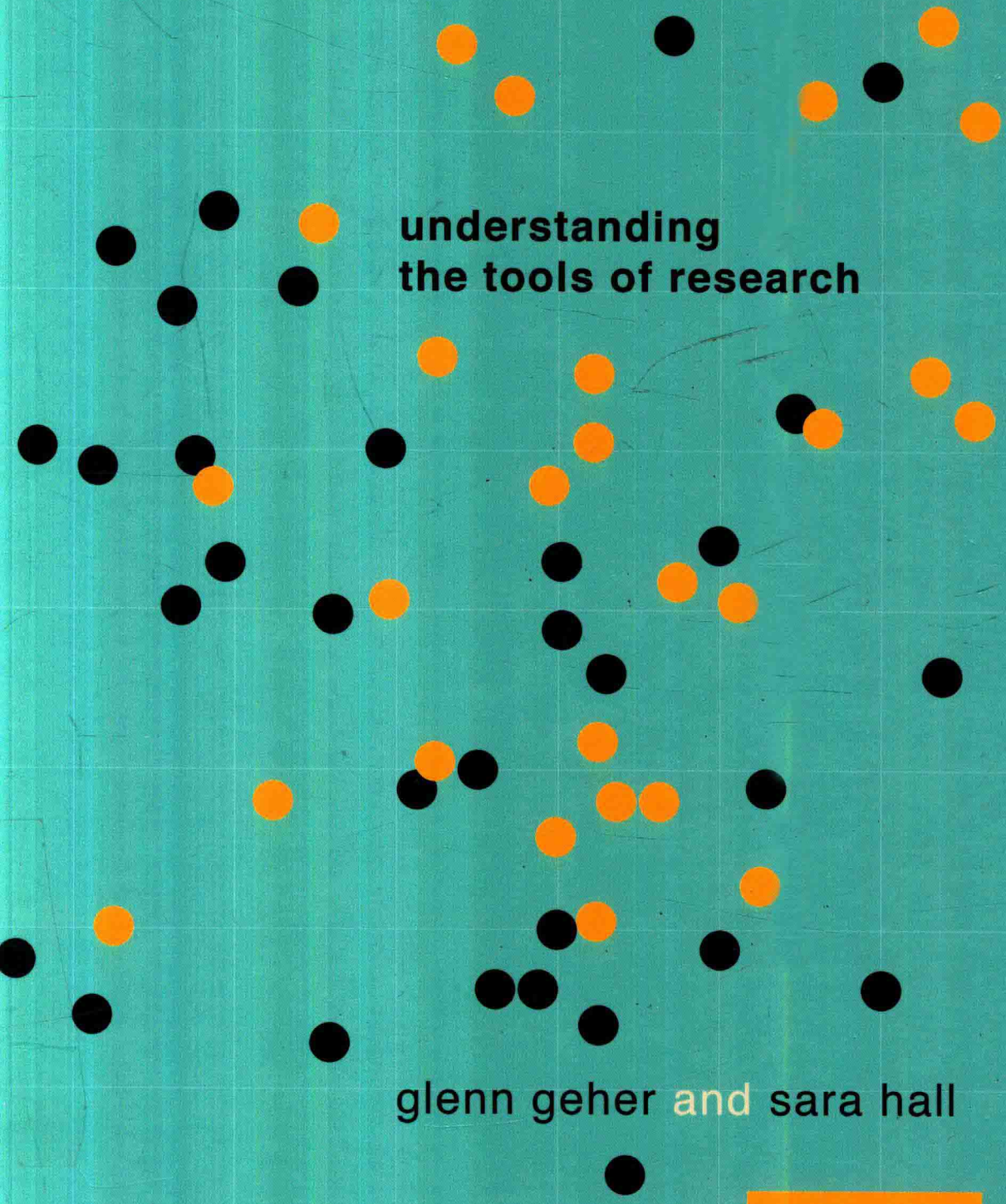
straightforward statistics



understanding
the tools of research

glenn geher and sara hall

OXFORD

STRAIGHTFORWARD STATISTICS

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Glenn Geher

AND

Sara Hall

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Glenn: For my dad, who has encouraged mathematical reasoning across my life. And for my mom, who has convinced me, always, that all stars are within reach.

Sara: To Benjamin, for everything, and to Jackson, Stella, Susanna, and Sailor, the best people I've ever met. Also to my parents, for giving me the confidence to live life fully and the ability to laugh about it.

PREFACE

The trend in the production of academic textbooks in general—and psychological-statistics textbooks in particular—is toward incorporating ever more bells and whistles. Typical statistics textbooks are replete with boxes, figures, and illustrations. Further, the textbook itself (nowadays) is simply one element in a package—often including a study guide, a software workbook, and an accompanying website (for students) as well as multiple instructor's manuals, a separate accompanying website (for faculty), a testbank, and a fancy set of PowerPoint presentations—tailored to each chapter.

Another trend in statistics textbooks in psychology tends toward watering down the content. This trend is driven by a motivation to strike a balance between covering the concepts in sufficiently deep and broad detail and presenting the information in a way that is accessible to an often-resistant and anxious clientele: Undergraduate students who are afraid of math. While this trend toward watering the content down makes sense, we don't think it's necessary.

Straightforward Statistics: Understanding the Tools of Research was designed from the outset to be written so as to effectively strike that balance between sufficiently covering the important concepts that underlie psychological statistics and presenting the information in an accessible manner.

Why should you trust Glenn and Sara to be able to achieve this balance successfully? Good question. Let's start with Glenn. I took two different statistics courses as an undergraduate psychology major at the University of Connecticut. I then took four different advanced statistics classes at the University of New Hampshire as a PhD student. But it wasn't until Victor Benassi, who was chair of the UNH Psychology Department at the time, told me that I was set to teach Statistics—an essential part of our undergraduate major—in Spring of 1996–that I had to prove myself. I was a bit nervous. But why? I'd pretty much aced every stats class I'd taken. I'd implemented several advanced statistics in my research and was able to publish a high-quality research article in the journal *Intelligence* based on that work. Why would I balk at this?

For whatever reason, I did. And when I first got up there with those 35 or so bright undergraduate New Englanders looking me in the eyes on Day 1, I realized I had to teach these young people something. Something real. Something useful. Something that they could tell their parents about!

So I got a highly recommended textbook from the time, written by that famous couple out of Stonybrook, Art and Elaine Aron. And I read that book (the 1994 edition, which served as a significant inspiration for the current work) like I'd never read a book before. This one was for blood. This one mattered. My ability to teach this material to young minds that are mildly afraid of the content depended on me having a masterful understanding of the content. This is no small thing.

In other areas of psychology, you maybe can fake it. In talking about emotion research, for instance, you can make the case some emotional states only show up in some conditions using some measures... what you're studying is pretty much "real," but not like "really real." Welcome to teaching statistics—where "*real* is *really real*." You better get it right! And that was the challenge to me in the Spring of1996. And given my tendency to take on pretty much any challenge that comes my way, I was up for it!

I taught the class—based loosely on Aron and Aron's textbook at the time. I loved it. And I think that the students tolerated it! My approach was sort of unique, because I didn't go in there feeling much above the students. My goal wasn't to show these people how smart I was or how smart they should be. Urgent message to college teachers—that's not the job! Rather, my goal has always been to best teach the content to the broadest number of learners. And to empower these individuals so that they want to learn and so that they feel they can move forward in life able to apply what we've taught them in all domains. When I first started teaching statistics, I worked really hard with this objective in mind. And this objective characterizes my teaching to this day. This book has that philosophy of teaching and learning entrenched on every page. The material progresses slowly and clearly—always connected to content that came before or that is on the horizon. And repetition rears its head throughout this book—based on the premise that the more repetition, the better with this kind of complex material.

When I first met Sara Hall (then Sara Hubbard), she was a 17-year-old college student who grew up in the middle of the farms of Oregon. The paper she wrote for my introductory psychology class was about 10 times longer than any of the other papers—and about 100 times better. The second I met her, this kid had arrived. At 17, she was fully able to discuss material at a PhD level—and was able to take an active role in research to help uncover important questions of human personality and development. She was like nothing I'd ever seen! After she transferred from Western Oregon University (where we met) to Southern Oregon University, she worked with a faculty member interested in the psychology of statistics—and, together, they presented research on this topic at several research meetings. Sara was shaping up to be an expert on the details of undergraduate education related to statistics. When it came time for me to look for a coauthor for this book—someone whom I could trust 100% to do a stellar job—Sara immediately came to mind.

From the outset, our goal has been to create an accessible, accurate, coherent, and engaging presentation of statistics that can stand alone in one's education if needed. We are pretty down-to-earth, and we very much hope that this fact trickled down to the words we use.

What Makes Our Approach to Teaching Statistics Unique?

1. A Narrative, Accessible Voice

People are prepared to follow coherent information—narratives, stories. Technical information is best presented in a way that's accessible and that is part of a broader story. Statistics includes lots of technical information—and to help convey this information, we take every bit

of it and work to integrate this information into narrative, meaningful passages designed to get students to really understand the point of the material.

2. Conceptual

In our experience, every statistics teacher in the world says that his or her approach is the conceptual approach. We're no different! Of course, we truly believe that our approach is highly conceptual in nature.

Every technical term and idea (e.g., the "sum of the squared deviation scores") is put into context: What is this term? Why do we compute it? What does it tell us? Well, it turns out that the sum of the squared deviation scores is one index of how much scores in a sample of scores tend to vary from one another—and the way that this is computed totally maps onto this fact. If scores vary a lot from each other in a sample, the sum of the squared deviation scores will be a high number. If they do not vary much from one another, this number will be relatively low. All the formulas and technical ideas in this class are explicated in such conceptual language—in terms of what these things actually mean!

3. Content

This book is also comprehensive for an undergraduate course in statistics. It includes 13 chapters addressing the basic topics that are used in modern behavioral statistics, along with appendices that help provide additional content related to advanced statistics and a special appendix that provides step-by-step instructions and guidance regarding how to use SPSS, the state-of-the-art software in our field, to compute many of the statistics that are presented in this class.

4. Current Research

Each chapter includes a section related to current research that pertains to the statistic at hand. Thus, after learning about, for instance, statistical regression, students will read a summary of a statistical regression analysis from a recently published article in the journal *Evolutionary Psychology* to help them see how these statistics play out in real research.

5. No Frills

Despite the fact that we're not all that old and we're somewhat technologically savvy, we employed an extraordinarily no-frills approach in writing this book. To really understand statistics, a piece of chalk, a good textbook, and a chalkboard (and a calculator with a square root function!) are pretty much all that are needed.

This no-frills approach goes beyond my "only chalk needed here" method. In my (GG's) 15+ years of teaching this class, I've never relied on "ancillary" materials such as test banks provided by the publisher, PowerPoint slides, and the like. If you're the teacher, then you should make the test. And you should make the materials that you present to the students. This philosophy ensures that the teacher is right in the trenches with the students.

Our primary rationale for such a no-frills approach is straightforward: A good statistics textbook—roughly having between 10-20 chapters of high-level academic material—is, if anything, *too much* information. And college students don't do well with too much.

If a good, solid statistics textbook alone is too much information, then a textbook plus the typical ancillary materials (e.g., PowerPoint slides, separate study book, etc.) may be more than too much! And if students don't do well with "too much information," they're likely to do worse with "more than too much."

Statistics tends to be so daunting and abstract for undergraduate students such that the bells and whistles don't necessarily help—rather, they may make things more complex and, ultimately, more difficult. The no-frills approach is designed to really encourage students and instructors to engage primarily with the material itself.

REFERENCE

Aron, A., & Aron, E.N. (1994). Statistics for Psychology. Upper Saddle River, NJ: Prentice-Hall.

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The folks at Oxford University Press fully live up their reputation! We initially signed with Oxford when Lori Handelman was the editor. Her warmth and insight helped shape this book along a very positive trajectory. We were fortunate to have this book picked up by our fearless editor, Abby Gross, who represents the best of the publishing world. From the start, this book has been in great hands! In addition, the follow-up by the folks at Oxford, including amazing editorial assistance by Elina Carmona, Joanna Ng, Marc Schneider, and Suzanne Walker, has been huge. And thanks to long-term collaborator, Scott Barry Kaufman, for suggesting Oxford as a venue for this book!

And huge thanks to our statistics teachers—particularly Rebecca Warner of the University of New Hampshire (statistician sine quo non)—whose brilliance lies in the fact that she can make any complex idea simple to understand for pretty much anyone. And many thanks to the wonderful Teaching Assistants that I (GG) have had at SUNY New Paltz—several of whom have seen and commented on earlier drafts of this book. In particular, Lisa Schimski has been a tour de force in providing detailed feedback and comments on this book—and has been hugely helpful in presenting an early version of this book to our statistics students at New Paltz. Thanks Lisa—you're awesome!

And many thanks to the folks who have made time in our lives so that we had time to create this book. This mostly includes our spouses! Ben is an all-star whose helpful and supportive nature fully allowed Sara to make time for this project. And Kathy, who learned statistics side-by-side with me (GG) at UNH back in the day when we used a "mainframe" computer—has been hugely helpful on this project from forever. And thanks to our kids—who are our ultimate motivators—for Sara, there are four—Jackson, Stella, Susanna, and Sailor—and Glenn's fortunate to have Andrew and Megan. We hope and trust that all six of these kids come to love statistics as much as we do some day!

CONTENTS

CHAPTER 1

PRELUDE: WHY DO I NEED TO LEARN STATISTICS?

"I went into psychology because I want to help people—not to learn a bunch of scientific math stuff."
"I majored in psych to avoid classes like this one..."
"I'm not good at math."
"I'm scared of this course."
"What does statistics have to do with psychology, anyway?"

In my 15+ years of teaching psychological statistics to undergraduate students, I find that these kinds of comments are typical when students first walk into the classroom. Teaching psychological statistics to undergraduates is particularly challenging given the facts that:

A. Students do not want to learn the material.
B. Students do not perceive the material as relevant to their interests.

and

C. Students are often downright scared of the course.

No other course in a typical undergraduate curriculum has such attitudinal barriers from the outset.

No problem. Each of these issues can be addressed in the teaching of this course. In fact, as this course progresses, students will see that the ideas from this class have the capacity to expand students' understanding of the world more so than most other classes in the psychology curriculum.

The content of other classes changes with time. What is considered a fact about human personality in 2013 may, from the perspective of textbooks to be published in 2028, eventually be deemed a strange, erroneous, and outdated belief resulting from the use of rudimentary methods. The same goes for the other content areas of psychology—from developmental psychology to social psychology to cognitive neuroscience. Statistics, on the other hand, has a universal and timeless quality to it. Many of the statistical procedures presented in this book—such as Pearson's correlation coefficient, the within-groups t-test, or the one-way analysis of

variance—have stood the test of time. This fact alone suggests that there is something useful about the ideas included in this course.

Let's consider the three barriers described here in turn. First, think about Barrier-to-Teaching-Statistics #1: Students do not want to learn the material. This barrier suggests that there is something uninteresting about the content of the course. It's perceived as boring and lifeless. This perception simply need not be true. There is no other course in the typical psychology curriculum that is so filled with right answers. Being able to arrive at right answers is, as you will see through this course, downright fun.

Further, the material in this course follows a coherent, logical pattern that simply does not typify any other course in psychology. For students who pay attention and stay on top of their work, the logic that underlies this course is sure to be rewarding.

But is it relevant? Consider Barrier-to-Teaching-Statistics #2: Students do not perceive the material as relevant to their interests. The good news is that, yes, statistics is extremely relevant to your interests! All people, to some extent, are psychologists—trying to understand the behavior of themselves and of the people around them (Kelley, 1967). Consider these kinds of questions that we ask ourselves on a regular basis:

> "Was that smile an expression of interest in me, or just friendliness? I wonder if there's a good way to tell such smiles apart."
>
> "Why is that guy so popular—I think he's such a jerk. Does being a jerk somehow make him popular?"
>
> "What should I do to make sure I study enough for the exams in this class? What are the best studying strategies to succeed in a stats course?"
>
> "I can't believe she just said that! What is it about some people that makes them say whatever they think while others are more reserved?"

In analyzing these kinds of questions in our day-to-day lives, we are, in effect, using statistical reasoning. For instance, consider the question of whether popular guys are jerks. In thinking about this hypothesis, you may go through the different men in your social circle—thinking about which ones are jerks and which aren't. You may even discuss these things with your friends—trying to come up with an answer to the question at hand. In an informal way, you are actually engaging in statistical reasoning. In this case, the reasoning may reflect what we call inferential statistics—designed to allow us to infer if some pattern we see in a small sample (e.g., the sample of guys in our social circle) may map onto some general aspect of the population at large (guys in general).

In short, we use statistical reasoning *all the time*. Understanding the elements of statistical procedures—and developing the language to express statistical concepts—will surely prove helpful in your attempts to understand the world in your future, regardless of your career path.

While statistics are useful in understanding the nature of our worlds in general, they are particularly useful in the scientific study of behavior—i.e., in Psychology. Nearly all the ideas you learn about in your other psychology classes are based on statistics. Consider social psychology. In this course, students typically learn the following *facts*:

A. People tend to be more giving toward members of their own group than members of other groups—even if group designations are based on non-meaningful groupings (Tajfel & Billig, 1981).
B. People tend to ignore situational factors that cause the behavior of others (Ross, 1977).

C. Symmetrical faces are perceived as more attractive than non-symmetrical faces (Langlois & Roggman, 1991).

Each of these facts—or summaries of findings from published studies in social psychology—is based on statistics. Thus, to understand where these findings come from, you must understand the nature of statistics. Further, to be able to effectively critique these findings, you must understand the nature of statistics. Lastly, to be able to produce similar findings by conducting your own research—on your own research questions—you must understand the nature of statistics. In short, understanding statistics is essential to your education in psychology. That's why we make you take this class.

Finally, consider Barrier-to-Teaching-Statistics #3: Students are scared of this course. Is there any reason to be scared of this course? Hogwash! Put simply: If you got into college, you can handle the content of this course. The math's not that hard. In fact, typically, the math involved in the statistics you'll be working with consists of nothing more complex than basic algebra—a topic regularly taught to 8th graders. If ever there were a course in which diligence pays off—it's this one. Come to class, do your homework, ask questions of your instructor, stay on top of things, and there's an incredibly good chance that you will excel.

THE NATURE OF FINDINGS AND FACTS IN THE BEHAVIORAL SCIENCES

In terms of your education in psychology, this course in statistics serves to help you interpret, understand, and question the many findings and facts that you come across. Consider, for example, the finding that men tend to be more bothered by infidelity of a sexual nature compared with women—and that women tend to be more bothered by emotional infidelity (i.e., their partner falling in love with someone else) than men. In the original study on this phenomenon, David Buss and his colleagues (Buss, Larsen, & Semmelworth, 1992) found that men show a bigger increase in heart rate when thinking about sexual infidelity than do women. Specifically, Buss et al. report that male pulse rate increased 4.76 beats per minute when they were presented with thoughts of sexual infidelity, while females' pulse rates increased by 2.25 beats per minute in response to those same thoughts. On the other hand, males' pulse rates increased 3.00 beats per minute to the emotional infidelity thoughts, while females' pulse rates increased by 2.57 beats per minute in this emotional-thought condition.

Since the publication of this article in 1992, many researchers have conducted follow-up research to address whether Buss et al.'s findings are valid. Some of these researchers clearly support Buss et al.—others don't. Are males more jealous in instances of sexual infidelity compared with females? To address this question seriously means looking at the scientific literature on this topic. In order to do that, for better or worse, you absolutely need to understand statistics. Otherwise, you're stuck in the position of just taking others' word. And a bright, educated individual should make a habit of avoiding that.

Let's take a look at Buss et al.'s finding. The presentation of average increases in pulse rate means that both males and females increased in pulse rates (from baseline) when thinking about sexual infidelity. On average, males' pulse rates increased more. In fact, males' pulse rate