Arthur Aron | Elliot J. Coups | Elaine N. Aron | Erin Cooley

SEVENTH EDITION

Statistics for Psychology

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W2 Applying Statistical Methods in Your Own Research Project

W3 Repeated Measures Analysis of Variance

W4 Integration and the General Linear Model

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Preface to the Instructor

The heart of this text was written over a summer in Paris, in a small apartment near the Place Saint Ferdinand, having been outlined in nearby cafés and on walks in the Bois de Boulogne. It is based on our collective experience of many decades of teaching, researching, and writing. We believe that the result is a text as different from the conventional lot of statistics texts as Paris is from Patagonia, yet still comfortable and stimulating to the long-suffering community of statistics instructors.

Our approach was developed over decades of successful teaching—successful not only in that students have consistently rated the course (a statistics course, remember) as a highlight of their major, but also that students come back to us long after graduating saying, "I was light years ahead of my fellow graduate students because of your course," or "Even though I don't do research, your course has really helped me read the journals in my field."

We have continued to improve the book with each of the prior six editions, and the response continues to be overwhelming. We do not mean to brag, but to reassure you. Over the years we have received hundreds of thank-you emails from instructors like yourself as well as students (surprising, yes?) from all over the world. Here is a recent email (reprinted with the student's permission): "I love the step-by-step method used in each chapter and the clear explanations of the logic behind each method. I think it's finally gone 'click!' for me and I'm very excited!" (Ira Philip, 2021).

We have received (and always welcome) feedback too, about things to improve, and we have listened closely. With each revision we have tried to maintain those things about the text that have been especially appreciated, while reworking it to take into account the feedback, plus our own experiences teaching with the text and advances and changes in the field. And as you can imagine, we continue to take advantage of opportunities made available by new technology. However, before turning to what's new in this latest revision, we want to reiterate what we said with the first edition about how this text, from the beginning, has been so different from other statistics texts.

How This Text Was Dramatically Different from the Start

Our fervent desire from the outset has been to provide a text that makes learning statistics truly more enjoyable and less distressing for students. Throughout we emphasize the intuitive, de-emphasize the mathematical, and work to explain everything in direct, simple language. Further, to accomplish our goal, we have in every edition stood by seven key innovations:

1. ***The definitional formulas are brought to center stage*** because they provide a concise symbolic summary of the logic of each procedure. All our explanations, examples, practice problems, and test bank items are based on these definitional formulas. (The amount of data to be processed in practice problems and test bank items is reduced appropriately to keep computations manageable.)

   Why this approach? Even in 2022, many statistics texts have still not faced the technological realities. What is important today is *not* that students learn to calculate a *t* test by hand with a large data set—software programs like SPSS can do this in an instant. What is important today is that students work problems in a way that keeps them constantly aware of the underlying logic of what they are doing. Consider the population variance—the average of the squared deviations from the mean. This concept is directly displayed in the definitional formula (once the student is used to the symbols). Repeatedly working problems using this formula ingrains the *meaning* in the student's mind: Variance begins with how much a score deviates from the mean; that deviation is squared, which eliminates signs (as well as other advantages); and then you add up the squared deviations and take the average. In contrast, the usual computational version of this formula only obscures this meaning.

   Teaching those tired computational formulas today is an anachronism—at least 50 years out-of-date. The use of statistical software makes the understanding of the basic principles, as they are symbolically expressed in the definitional formulas, more important than ever. Students still need to work problems by hand to learn the material. But they need to work them using the definitional formulas that reinforce the concepts. Not since the era when Lyndon B. Johnson was U.S. president, and researchers had to work with large data sets by hand, have those computational formulas been necessary for students to become skilled with. Even then they were poor teaching tools. (Because some instructors may feel naked without them, we still provide the computational formulas, usually in a brief footnote.)

Of note, these ideas—of emphasizing conceptual understanding beyond mere calculations—are also supported by current guidelines for strong statistical education from the American Statistical Association (see Wood et al., 2018 for a broader discussion).

2. ***Each procedure is taught both verbally and numerically—and usually visually as well.*** In fact, when we introduce *every* formula, it has attached to it a concise statement of the formula in words. (The formulas *with their verbal descriptions* are also repeated at the end of the book.) Typically, each example lays out the procedures in worked-out formulas, then in words (often with a list of numbered steps), and then also illustrated with easy-to-grasp figures. Practice problems and test bank items, in turn, require the student to calculate results, write a short explanation in layperson's language of what they have done, and make a sketch (for example, of the distributions involved in a *t* test). The chapter material completely prepares the student for these kinds of practice problems and test questions.

   It is our repeated experience that these different ways of expressing an idea are crucial for establishing a concept in a student's mind. Many psychology students are more at ease with words than with numbers. In fact, some have a positive fear of all mathematics. Writing the formula in words and providing the lay-language explanation gives them an opportunity to do what they do best.

3. ***A main goal of any introductory statistics course in psychology is to prepare students to read research articles.*** The way a procedure such as a *t* test or an analysis of variance is described in a research article is often quite different from what the student expects after reading standard textbook discussions. Therefore, as we teach a statistical method, we also give examples of how that method is reported in current journal articles. And we don't just leave it there. The practice problems and test bank items also include excerpts from journal articles for the student to explain.

4. ***This text is unusually up-to-date.*** Most introductory statistics textbooks read as if they were written in the 1950s. The basics are still the basics, but statisticians and researchers think far more subtly about those basics now. Today, the basics are undergirded by a new appreciation of issues such as effect size, confidence intervals, power, limitations of significance testing, the accumulation of results through meta-analysis, the critical role of models, the underlying unity of difference and association statistics, the growing prominence of regression and associated methods, and a host of new developments arising from the central role of the computer in statistical analyses. We are much engaged in the latest thinking in statistical theory and application, and this text reflects that engagement. For example, we devote an entire early chapter (*Making Sense of Statistical Significance*) to effect size and power and then return to these topics as we teach each technique. We think students can and should learn about some of this from the start. It makes the field seem dynamic—which it is.

5. ***We capitalize on the students' motivations.*** We do this in two ways. First, our examples emphasize topics or populations that students seem to find most interesting. We begin right away with a real study in which students in their first week of an introductory statistics class rated how much stress they felt they were under. Other examples emphasize clinical, organizational, social, educational, and health psychology, while being sure to include sufficient interesting examples from cognitive, developmental, and behavioral psychology as well as social and cognitive neuroscience to inspire students with the value of those approaches. (Also, our examples continually emphasize the usefulness of statistical methods and ideas as tools in the research process, never allowing students to feel that they are being taught statistical theory just for the sake of it.)

   Second, we have worked to make the text extremely straightforward and systematic in its explanation of basic concepts, so that students can have frequent "aha" experiences. Such experiences bolster self-confidence and motivate further learning. It is quite inspiring to us to see students who had expected the course to be nothing but struggle then suddenly glow from having mastered a concept like negative correlation or the distinction between failing to reject the null hypothesis and supporting the null hypothesis. At the same time, we do not constantly remind them how greatly oversimplified we have made things, as some books do. Instead, we show students, in the controversy sections that there is much for them to consider deeply, even in an introductory course.

6. ***We emphasize statistical methods as a living, growing field of research.*** We take the time to describe ongoing issues in the field, such as the relative merits of both significance testing and confidence intervals, the importance of sample size, or the latest controversies, such as the possibilities for Bayesian methods. In addition, each chapter includes one or more boxes about famous statisticians or interesting sidelights. The goal is for students to see statistical methods as human efforts to make sense out of the jumble of numbers generated by a research study—to see that statistics are not given by nature, not infallible, not perfect descriptions of the events they try to describe, but rather a language that is constantly improving through the careful thought of those who use it. We hope that this orientation will help

them maintain a questioning, alert attitude as students and later as professionals.

7. ***The final chapter looks at advanced procedures.*** Without actually teaching them in detail. It explains in simple terms how to make sense out of these statistics when they are encountered in research articles. A great many psychology research articles today use methods not covered in the preceding chapters of this text because they are fairly advanced and hence rarely covered in intro statistics courses. A few statistics commonly used makes this clear: analysis of covariance, multivariate analysis of variance, multilevel modeling, mediation, factor analysis, and structural equation modeling. To us it is wrong to let students complete introductory statistics so ill equipped to comprehend most of the articles they must read to prepare a paper or study a course topic in further depth. This chapter makes use of the basics that students have just learned (along with extensive excerpts from current research articles) to give a rudimentary understanding of these advanced procedures. This chapter also serves as a reference guide that students can keep and use in the future when reading such articles.

What's New in This Seventh Edition

With each new edition we have worked to improve this text, based on our experience teaching from it and the wonderful input we have received from our fellow instructors using it all over the world. These are some of our latest endeavors.

In this seventh edition, we have continued to focus on simplifying exposition and have done our usual extensive updating of content, examples, boxes, controversies, and other elements. For example, the text includes more than 50 references to research articles and texts that were published since 2020. In addition, we made a host of minor adjustments to make the text more effective. For example, in the chapter *The General Linear Model and Making Sense of Advanced Statistical Procedures in Research Articles*, our examples span a variety of new engaging topics (e.g., whether wanting to spend time alone is necessarily a bad thing among adolescents; how certain resilience resources can contribute to student well-being; and how the music we listen to affects us emotionally), while still being easy to follow. We also updated all of the *Using SPSS* sections using SPSS 27, the latest version available at the time of preparing this new edition.

Our huge loss: As we were just starting this revision, our brilliant collaborator of many years, Elliot Coups, suddenly died of COVID-19. Elliot began collaborating with us 15 years ago, on the fourth edition. We came across him because he had been one of Pearson's reviewers of the previous edition, recruited to help us prepare the new one. He had made not just useful suggestions, but really creative and valuable ones. (For example, the "Tips for Success" sidebars throughout the chapters were his idea.) Elliot was a real pleasure to work with and made valuable contributions to each revision. It is a huge loss.

Our wonderful gain: While we were still grieving the loss of Elliot, we realized we had to search for a new collaborator to help us with this seventh edition. We found Erin Cooley through the recommendation of one of our prior doctoral students, and realized she was a perfect fit for the job. She has been teaching statistics for psychology since she joined Colgate University's faculty in 2016. And, the use of statistics in psychological research was part of what drew her into wanting to be a research psychologist. Even as an undergraduate she found statistics empowering and exciting: statistics provide a crucial tool to address pressing social issues across many different fields of study. And, statistics are not static, they are continuously evolving, often after rigorous debates about best practices. Now, as an Associate Professor, she enjoys trying to spark excitement for statistics in her students and hopes this text will do the same for your students! She also publishes regularly, her focus being on social inequality, and this expertise has brought excellent new examples to this text. In short, she has been the ideal addition to our team. We feel very fortunate to have her.

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- ***Educational videos.*** Produced with authors and key contributors, our large library of assignable product videos helps students visualize complex concepts and, in some cases, solve problems.

WEB CHAPTERS

Four downloadable Web chapters (listed in the text's Table of Contents) are available for this text (at Student Resource Page–*https://media.pearsoncmg.com/cmg/pmmg_mml_shared/mathstatsresources/home/index.html* and also at *www.pearson.com/mylab/statistics* for MyLab Statistics users): (1) the basics of research methods, (2) applying statistics in one's own research projects, (3) repeated measures analysis of variance, and (4) integration of statistical tests and the general linear model (which also serves as an excellent review and overview of the entire text). Over the years, many instructors have asked for these topics, so we chose to make these chapters available in this way without adding more content to the text itself.

INSTRUCTOR'S MANUAL

Prepared by Dr. Suzanne Riela, the *Instructor's Manual* begins with a chapter summarizing what author's have gleaned from thier own teaching experience and the research literature on effectiveness in college teaching. The next chapter discusses alternative organizations of the course, tables of possible schedules and a sample syllabus, advice on structuring exams, an example test, and more. Then each chapter, corresponding to the text chapters, provides full lecture outlines and additional worked-out examples not found in the text. These lecture outlines and worked-out examples are especially useful to new instructors or those using our text for the first time, since structuring lectures and creating good examples is one of the most demanding parts of teaching the course.

TEST BANK

Prepared by Dr. Marie Thomas, the test bank offers approximately 40 multiple-choice, 25 fill-in, and 10 to 12 problem/essay questions for each chapter. The test bank is also available in Pearson's MyTest computerized testing software program. *http://pearsonmytest.com*.

POWERPOINT LECTURE NOTES

Prepared by Dr. Suzanne Riela, East Carolina University, these slides contain the lecture outlines and worked problems, to decrease lecture preparation time and enrich in-class instruction.

Keep in Touch

Our goal is to do whatever we can to help you make your course a success. If you have any questions or suggestions, please send us an email (*arthur.aron@stonybrook.edu* will do for all of us). Also, if you should find an error somewhere, for everyone's benefit, please let us know right away. When errors have come up in the past, we have usually been able to fix them in the very next update.

Acknowledgments

First and foremost, we are grateful to our students through the years, who have shaped our approach to teaching by rewarding us with their appreciation and offering wonderfully helpful suggestions for further improvements. We also deeply appreciate all those instructors who have sent us their ideas and encouragement.

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Arthur Aron

Elaine N. Aron

Erin Cooley

And, in memory of Elliot J. Coups (1973–2020)

Credits

Introduction to the Student

The goal of this text is to help you understand statistics. We emphasize meaning and concepts, not just symbols and numbers.

This emphasis plays to your strengths. Most psychology majors are not lovers of mathematics but are keenly attuned to ideas. And we want to underscore the following, based on our collective many decades of teaching experience: *We have never had a student who could do well in other university courses who could not also do well in this course.* (However, we admit that doing well in this course may require more work than doing well in others.)

In this introduction, we discuss why you are taking this course and how you can gain the most from it.

Why Learn Statistics, Other Than to Fulfill a Requirement?

1. ***Understanding statistics is crucial to being able to read psychology research articles.*** Nearly every course you will take as a psychology major will emphasize the results of research studies, and these almost always are expressed using statistics. If you do not understand the basic logic of statistics—if you cannot make sense of the jargon, the tables, and the graphs that are at the heart of any research report—your reading of research will be very superficial. (We also recommend that you take a course on how to design and evaluate good research. In this text, we focus on the statistical methods for making sense of the data collected through research. However, we have included a brief downloadable Web chapter on research methods—available at Student Resource Page–*https://media.pearsoncmg.com/cmg/pmmg_mml_shared/mathstatsresources/home/index.html* (and also at *www.pearson.com/mylab/statistics* for MyLab Statistics users)—that provides an overview of the logic and language of psychology research.)
2. ***Understanding statistics is crucial to doing research yourself.*** Many psychology majors eventually decide to go on to graduate school. Graduate study in psychology—even in clinical and counseling psychology and other applied areas—almost always involves *doing* research. In fact, learning to do research on your own is often the main focus of graduate school, and doing research almost always involves statistics. This course gives you a solid foundation in the statistics you need for doing research. Further, by mastering the basic logic and ways of thinking about statistics, you will be unusually well prepared for the advanced statistics courses almost always required in graduate school, which focus on the nitty gritty of analyzing research results.

   Many psychology programs also offer opportunities for undergraduates to do research. The main focus of this text is understanding statistics, not using statistics. Still, you will learn the basics you need to analyze the results of the kinds of research you are likely to do. Also, we have included a downloadable Web chapter—available at Student Resource Page–*https://media.pearsoncmg.com/cmg/pmmg_mml_shared/mathstatsresources/home/index.html* (and also at *www.pearson.com/mylab/statistics* for MyLab Statistics users)—that helps you with practical issues in using what you learn in this text for analyzing results of your own research.
3. ***Understanding statistics develops your analytic and critical thinking.*** Psychology majors are often most interested in people and in improving things in the practical world. This does not mean that you avoid abstractions. In fact, the students we know are exhilarated most by the almost philosophical levels of abstraction where the secrets of human experience so often seem to hide. Yet even this kind of abstraction often is grasped only superficially at first, as slogans instead of useful knowledge. Of all the courses you are likely to take in psychology, this one will probably do the most to help you learn to think more precisely, to evaluate information, and to apply logical analysis when reading psychology research articles. Moreover, you will find that these skills will also help you to evaluate media reports of psychology research, which are becoming increasingly common across all types of digital and print media. We hope you will also discover that this course provides the ideal foundation for successfully tackling more advanced statistics (as well as research methods) courses in psychology and a host of other fields, spanning the behavioral, social, political, and biomedical sciences.

How to Gain the Most from This Course

There are five things we can advise:

1. ***Keep your attention on the concepts.*** Treat this course less like a math course and more like a course in logic. When you read a section of a chapter, your attention should be on grasping the principles. When working

the exercises, think about why you are doing each step. If you simply try to memorize how to come up with the right numbers, you will have learned very little of use in your future studies—nor will you do very well on the exams in this course.

2. ***Be sure you know each concept before you go on to the next.*** Statistics is cumulative. Each new concept is built on the last one. There are short "How are you doing?" self-tests at the end of each main chapter section. Be sure you do them. You may also find it helpful to review the "How are you doing?" sections before working on the practice problems and when studying for exams. If you are having trouble answering a question at any time—or even if you can answer it but aren't sure you really understand it—stop. Reread the section, rethink it, ask for help. Do whatever you need to do to grasp it. Don't go on to the next section until you are completely confident you have gotten this one. If you are not sure, and you've already done the "How are you doing?" questions, take a look at the *Example Worked-Out Problems* toward the end of the chapter, or try working a practice problem on this material from the end of the chapter. The answers to the Set I Practice Problems are given toward the end of the text so that you will be able to check your work. Also, if your instructor has made it available for your course, be sure to take full advantage of the extensive resources available as part of the MyLab Statistics Web site for the text (*www.pearson.com/mylab/statistics*). We think you will especially like the interactive tutorial exercises and video walkthroughs of key concepts (for more information, see page xi).

   Having to read the material in this text over and over does not mean that you are stupid. Most students have to read each chapter several times. And each reading in statistics is usually much slower than that in other textbooks. Statistics reading has to be pored over with clear, calm attention for it to sink in. Allow plenty of time for this kind of reading and rereading.

3. ***Keep up.*** Again, statistics is cumulative. If you fall behind in your reading or miss lectures, the lectures you do attend will be almost meaningless. It will get harder and harder to catch up.

4. ***Study especially intensely in the first half of the course.*** It is particularly important to master the material thoroughly at the start of the course. Everything else you learn in statistics is built on what you learn at the start. Yet the beginning of the semester is often when students study least.

   If you have mastered the first half of the course—not just learned the general idea, but really know it—the second half will be substantially easier. If you have not mastered the first half, the second half will be close to impossible.

5. ***Help each other.*** There is no better way to solidify and deepen your understanding of statistics than to try to explain it to someone who is having a harder time (which is almost always due to having less exposure to the material in past courses). Of course, this explaining has to be done with patience and respect. For those of you who are having a harder time, first remind yourself that this is perfectly normal. Many times, those who find that the material comes easily have simply had more experience learning similar topics in the past. There is no better way to work through the difficult parts than by learning from another student who has just worked through, and mastered the same material.

   Thus, we strongly urge you to form study groups with one to three other students. It is best if your group includes some who expect to have more familiarity with the topics and some who don't. Those who learn statistics easily will get the most from helping others who struggle with it—the latter will tax the former's supposed understanding enormously. Those who fear trouble ahead need to work with those who do not. Pick group members who live near you so that it is easy for you to get together. Also, meet often—between each class, if possible.

A Final Note

Believe it or not, we love teaching statistics. Time and again, we have had the wonderful experience of having beaming students come to us to say, "Professor, I got a 90% on this exam. I can't believe it! Me, a 90 on a statistics exam!" Or the student who tells us, "This is actually fun. Don't tell anyone, but I'm actually enjoying . . . statistics, of all things!" We hope you will have these kinds of experiences in this course.

Arthur Aron

Elaine N. Aron

Erin Cooley

And, in memory of Elliot J. Coups (1973–2020)

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Chapter 1

Displaying the Order in a Group of Numbers Using Tables and Graphs

Learning Objectives

1-1 Understand and differentiate between descriptive and inferential statistics

1-2 Define basic statistical concepts

1-3 Display and clarify data using frequency tables

1-4 Create histograms and bar graphs from frequency tables

1-5 Identify the shape of a distribution of data

1-6 Consider the importance of how we measure variables

1-7 Understanding tables and graphs of frequency distributions in research articles

Welcome to *Statistics for Psychology*. We imagine you to be like other students we have known who have taken this course. You have chosen to major in psychology or a related field because you are fascinated by people: Fascinated by their visible behaviors and less visible inner lives, as well as perhaps by your own psychology. Some of you are highly scientific sorts; others are more intuitive. Some of you are fond of math; others are less so. Whatever your style, we welcome you. We want to assure you that if you give this text some special attention, you will learn statistics. The approach used in this text has successfully taught all sorts of students before you, including those who had taken statistics previously and done poorly. With this text and your instructor's help, you will learn statistics and learn it well.

More importantly, we want to assure you that whatever your reason for studying psychology or a related field, this course is not a waste of time. Learning about statistics helps you to read the work of other psychologists, to do your own research if you so choose, and to hone both your reasoning and intuition. It also helps you to evaluate reports of scientific research in the media. Statistics really can make an important contribution to the next phase of your life.

Formally, **statistics** is a branch of mathematics that focuses on the organization, analysis, and interpretation of a group of numbers. But really what is statistics? Think of statistics as a tool that has evolved from a basic thinking process employed by every human: You observe a thing; you wonder what it means or what caused it; you have an insight or make an intuitive guess; you observe again, but now in detail, or you try making little changes in the process to test your intuition. Then you face the eternal problem: Was your hunch confirmed or not? What are the chances that what you observed this second time will happen again and again, so that you can announce your insight to the world as something probably true?

statistics
branch of mathematics that focuses on the organization, analysis, and interpretation of a group of numbers.

In other words, statistics is a method of pursuing truth. At a minimum, statistics can tell you the likelihood that your hunch is true in this time and place and with these sorts of people. This type of pursuit of truth, especially in the form of an event's future likelihood, is the essence of psychology, of science, and of human evolution. Think of the first research questions: What will the mammoths do next spring? What will happen if I eat this root? It is easy to see how the early accurate researchers survived. You are here today because your ancestors exercised brains as well as brawn. Do those who come after you the same favor: Think carefully about outcomes. Statistics is one good way to do that.

Tip for Success The issue of how to design good research is a topic in itself, summarized in the Website chapter "*Overview of the Logic and Language of Psychology Research*" available at *https://media.pearsoncmg.com/cmg/pmmg_mml_shared/mathstatsresources/home/index.html* (and also at *www.pearson.com/mylab/statistics* for MyLab Statistics users). Research design affects which type of statistical procedures are appropriate and influences the types of conclusions we can make with our data. So, as you begin to gain an understanding of statistical methods—the focus of this text—keep an eye on the research design that underlies data collection.

Psychologists use statistical methods to help them make sense of the numbers they collect when conducting research. Psychologists usually use statistical software to carry out statistical procedures such as the ones you will learn in this text. However, the best way to develop a solid understanding of statistics is actually to do the procedures by hand for a while (with the help of a calculator—it's not the multiplying and adding that you learn from, but the going through all the steps). To minimize the amount of mindless figuring you have to do, we use relatively small groups of simple numbers in each chapter's examples and practice problems. All of this allows you to focus on the *underlying principles and logic* of the statistical procedures as you manipulate the numbers. (See the *Introduction to the Student* on pp. xiv–xv for more information on the goals of this text.) Having said that, we also recognize the importance for many of you of learning how to do statistical procedures on a computer so that, for example, you can conduct your own research, maybe starting with a senior project. Therefore, at the end of relevant chapters there is a section called Using SPSS. SPSS statistical software is commonly used by psychologists and other behavioral and social scientists to carry out statistical analyses. Check with your instructor to see if you have access to SPSS at your institution. (There are also a number of other statistical programs used by researchers, such as "R," Stata, and SAS; and many basic statistical procedures can be carried out using standard spreadsheet programs such as Excel. For those of you not using SPSS, the SPSS sections will still be helpful in giving you the general idea of how one does such problems on a computer.)

1.1 The Two Branches of Statistical Methods

1-1 Understand and differentiate between descriptive and inferential statistics

There are two main branches of statistical methods.

descriptive statistics procedures for summarizing a group of numbers or otherwise making them more understandable.

inferential statistics procedures for drawing conclusions based on the numbers collected in a research study but going beyond them.

1. **Descriptive statistics:** Psychologists use descriptive statistics to summarize and describe a group of numbers from a research study.
2. **Inferential statistics:** Psychologists use inferential statistics to draw conclusions and to make inferences that are based on the numbers from a research study but that go beyond the numbers that were actually observed. For example, inferential statistics allow researchers to make inferences about a large group of individuals based on a research study in which a much smaller number of individuals took part.

In this chapter and the next, we focus on descriptive statistics. This topic is important in its own right, but it also prepares you to understand inferential statistics. Inferential statistics are the focus of the remainder of this text.

In this chapter, we introduce you to some basic concepts, and then you will learn to use tables and graphs to describe a group of numbers. The purpose of descriptive statistics is to make a group of numbers easy to understand. As you will see, tables and graphs help a great deal.

1.2 Some Basic Concepts

1–2 Define basic statistical concepts

1.2.1 Variables, Values, and Scores

One of the authors (AA) gave a questionnaire to students in one of his large introductory statistics classes. This questionnaire was distributed during the first week of the course as part of a larger study on another topic, in which he was able to include the question, "How stressed have you been in the last 2½ weeks, on a scale of 0 to 10, with 0 being *not at all stressed* and 10 being *as stressed as possible?*" (How would you answer?) In this study, we used a survey to look at students' level of stress. Other methods that researchers use to study stress include creating stress with laboratory tasks (such as having to be videotaped giving a talk for humans or swimming in water for rats) and measuring stress-related hormones or brain changes.

In this example, level of stress is a **variable**, which can have **values** from 0 to 10, and the value of any particular person's answer is the person's **score**. If you answered 6, your score is 6; your score has a value of 6 on the variable called "level of stress."

variable
characteristic that can have different values.

values
possible number or category that a score can have.

score
particular person's value on a variable.

More formally, a variable is a condition or characteristic that can have different values. In short, it can vary. In our example, the variable was level of stress, which can have the values of 0 through 10. Height is a variable, social class is a variable, score on a creativity test is a variable, type of psychotherapy received by patients is a variable, speed on a reaction time test is a variable, number of people absent from work on a given day is a variable, and so forth.

A value is just a number, such as 4, –81, or 367.12. A value can also be a category, such as psychology versus another major, or a psychiatric diagnosis—major depression, post-traumatic stress disorder—and so forth.

Finally, on any variable, each person studied has a particular number or score—that is his or her value on the variable. As we've said, your score on the stress variable might have a value of 6. Another student's score might have a value of 8.

Psychology research is about variables, values, and scores (see Table 1–1). The formal definitions are a bit abstract, but in practice, the meaning is usually clear.

Table 1–1 Some Basic Terminology

Term	Definition	Examples
Variable	Condition or characteristic that can have different values	Stress level; age; sex; religion
Value	Number or category	0, 1, 2, 3, 4; 25, 85; female; Catholic
Score	A particular person's value on a variable	0, 1, 2, 3, 4; 25, 85; female; Catholic

1.2.2 Levels of Measurement (Kinds of Variables)

Most of the variables psychologists use are like those in the stress ratings example: The scores are numbers that tell you how much there is of what is being measured. In the stress ratings example, the higher the number is, the more stress there is. This is an example of a **numeric variable**. Numeric variables are also called *quantitative variables*.

numeric variable
variable whose values are numbers (as opposed to a nominal variable). Also called *quantitative variable*.

There are several kinds of numeric variables. In psychology research the most important distinction is between two types: Equal-interval variables and rank-order variables. An **equal-interval variable** is a variable in which the numbers stand for approximately equal amounts of what is being measured. For example, grade point average (GPA) is a roughly equal-interval variable, since the difference between a GPA of 2.5 and 2.8 means about as much as the

equal-interval variable
variable in which the differences between adjacent numbers stand for approximately equal amounts of what is being measured.

difference between a GPA of 3.0 and 3.3 (each is a difference of 0.3 of a GPA). Most psychologists also consider scales like the 0-to-10 stress ratings as roughly equal interval. So, for example, a difference between stress ratings of 4 and 6 means about as much as the difference between 7 and 9.

rank-order variable numeric variable in which the values are ranks, such as class standing or place finished in a race. Also called *ordinal variable*.

The other main type of numeric variable, a **rank-order variable**, is a variable in which the numbers stand only for relative ranking. (Rank-order variables are also called *ordinal variables*.) A student's standing in his or her graduating class is an example. The amount of difference in underlying GPA between being second and third in class standing could be very unlike the amount of difference between being eighth and ninth.

A rank-order variable provides less information than an equal-interval variable. That is, the difference from one rank to the next doesn't tell you the exact difference in amount of what is being measured. However, psychologists often use rank-order variables because they are the only information available. Also, when people are being asked to rate something, it is sometimes easier and less arbitrary for them to make rank-order ratings. For example, when rating how much you like each of your friends, it may be easier to rank them by how much you like them than to rate your liking for each of them on a scale. Yet another reason researchers often use rank-order variables is that asking people to do rankings forces them to make distinctions. For example, if asked to rate how much you like each of your friends on a 1-to-10 scale, you might rate several of them at exactly the same level, but ranking would avoid such ties.

nominal variable variable with values that are categories (that is, they are names rather than numbers). Also called *categorical variable*.

Another major type of variable used in psychology research, which is not a numeric variable at all, is a **nominal variable** in which the values are names or categories. The term *nominal* comes from the idea that its values are names. (Nominal variables are also called *categorical variables* because their values are categories.) For example, for the nominal variable psychiatric diagnosis, the values could include major depression, post-traumatic stress disorder, schizophrenia, and obsessive-compulsive disorder. A person's score on this variable could have one of these four values (among others). Another example is gender, which has values such as man and women (see the Controversy section later for a relevant discussion).

levels of measurement types of underlying numerical information provided by a measure, such as equal-interval, rank-order, and nominal (categorical).

These different kinds of variables represent different **levels of measurement** (see Table 1–2). Researchers sometimes have to decide how they will measure a particular variable. For example, they might use an equal-interval scale, a rank-order scale, or a nominal scale. The level of measurement selected affects the type of statistics that can be used with a variable. Suppose a researcher is studying the effects of a particular type of brain injury on being able to recognize objects. One approach the researcher might take would be to measure the number of different objects an injured person can observe at once. This is an example of an equal-interval level of measurement. Alternately, the researcher might rate people as able to observe no objects (rated 0), only one object at a time (rated 1), one object with a vague sense of other objects (rated 2), or ordinary vision (rated 3). This would be a rank-order approach. Finally, the researcher might divide people into those who can identify the location of an object but not what the object is (rated L), those who can identify what the object is but not locate it in space (rated I), those who can both locate and identify an object but have other abnormalities of object perception (rated O), those who are completely blind (rated B), and those with normal visual perception (rated N). This is a nominal level of measurement.

In this text, as in most psychology research, we focus mainly on numeric, equal-interval variables (or variables that roughly approximate equal-interval variables). We discuss statistical methods for working with nominal variables in the chapter *Chi-Square Tests* and methods for working with rank-order variables in the chapter *Strategies When Population Distributions Are Not Normal*.

Table 1–2 Levels of Measurement

Level	Definition	Example
Equal-interval	Numeric variable in which differences between values correspond to differences in the underlying thing being measured	Stress level; age
Rank-order	Numeric variable in which values correspond to the relative position of things measured	Class standing; position finished in a race
Nominal	Variable in which the values are categories	Sex; religion

Another distinction that researchers sometimes make is between discrete variables and continuous variables. A **discrete variable** is one that has specific values and cannot have values between the specific values. For example, the number of times you went to the dentist in the last 12 months is a discrete variable. You may have gone 0, 1, 2, 3, or more times, but you can't have gone 1.72 times or 2.34 times. Nominal variables, such as religious affiliation and college major, can also be considered to be discrete variables. With a **continuous variable**, there are, in theory, an infinite number of values between any two values. So, even though we usually answer the question "How old are you?" with a specific age, such as 19 or 20, you could also answer it by saying that you are 19.26 years old. Height, weight, and time are examples of other continuous variables.

discrete variable variable that has specific values and that cannot have values between these specific values.

continuous variable variable for which, in theory, there are an infinite number of values between any two values.

1-1 How are you doing?

1. A child rates their parent as a 2 on a 7-point scale (from 1 to 7) of crankiness. In this example, (a) what is the variable, (b) what is the score, and (c) what is the range of values?
2. What is the difference between a numeric and a nominal variable?
3. Give the level of measurement of each of the following variables: (a) a person's nationality (Mexican, Chinese, Ethiopian, Australian, etc.), (b) a person's score on a standard IQ test, (c) a person's place on a waiting list (first in line, second in line, etc.).
4. What is the difference between a discrete and a continuous variable?

BOX 1–1 Important Trivia for Poetic Statistics Students

The word *statistics* comes from the Italian word *statista*, a person dealing with affairs of state (from *stato*, "state"). It was originally called *state arithmetic*, involving the tabulation of information about nations, especially for the purpose of taxation and planning the feasibility of wars.

Statistics were needed in ancient times to figure the odds of shipwrecks and piracy for marine insurance that would encourage voyages of commerce and exploration to far-flung places. The modern study of mortality rates and life insurance descended from the 17th-century plague pits—counting the bodies of persons cut down in the bloom of youth. The theory of errors (see the chapter *Prediction*) began in astronomy, that is, with stargazing; the theory of correlation (see the chapter *Correlation*) has its roots in biology, from the observation of parent and child differences. Probability theory (see the chapter *Some Key Ingredients for Inferential Statistics*) arose in the tense environs of the gambling table. The theory of analysis of experiments (see the chapter *Introduction to t Tests*) began in breweries and out among waving fields of wheat, where correct guesses determined not only the survival of a tasty beer but of thousands of marginal farmers. Theories of measurement and factor analysis (see the chapter *The General Linear Model and Making Sense of Advanced Statistical Procedures in Research Articles*) derived from personality psychology, where the depths of human character were first explored with numbers. And chi-square (see the chapter *Chi-Square Tests*) came to us from sociology, where it was often a question of class.

In the early days of statistics, it was popular to use the new methods to try to prove the existence of God. For example, John Arbuthnot discovered that more male than female babies were born in London between 1629 and 1710. In what is considered the first use of a statistical test, he demonstrated that the male birthrate was higher than could be expected by chance (assuming that 50:50 was chance) and concluded that there was a plan operating, since males face more danger to obtain food for their families, and only God, he said, could do such planning.

In 1767, John Michell also used probability theory to try to prove the existence of God when he argued that the odds were 500,000 to 1 against six stars being placed as close together as those in the constellation Pleiades; so their placement had to have been a deliberate act of the Creator.

Statistics in the state arithmetic sense are legally endorsed by most governments today. For example, the first article of the U.S. Constitution requires a census. And statistics helped the United States win the Revolutionary War. John Adams obtained critical aid from Holland by pointing out certain vital statistics, carefully gathered by the clergy in local parishes, demonstrating that the colonies had doubled their population every 18 years, adding 20,000 fighting men per annum. "Is this the case of our enemy, Great Britain?" Adams wrote. "Which then can maintain the war the longest?"

Similar statistics were observed by U.S. President Thomas Jefferson in 1786. He wrote that his people "become uneasy" when there are more of them than 10 per square mile and that given the population growth of the new country, within 40 years these restless souls would fill up all of their country's "vacant land." Some 17 years later, Jefferson doubled the size of the United States' "vacant" land through the Louisiana Purchase.

SOURCE: Charles Francis Adams (1850) The works of John Adams, second President of the United States: with a life of the author, notes and illustrations. Boston: Little, Brown and Company.

1.3 Frequency Tables

1–3 Display and clarify data using frequency tables

1.3.1 An Example

Let's return to the stress ratings example. Recall that in this study, students in an introductory statistics class during the first week of the course answered the question, "How stressed have you been in the last 2½ weeks, on a scale of 0 to 10, with 0 being *not at all stressed* and 10 being *as stressed as possible?*" The actual study included scores from 151 students. To ease the learning for this example, we are going to use a representative subset of scores from 30 of the 151 students (this also saves you time if you want to try it for yourself). The 30 students' scores (their ratings on the scale) are:

8, 7, 4, 10, 8, 6, 8, 9, 9, 7, 3, 7, 6, 5, 0, 9, 10, 7, 7, 3, 6, 7, 5, 2, 1, 6, 7, 10, 8, 8.

Looking through all these scores gives some sense of the overall tendencies, but this is hardly an accurate method. One solution is to make a table showing how many students used each of the 11 values that the ratings can have (0, 1, 2, and so on, through 10). That is, the number of students who used each particular rating is the frequency of that value. We have done this in Table 1–3. We also figured the percentage that each value's frequency is of the total number of scores. Tables like this sometimes give only the raw-number frequencies, not the percentages, or only the percentages and not the raw-number frequencies.

In addition, some frequency tables include, for each value, the total number of scores with that value and all values preceding it. These are called *cumulative frequencies* because they tell how many scores are accumulated up to this point on the table. If percentages are used, cumulative percentages also may be included (e.g., see Figure 1–18 in the Using SPSS section on p. 27). Cumulative percentages give, for each value, the percentage of scores up to and including that value. The cumulative percentage for any given value (or for a score having that value) is also called a *percentile*. Cumulative frequencies and cumulative percentages allow you to see where a particular score falls in the overall group of scores.

frequency table ordered listing of number of individuals having each of the different values for a particular variable.

Table 1–3 is called a **frequency table** because it shows how frequently (how many times) each score was used. A frequency table makes the pattern of numbers easy to see. In this example, you can see that most of the students rated their stress level around 7 or 8, with few rating it very low.

1.3.2 How to Make a Frequency Table

There are four steps in making a frequency table.

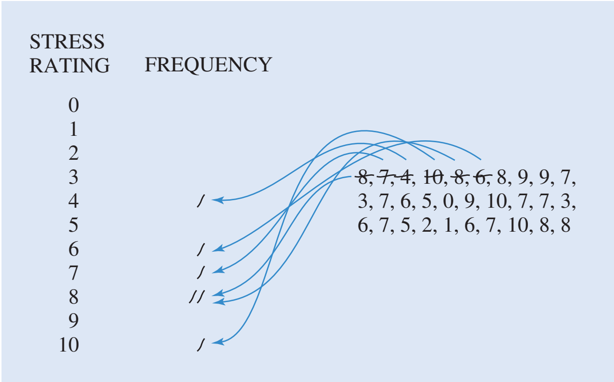
❶ **Make a list down the page of each possible value, from lowest to highest.** In the stress ratings results, the list goes from 0, the lowest possible rating, up to 10, the highest possible

Table 1–3 Frequency Table of Number of Students Rating Each Value of the Stress Scale

Stress Rating	Frequency	Percent
0	1	3.3
1	1	3.3
2	1	3.3
3	2	6.7
4	1	3.3
5	2	6.7
6	4	13.3
7	7	23.3
8	5	16.7
9	3	10.0
10	3	10.0

SOURCE: Aron, A., Paris, M., & Aron, E. N. (1995). Falling in love: Prospective studies of self-concept change. *Journal of Personality and Social Psychology*, 69, 1102–1112.

Figure 1–1 Making a frequency table for the stress ratings scores.



SOURCE: Aron, A., Paris, M., & Aron, E. N. (1995). Falling in love: Prospective studies of self-concept change. *Journal of Personality and Social Psychology*, 69, 1102–1112.

rating.[1] Note that even if one of the ratings between 0 and 10 is not used, you still include that value in the listing, showing it as having a frequency of 0. For example, if no one had given a stress rating of 2, you would still include 2 as one of the values on the frequency table.

❷ **Go one by one through the scores, making a mark for each next to its value on your list.** This is shown in Figure 1–1.

❸ **Make a table showing how many times each value on your list is used.** That is, add up the number of marks beside each value.

❹ **Figure the percentage of scores for each value.** To do this, take the frequency for that value, divide it by the total number of scores, and multiply by 100. You may need to round off the percentage. We recommend that you round percentages to one decimal place. Note that because of the rounding, your percentages do not usually add up to exactly 100% (but the total should be very close to 100%).

Tip for Success When doing Step ❷, cross off each score as you mark it on the list. This should help you avoid mistakes, which are common in this step.

1.3.3 Frequency Tables for Nominal Variables

The preceding steps assume you are using numeric variables, the most common situation. However, you can also use a frequency table to show the number of scores for each value (that is, for each category) of a nominal variable. For example, researchers (Aron, Aron, & Smollan, 1992) asked 208 students to name the closest person in their life. As shown in Table 1–4, 33 students selected a family member, 76 a nonromantic friend, 92 a romantic partner, and 7 selected some other person. Also in Table 1–4, the values listed on the left hand side of the frequency table are the values (the categories) of the variable. [Note: Similar frequencies among university students have been found in more recent studies on this topic (for a review, see Gächter, Starmer, & Tufano, 2015).]

Table 1–4 Frequency Table for a Nominal Variable: Closest Person in Life for 208 Students

Closest Person	Frequency	Percent
Family member	33	15.9
Nonromantic friend	76	36.5
Romantic partner	92	44.2
Other	7	3.4

SOURCE: Data from Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of Other in the Self Scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, 63, 596–612.

1.3.4 Another Example

Boykin and his colleagues (2021) had 94 introductory psychology students keep a diary of their social interactions for a week during the regular semester. Each time a participant had a social interaction lasting 10 minutes or longer, they would fill out a card. The card had questions about various aspects of the conversation and the conversation partner. Excluding family and work situations, the number of social interactions 10 minutes or longer over a week for these students were as follows:

48, 15, 33, 3, 21, 19, 17, 16, 44, 25, 30, 3, 5, 9, 35, 32, 26, 13, 14, 14, 47, 47, 18, 11, 5, 19, 24, 17, 6, 25, 8, 18, 29, 1, 18, 22, 3, 22, 29, 2, 6, 10, 29, 10, 29, 21, 38, 41, 16, 17, 8, 40, 8, 10, 18, 7, 4, 4, 8, 11, 3, 23, 10, 19, 21, 13, 12, 10, 4, 17, 11, 21, 9, 8, 7, 5, 3, 22, 14, 25, 4, 11, 10, 18, 1, 28, 27, 19, 24, 35, 9, 30, 8, 26.

Now, let's follow our four steps for making a frequency table.

1. **Make a list down the page of each possible value, from lowest to highest.** The lowest possible number of interactions is 0. In this study, the highest number of interactions could be any number. However, the highest actual number in this group is 48; so we can use 48 as the highest value. Thus, the first step is to list these values down a page. (It might be good to use several columns so that you can have all the scores on a single page.)
2. **Go one by one through the scores, making a mark for each next to its value on your list.** Figure 1–2 shows the results of this step.
3. **Make a table showing how many times each value on your list is used.** Table 1–5 is the result.
4. **Figure the percentage of scores for each value.** We have *not* done so in this example because it would not help much for seeing the pattern of scores. However, if you want to check your understanding of this step, the first five percentages would be 0.0%, 2.1%, 1.1%, 5.3%, and 4.3%. (These are the percentages for frequencies of 0, 2, 1, 5, and 4, rounded to one decimal place.)

1.3.5 Grouped Frequency Tables

Sometimes there are so many possible values that an ordinary frequency table is too awkward to give a simple picture of the scores. The last example was a bit like that, wasn't it? The solution is to make groupings of values that include all values in a certain range. Consider the stress ratings example (revisit Table 1–3 for these data). Instead of having a separate frequency figure for the group of students who rated their stress as 8 and another for those who rated it as 9, you could

Figure 1–2 Making a frequency table of students' social interactions over a week.

0 -	17 - ////	34 -
1 - //	18 - 𝍸	35 - //
2 - /	19 - ////	36 -
3 - 𝍸	20 -	37 -
4 - ////	21 - ////	38 - /
5 - ///	22 - ///	39 -
6 - //	23 - /	40 - /
7 - //	24 - //	41 - /
8 - 𝍸 /	25 - ///	42 -
9 - ///	26 - //	43 -
10 - 𝍸 /	27 - /	44 - /
11 - ////	28 - /	45 -
12 - /	29 - ////	46 -
13 - //	30 - //	47 - //
14 - ///	31 -	48 - /
15 - /	32 - /	
16 - //	33 - /	

SOURCE: Data from Boykin, C. M., et. al. (in prep) Social interactions and intergroup prejudice: Quantity versus quality. Paper presented at the Annual Meeting of the Society for Personality and Social Psychology, San Antonio, TX.

Table 1–5 Frequency Table for Number of Social Interactions During a Week for 94 University Students

Score	Frequency	Score	Frequency	Score	Frequency
0	0	17	4	34	0
1	2	18	5	35	2
2	1	19	4	36	0
3	5	20	0	37	0
4	4	21	4	38	1
5	3	22	3	39	0
6	2	23	1	40	1
7	2	24	2	41	1
8	6	25	3	42	0
9	3	26	2	43	0
10	6	27	1	44	1
11	4	28	1	45	0
12	1	29	4	46	0
13	2	30	2	47	2
14	3	31	0	48	1
15	1	32	1		
16	2	33	1		

SOURCE: Data from Boykin, C. M., et. al. (in prep) Social interactions and intergroup prejudice: Quantity versus quality. Paper presented at the Annual Meeting of the Society for Personality and Social Psychology, San Antonio, TX.

have a combined category of 8 and 9. This combined category is a range of values that includes these two values. A combined category like this is called an **interval**. This particular interval of 8 and 9 has a frequency of 8 (the 5 scores with a value of 8 plus the 3 scores with a value of 9, as seen in Table 1–3).

interval range of values in a grouped frequency table that are grouped together (e.g., if the interval size is 10, one of the intervals might be from 10 to 19.)

Tip for Success Be sure to check your work by adding the frequencies for all of the scores. This sum should equal the total number of scores you started with.

A frequency table that uses intervals is called a **grouped frequency table**. Table 1–6 is a grouped frequency table for the stress ratings example. (Note that in this example the full frequency table has only 11 different values. Thus, a grouped frequency table is not really necessary.) Table 1–7 is a grouped frequency table for the 94 students' number of social interactions over a week.

grouped frequency table frequency table in which the number of individuals (frequency) is given for each interval of values.

A grouped frequency table can make information even more directly understandable than an ordinary frequency table can. Of course, the greater understandability of a grouped frequency table is at a cost. You lose some information: The details of the breakdown of frequencies in each interval.

Table 1–6 Grouped Frequency Table for Stress Ratings

Stress Rating Interval	Frequency	Percent
0–1	2	6.7
2–3	3	10.0
4–5	3	10.0
6–7	11	36.7
8–9	8	26.7
10–11	3	10.0

SOURCE: Aron, A., Paris, M., & Aron, E. N. (1995). Falling in love: Prospective studies of self-concept change. *Journal of Personality and Social Psychology,* 69, 1102–1112.

Table 1–7 Grouped Frequency Table for Numbers of Social Interactions During a Week for 94 University Students

Interval	Frequency	Percent
0–4	12	12.8
5–9	16	17.0
10–14	16	17.0
15–19	16	17.0
20–24	10	10.6
25–29	11	11.7
30–34	4	4.3
35–39	3	3.2
40–44	3	3.2
45–49	3	3.2

SOURCE: Data from Boykin, C. M., et. al. (in prep) Social interactions and intergroup prejudice: Quantity versus quality. Paper presented at the Annual Meeting of the Society for Personality and Social Psychology, San Antonio, TX.

When you are setting up a grouped frequency table, it makes a big difference how many intervals you use. There are guidelines to help researchers with this, but in practice it is done automatically by the researcher's computer (see this chapter's Using SPSS section for instructions on how to create frequency tables using statistical software). Thus, we will not focus on it in this text. However, should you have to make a grouped frequency table on your own, the key is to experiment with the interval size until you come up with one that is a round number (such as 2, 3, 5, or 10) and that creates about 5 to 15 intervals. Then, when actually setting up the table, be sure you set the start of each interval to a multiple of the interval size and the top end of each interval to the number just below the start of the next interval. For example, Table 1–6 uses six intervals with an interval size of 2. The intervals are 0–1, 2–3, 4–5, 6–7, 8–9, and 10–11. Note that each interval starts with a multiple of 2 (0, 2, 4, 6, 8, 10) and the top end of each interval (1, 3, 5, 7, 9) is the number just below the start of the next interval (2, 4, 6, 8, 10). Table 1–7 uses 10 intervals with an interval size of 5. The intervals are 0–4, 5–9, 10–14, 15–19, and so on, with a final interval of 45–49. Note that each interval starts with a multiple of 5 (0, 5, 10, 15, and so on) and that the top end of each interval (4, 9, 14, 19, and so on) is the number just below the start of the next interval (5, 10, 15, 20, and so on).

1–2 How are you doing?

1. What is a frequency table?
2. Why would a researcher want to make a frequency table?
3. Make a frequency table for the following scores: 5, 7, 4, 5, 6, 5, 4.
4. What does a grouped frequency table group?
5. Why wouldn't it be appropriate to talk about cumulative frequencies for nominal variables?

1.4 Histograms and Bar Graphs

1–4 Create histograms and bar graphs from frequency tables

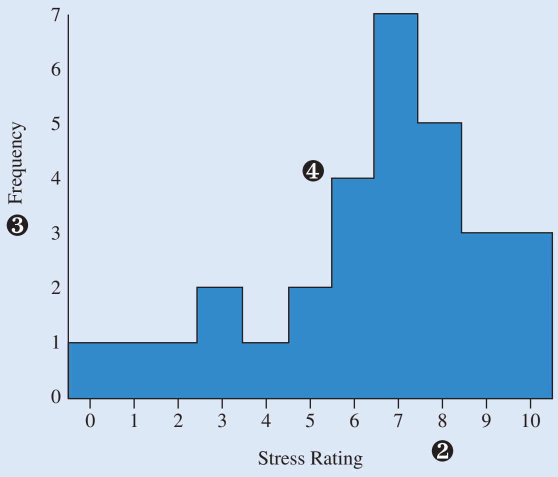
A graph is another good way to make a large group of scores easy to understand. A picture may be worth a thousand words, but it is also sometimes worth a thousand numbers. A straightforward approach is to make a graph of the frequency table. One kind of

Figure 1–3 Histograms based on (a) frequency table and (b) a grouped frequency for the stress ratings example.

(a) Frequency Table

❶

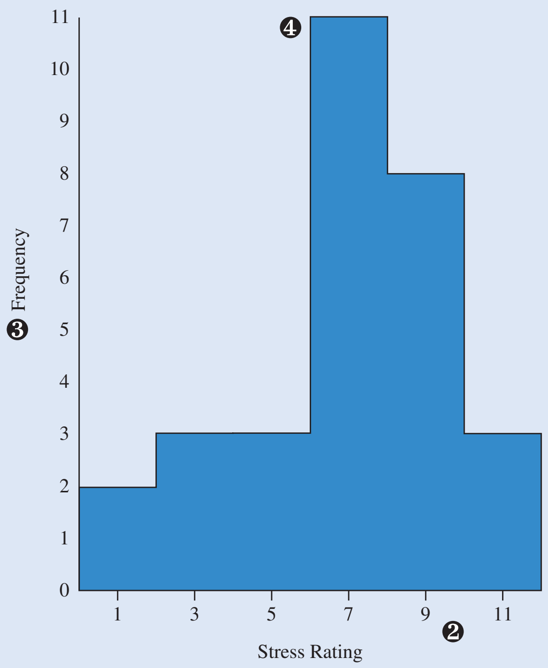
STRESS RATING	FREQUENCY
0	1
1	1
2	1
3	2
4	1
5	2
6	4
7	7
8	5
9	3
10	3



(b) Grouped Frequency Table

❶

STRESS RATING INTERVAL	FREQUENCY
0–1	2
2–3	3
4–5	3
6–7	11
8–9	8
10–11	3



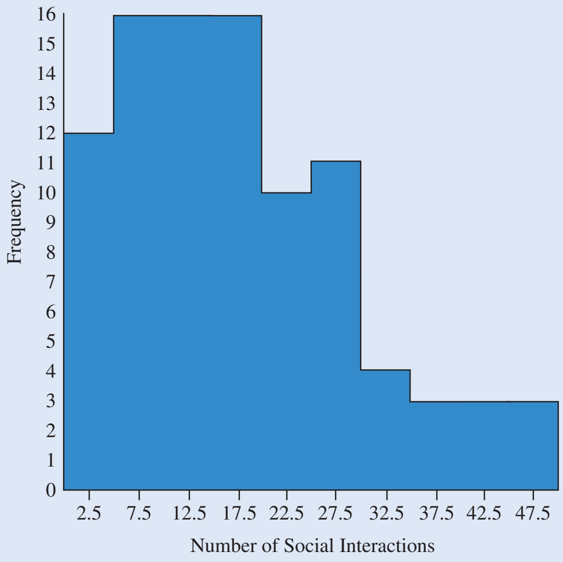
SOURCE: Aron, A., Paris, M., & Aron, E. N. (1995). Falling in love: Prospective studies of self-concept change. *Journal of Personality and Social Psychology*, 69, 1102–1112.

graph of the information in a frequency table is a kind of bar chart called a **histogram**. In a histogram, the height of each bar is the frequency of each value in the frequency table. Ordinarily, in a histogram, all the bars are put next to each other with no space in between. The result is that a histogram looks a bit like a city skyline. Figure 1–3 shows two histograms based on the stress ratings example (one based on the ordinary frequency table and one based on the grouped frequency table). Figure 1–4 shows a histogram based on the grouped frequency table for the example of the numbers of students' social interactions in a week.

histogram
barlike graph of a frequency distribution in which the values are plotted along the horizontal axis and the height of each bar is the frequency of that value; the bars are usually placed next to each other without spaces, giving the appearance of a city skyline.

Figure 1–4 Histogram for number of social interactions during a week for 94 university students, based on grouped frequencies.

INTERVAL	FREQUENCY
0–4	12
5–9	16
10–14	16
15–19	16
20–24	10
25–29	11
30–34	4
35–39	3
40–44	3
45–49	3



SOURCE: Data from Boykin, C. M., et. al. (in prep) Social interactions and intergroup prejudice: Quantity versus quality. Paper presented at the Annual Meeting of the Society for Personality and Social Psychology, San Antonio, TX.

1.4.1 How to Make a Histogram

There are four steps in making a histogram.

❶ **Make a frequency table (or grouped frequency table).**

❷ **Put the values along the bottom of the page, from left to right, from lowest to highest.** If you are making a histogram from a grouped frequency table, the values you put along the bottom of the page are the interval midpoints. The midpoint of an interval is halfway between the start of that interval and the start of the next highest interval. So, in Figure 1–4, the midpoint for the 0–4 interval is 2.5, because 2.5 is halfway between 0 (the start of the interval) and 5 (the start of the next highest interval). For the 5–9 interval, the midpoint is 7.5 because 7.5 is halfway between 5 (the start of the interval) and 10 (the start of the next highest interval). Do this for each interval. When you get to the last interval, find the midpoint between the start of the interval and the start of what would be the next highest interval. So, in Figure 1–4, the midpoint for the 45–49 interval is halfway between 45 (the start of the interval) and 50 (the start of what would be the next interval), which is 47.5.

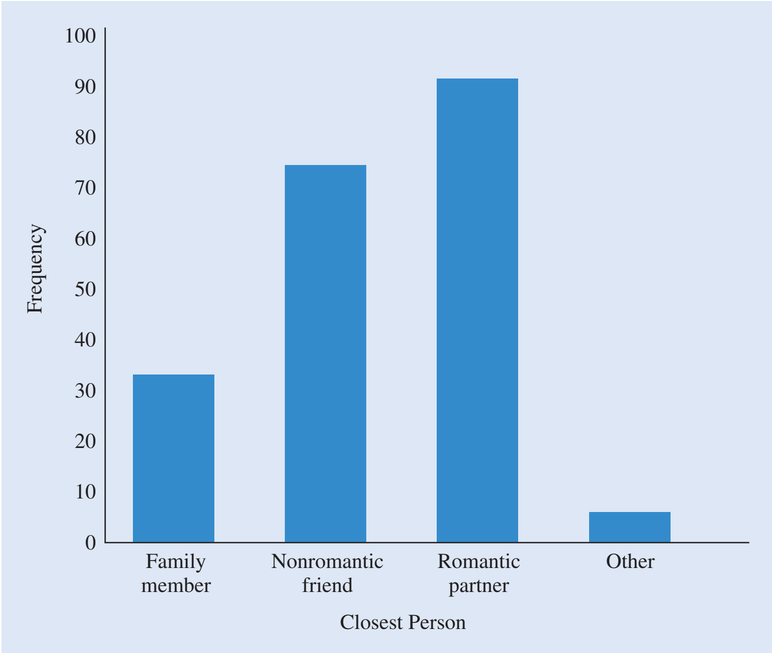
❸ **Make a scale of frequencies along the left edge of the page that goes from 0 at the bottom to the highest frequency for any value.**

Tip for Success Now try this yourself! Work out the interval midpoints for the grouped frequency table for the stress ratings example shown in Table 1–6. Remember, you are not finding the middle point of the interval, but rather the middle point between where one interval starts and the next one begins. Your answers should be the same as the values shown along the bottom of Figure 1–3b.

❹ **Make a bar above each value with a height for the frequency of that value.** For each bar, make sure that the middle of the bar is above its value.

When you have a nominal variable, the histogram is called a *bar graph*. Since the values of a nominal variable are not in any particular order, you leave a space between the bars. Figure 1–5 shows a bar graph based on the frequency table in Table 1–4.

Figure 1–5 Bar graph for the closest person in life for 208 students (see Table 1–4).



SOURCE: Data from Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of Other in the Self Scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology,* 63, 596–612.

BOX 1–2 Statistics Anxiety, Test Anxiety, and You

Feeling nervous about this course? Most of you probably are and your instructor knows it too. When one of us was speaking on teaching statistics to more than 100 instructors at a conference, we used a questionnaire to ask, "What's your greatest problem teaching stats?" By far the most common answer had to do with their students' anxiety about the course. We need to tackle this right now.

Math Anxiety from Your Past or Statistics Anxiety in Your Present?

Math anxiety is the subject of many good books and studies, and now statistics anxiety is as well. The standard test of statistics anxiety (Cruise & Wilkins, 1985) has been carefully analyzed (Siew, McCartney, & Vitevitch, 2019) using network science, a mathematical tool to understand the relationships among parts in a system. The problems behind statistic anxiety differ according to how much it is troubling you. If it is a big issue, most likely you doubt your mathematical ability and, very interestingly but maybe not surprisingly, you also fear your statistics instructor. After all, that is the person who may uncover your fatal flaw, feeling useless at math.

Fortunately, we can reassure you on both points. First, statistics differs greatly from other math courses you may have taken. Your past performance in (or avoidance of) geometry, trigonometry, calculus, or similar horrors need not influence in any way how well you do in this course. If you did OK in basic high school algebra, you will be fine. Forgotten that? You can review it.

Second, although only anecdotal evidence, many former students have approached us over the years saying how this course was different because of this text. They said this text made statistics far less difficult, more interesting, understandable, and valuable than they expected. (For every point we cover, we try to explain it in words, the underlying logic, and if possible images, as well as with numbers.) Some even conquered their fear enough to pursue graduate work, instead of ruling out higher level courses because of the required statistics. We think your finding this text friendlier and easier to follow may rub off on your perception of your instructor. Or, you can imagine us up there teaching and grading!

Even with our reassurances, math anxiety may still be an issue for you. A website search for "mathematics anxiety" will yield many excellent resources. Perhaps it will also be reassuring that it is a problem all over the world (Foley et al., 2017). You are not alone. But here's what we have seen help statistics-anxious students when we teach statistics ourselves:

- Go to class faithfully and stay alert throughout its entirety.
- Do your statistics homework before you are tired.
- Ask for help from your instructor, teaching assistants, or anyone you know in the class early in the semester (delaying this request for help can make things much harder on you, and the people helping you, given that statistics understanding is inherently cumulative).
- Form a study group. If you don't understand something, try explaining it to someone who understands it even less.
- Read ahead, so that what you hear in class is already familiar.
- Do not expect to understand things instantly; treat yourself gently.

Test Anxiety

Now let's focus on exams. You may feel you will understand the material, but still fear not being able to demonstrate this on tests.

(continued)

Anxiety produces physiological arousal; in fact, one of the best understood relationships in psychology is between arousal and performance. However, while too much arousal reduces performance, moderate arousal actually helps performance, including performance on statistics exams (Keeley, Zayac, & Correia, 2008) and your overall grade (Macher et al., 2012; Macher et al., 2013). Do trust these findings, now replicated many times. Read that again, because research (Brady, Hard, & Gross, 2018) finds that your test performance may be further improved by just knowing that a little test anxiety can actually improve your grade on an exam. That is, try to stop being anxious about being anxious.

One of the leading researchers in the field of test anxiety, Sian Beilock, in 2011 wrote a book titled *Choke*, which validates our own students' experiences. Recommended strategies include the following:

1. Overprepare until it seems you cannot possibly fail, even when anxiety has reduced your working memory. Overprepare especially for the first test, when there is no old material to review. A good score on it will make you less anxious about the next test.
2. Practice working under pressure. Do a practice test of homework problems, making it as similar to a real test as possible. (You can do this by selecting some of the Part I Practice Problems at the end of each relevant chapter that were not assigned as homework, and which have the answers in this text.) Duplicate the most bothersome aspects by setting a time limit. Having to write answers fully and legibly can make you feel slow during a test, so do that too.
3. If the presence of other people bothers you, do a practice test with others in your course. When you do, look at why taking a test with others in the room adds pressure. If it is just the extra stimulation (e.g., little noises and such); try taking more practice tests in noisy places like cafés. If the classroom specifically bothers you, perhaps it makes you feel as if you are competing against those around you. Sometimes there is a definite atmosphere of competition, in a class or an entire field, which can make some people feel they do not even belong there. Whether these imposter feelings are imagined or created by the group, research finds that these feelings can seriously interfere with a student's studies (Canning et al., 2020). If you have such feelings at times, review the facts. Yes. Some of those in this particular class may be more comfortable with the material than you, but that is likely just because they have had more experience with the material (e.g., already completed a related course). With all of your preparation, you are surely doing well enough to pass the course, which means you are no imposter! If you are studying with others in the same class, maybe cautiously initiate a discussion about teamwork and collaboration, the basis of most good science today. How might working together help you all do well in class? Perhaps you can commit to coming to class and studying as a team in order to neutralize any toxic competitive atmosphere.
4. Try expressive writing about your anxiety just before the test. Quite paradoxically, this helps math-anxious students perform as well as low-anxious students, and better than a control group sitting quietly just before the exam (Park, Ramierez, & Beilock, 2014). Specifically, about 10 minutes before the exam, write about how you feel. Be very explicit about your anxiety, what is it is all about, and other times you have felt it. Be honest. No one will see it.
5. Look for which sections are given the most points during the exam. If these are not difficult for you, begin with these. Otherwise start with the questions easiest for you. Read instructions carefully! On a multiple-choice exam, check the total number of questions so you can pace yourself. Skip questions you are not sure about, maybe noting the most likely answer so, if necessary, you can guess at the end and have an answer for everything.
6. Try to ignore the people around you. Some people may seem to be working faster, but they may not be working as well as you. This is not a horse race.

Is your problem general anxiety or general lack of confidence? If yes, we suggest that you visit your university's counseling center.

Lastly, could you be highly sensitive? High sensitivity is an innate trait found in about 20% of humans and is mostly a very useful characteristic, but a downside is being easily overaroused under pressure. You can find out if you are highly sensitive at *http://www.hsperson.com*. If you are, appreciate the trait's assets, which will definitely help you throughout your life, and make some allowances for its one disadvantage (overarousal).

1–3 How are you doing?

1. Why do researchers make histograms?
2. When making a histogram from a frequency table, (a) what goes along the bottom, (b) what goes along the left edge, and (c) what goes above each value?
3. Make a histogram based on the following frequency table:

Value	Frequency
1	3
2	4
3	8
4	5
5	2

4. How is a histogram based on a nominal variable different from one based on a numeric equal-interval variable?

1.5 Shapes of Frequency Distributions

1–5 Identify the shape of a distribution of data

A **frequency distribution** shows the pattern of frequencies over the various values. A frequency table or histogram describes a frequency distribution because each shows the pattern or shape of how the frequencies are spread out, or "distributed." Psychologists also describe this shape in words. Describing the shape of a distribution is important, both in the descriptive statistics we focus on in this chapter and the next and also in the inferential statistics you will learn in later chapters.

frequency distribution pattern of frequencies over the various values of a given variable; a graph that represents the values taken from a frequency table.

1.5.1 Unimodal and Bimodal Frequency Distributions

One question is whether a distribution's shape has only one main high point: One high "tower" in the histogram. For example, in the stress ratings study, the most frequent value is 7, giving a graph only one very high area. This is a **unimodal distribution**. If a distribution has two fairly equal high points, it is a **bimodal distribution**. Any distribution with two or more high points is called a **multimodal distribution**. (Strictly speaking, a distribution is bimodal or multimodal only if the peaks are exactly equal. However, psychologists use these terms more informally to describe the general shape.) Finally, a distribution with values of all about the same frequency is a **rectangular distribution**. Figure 1–6 shows examples of these frequency distribution shapes. As you will see, the graphs in Figure 1–6 are not histograms, but special line graphs called *frequency polygons*, which are another way to graph a frequency table. In a frequency polygon, the line moves from point to point. The height of each point shows the number of scores with that value. This creates a mountain-peak skyline.

The scores from most psychology studies are usually an approximately unimodal distribution. Bimodal and other multimodal distributions occasionally turn up. A bimodal example is the distribution of the ages of people in a toddlers' play area in a park, who are mostly either toddlers of ages around 2 to 4 years or caretakers with ages of 20 to 45 years or so (with a few infants, a few siblings aged 5 to 19 years, and a few grandparents above 45 years). Thus, if you make a frequency distribution of these ages, the large frequencies are at the values for toddler ages (2 to 4) and for higher ages (20 to 45 or so). An example of a rectangular distribution is the number of children at each grade level at an elementary school; there is about the same number in first grade, second grade, and so on. Figure 1–7 shows these examples.

unimodal distribution frequency distribution with one value clearly having a larger frequency than any other.

bimodal distribution frequency distribution with two approximately equal frequencies, each clearly larger than any of the others.

multimodal distribution frequency distribution with two or more high frequencies separated by a lower frequency; a bimodal distribution is the special case of two high frequencies.

rectangular distribution frequency distribution in which all values have approximately the same frequency.

Figure 1–6 Examples of (a) unimodal, (b) approximately bimodal, and (c) approximately rectangular frequency polygons.

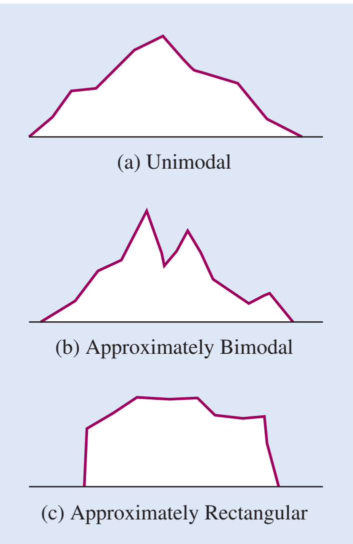
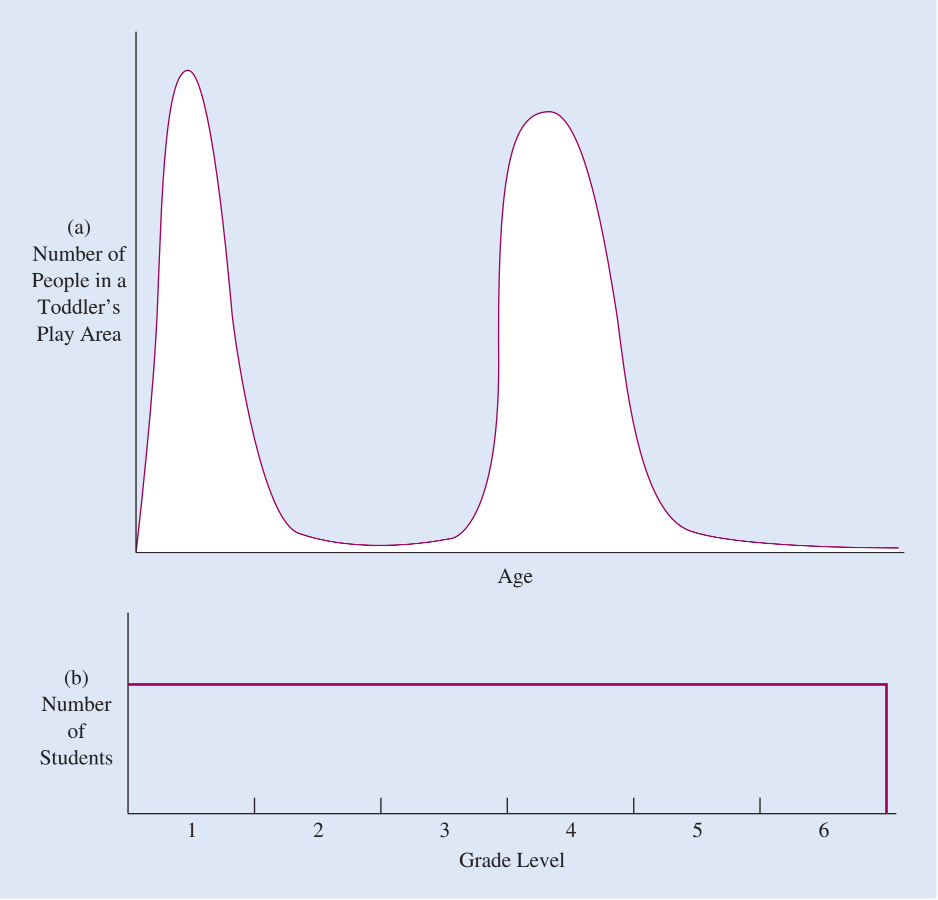


Figure 1–7 Fictional examples of distributions that are not unimodal: (a) A bimodal distribution showing the possible frequencies for people of different ages in a toddler's play area. (b) A regular distribution showing the possible frequencies of students at different grade levels in an elementary school.



1.5.2 Symmetrical and Skewed Distributions

symmetrical distribution distribution in which the pattern of frequencies on the left and right side are mirror images of each other.

skewed distribution distribution in which the scores pile up on one side of the middle and are spread out on the other side; distribution that is not symmetrical.

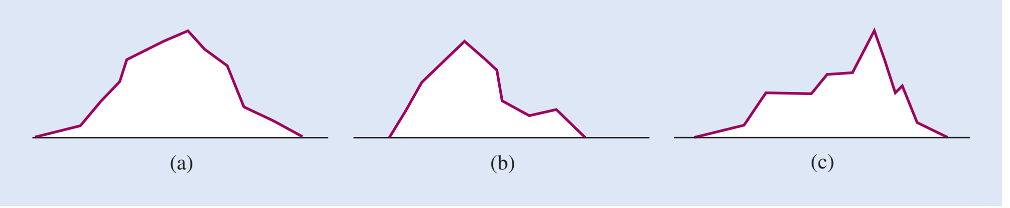
Look again at the histograms of the stress ratings example (Figure 1–3 on p. 11). The distribution is lopsided, with more scores near the high end. This is somewhat unusual. Most things we measure in psychology have about equal numbers on both sides of the middle. That is, most of the time in psychology, the scores follow an approximately **symmetrical distribution** (if you fold the graph of a symmetrical distribution in half, the two halves look the same).

A distribution that clearly is not symmetrical is called a **skewed distribution**. The stress ratings distribution is an example. A skewed distribution has one side that is long and spread out, somewhat like a tail. The side with the *fewer* scores (the side that looks like a tail) is considered the direction of the skew. Thus, the stress study example, which has too few scores at the low end, is skewed to the left. However, the social interactions example, which has too few scores at the high end, is skewed to the right (see Figure 1–4). Figure 1–8 shows examples of approximately symmetrical and skewed distributions.

Tip for Success It helps you remember the direction of the skew to know that the word *skew* comes from the French *queue*, which means line or tail. Thus, the direction of the skew is the side that has the long line, or tail.

A distribution that is skewed to the right is also called *positively skewed*. A distribution skewed to the left is also called *negatively skewed*.

Figure 1–8 Examples of frequency polygons of distributions that are (a) approximately symmetrical, (b) skewed to the right (positively skewed), and (c) skewed to the left (negatively skewed).



Strongly skewed distributions come up in psychology research mainly when what is being measured has some upper or lower limit. For example, a family cannot have fewer than zero children. When many scores pile up at the low end because it is impossible to have a lower score, the result is called a **floor effect**. A skewed distribution caused by a lower limit is shown in Figure 1–9a.

A skewed distribution caused by an upper limit is shown in Figure 1–9b. This is a distribution of adults' scores on a multiplication table test. This distribution is strongly skewed to the left. Most of the scores pile up at the right, the high end (a perfect score). This shows a **ceiling effect**. The stress ratings example also shows a mild ceiling effect because many students had high levels of stress, the maximum rating was 10, and people often do not like to use ratings right at the maximum.

floor effect
situation in which many scores pile up at the low end of a distribution (creating skewness to the right) because it is not possible to have any lower score.

ceiling effect
situation in which many scores pile up at the high end of a distribution (creating skewness to the left) because it is not possible to have a higher score.

1.5.3 Normal and Kurtotic Distributions

Psychologists also describe a distribution in terms of whether the middle of the distribution is particularly peaked or flat. The standard of comparison is a bell-shaped curve. In psychology research and in nature generally, distributions often are similar to this bell-shaped standard, called the **normal curve**. You will notice that the normal curve also has a smoothed-out shape (see Figure 1–10a) that is a bit less jagged than the frequency polygons we have been looking at thus far. We discuss this curve in some detail in later chapters. For now, however, the important thing is that the normal curve is a unimodal, symmetrical curve with an average peak. Both the stress ratings and the social interactions examples are somewhat skewed. In our experience, most distributions that result from psychology research are closer to the normal curve than are these two examples.

normal curve
specific, mathematically defined, bell-shaped distribution that is symmetrical and unimodal; distributions observed in nature and in research commonly approximate it.

Figure 1–9 (a) A distribution skewed to the right due to a floor effect: fictional distribution of the number of children in families. (b) A distribution skewed to the left due to a ceiling effect: fictional distribution of adults' scores on a multiplication table test.

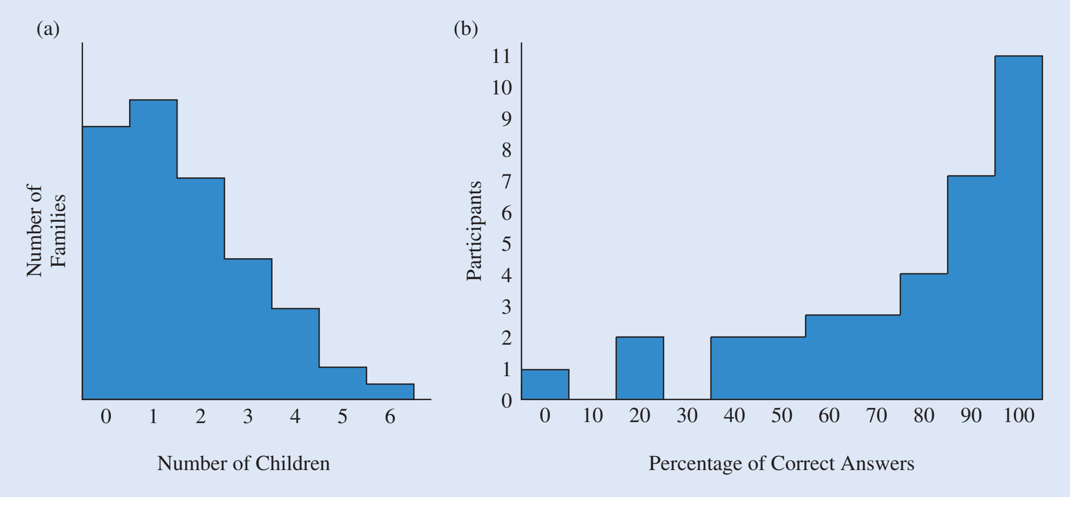
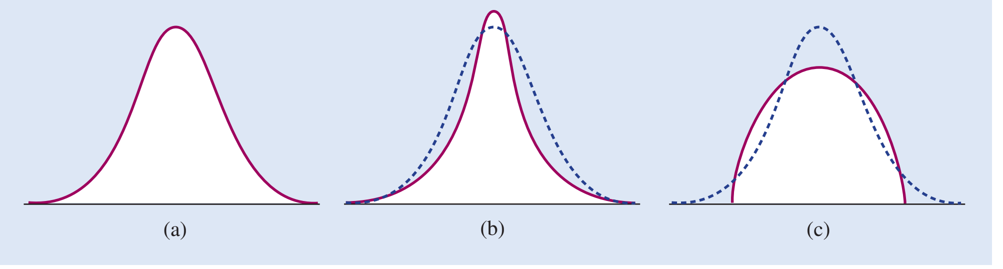


Figure 1–10 Examples of (a) normal, (b) heavy-tailed, and (c) light-tailed distributions. The normal distribution is shown as a dashed line in (b) and (c).



SOURCE: Based on from DeCarlo, T. (1997). On the meaning and use of kurtosis. *Psychological Methods*, 3, 292–307. American Psychological Association.

kurtosis
extent to which a frequency distribution deviates from a normal curve in terms of whether its curve in the middle is more peaked or flat than the normal curve.

Kurtosis is how much the shape of a distribution differs from a normal curve in terms of whether its curve in the middle is more peaked or flat than the normal curve (DeCarlo, 1997). Kurtosis comes from the Greek word *kyrtos*, "curve." Figure 1–10b shows a kurtotic distribution with a more extreme peak than the normal curve. Figure 1–10c shows an extreme example of a kurtotic distribution, one with a very flat distribution. (A rectangular distribution would be even more extreme.)

Distributions that are more peaked or flat than a normal curve also tend to have a different shape in the tails. Those with a very peaked curve usually have more scores in the tails of the distribution than the normal curve (see Figure 1–10b). It is as if the normal curve got pinched in the middle and some of it went up into a sharp peak and the rest spread out into thick tails. Distributions with a flatter curve usually have fewer scores in the tails of the distribution than the normal curve (see Figure 1–10c). It is as if the tails and the top of the curve both got sucked in toward the middle on both sides. Although it is often easiest to identify kurtosis in terms of how peaked or flat the distribution is, the number of scores in the tails is what matters.

1–4 How are you doing?

1. Describe the difference between a unimodal and multimodal distribution in terms of (a) a frequency graph and (b) a frequency table.
2. What does it mean to say that a distribution is skewed to the left?
3. What kind of skew is created by (a) a floor effect and (b) a ceiling effect?
4. When a distribution is described as being peaked or flat, what is it being compared to?

1.6 Controversy: Measurement Decisions

1–6 Consider the importance of how we measure variables

After researchers develop a research question, they must next decide how to measure the variables they are interested in. For example, when one of the authors of this text wanted to assess the stress level of the students in his statistics course, the author needed to decide how to measure stress. As you saw earlier, the author chose an interval-level measurement that assessed stress on a 0 = not at all stressed to 10 = as stressed as possible scale. When doing this, the author chose to treat stress as a continuous variable. However, another strategy would have been to simply treat "stress" as a category by asking students to respond to a slightly altered question: "How are you feeling?" with response options of "calm," or "stressed." Although these decisions about how to measure may not seem controversial, in some cases they can be.

An interesting example of such a controversy applies to measuring someone's race. As many of us who have filled out surveys know, our race is often treated as nominal/categorical (e.g.,

Figure 1–11 Example of a nominal measurement of race.

What is your race?

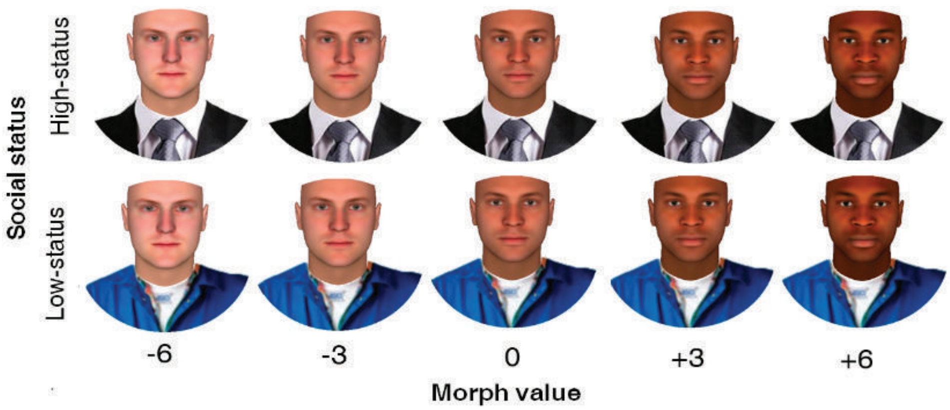
- ☐ White or Caucasian
- ☐ Black or African American
- ☐ Native American or Pacific Islander
- ☐ Asian
- ☐ Multiracial (more than one race) please specify: ____
- ☐ Another race/ethnicity: ____

Black, White, Asian, etc.; see Figure 1–11). However, some researchers have begun to argue that we shouldn't think of race as distinct categories (Richeson & Sommers, 2016), perhaps especially in the case of multiracial people (Gaither, 2018).

Take a look at Figure 1–12 to see how Freeman and colleagues (2011) chose to represent race. In this image you can see that the researchers created morphs of Black and White men so as to create a gradient of race from Black to White. The researchers chose this strategy because they wanted to test whether cues to social status (e.g., clothing) would affect how "Black" or "White" people perceived these people to be. Interestingly, they found that high-status clothes (e.g., suits) led people to perceive faces as "White."

The answer to whether a person's race is a distinct category, or continuous and flexible, is likely to be viewed differently by different people. Statistically, this decision is going to change the ways you can analyze your data and, in some cases, the integrity of your analyses (MacCallum et al., 2002). If it were up to you, how would you choose to measure race? Gender

Figure 1–12 Example of a continuous consideration of race.



is another facet of identity that raises important questions about whether it is best treated as categorical or continuous/fluid—how would you choose to measure gender (see Hyde et al., 2019 for a discussion)? As we move forward, you will begin to see how your answers to these questions will influence the types of statistical tests that you can conduct.

1.7 Frequency Tables, Histograms, and Bar Graphs in Research Articles

1–7 Understanding tables and graphs of frequency distributions in research articles

Psychology researchers mainly use frequency tables and histograms as an important first step before conducting more elaborate statistical analyses. As you will learn in the chapter *Strategies When Population Distributions Are Not Normal*, knowing the distribution of the variables in your research study can influence the type of statistical analysis that you conduct. The best way to identify the distribution of a variable is to look at it visually, using a frequency table or histogram. However, frequency tables and histograms are usually not included in research articles, and when they are, just because they are so rare, they are often not standard in some way. Lee and colleagues (2020) conducted a study to examine the effect of getting fewer "likes" on social media on adolescents' emotional distress. Table 1–8 is data from Lee and colleagues (2020). In particular, you can see a frequency table showing the demographic characteristics of the participants in their studies. This is a common use for frequency tables in research articles. The authors conducted three separate studies to test their research questions. The table shows that for Study 1, the sample was 55% girls, a little less than half (44.9%) of the participants were White/European American, and about one-fifth (20.9%) of their mothers were highly-educated with a Master's degree or above. You can also see how these percentages vary slightly across the three studies.

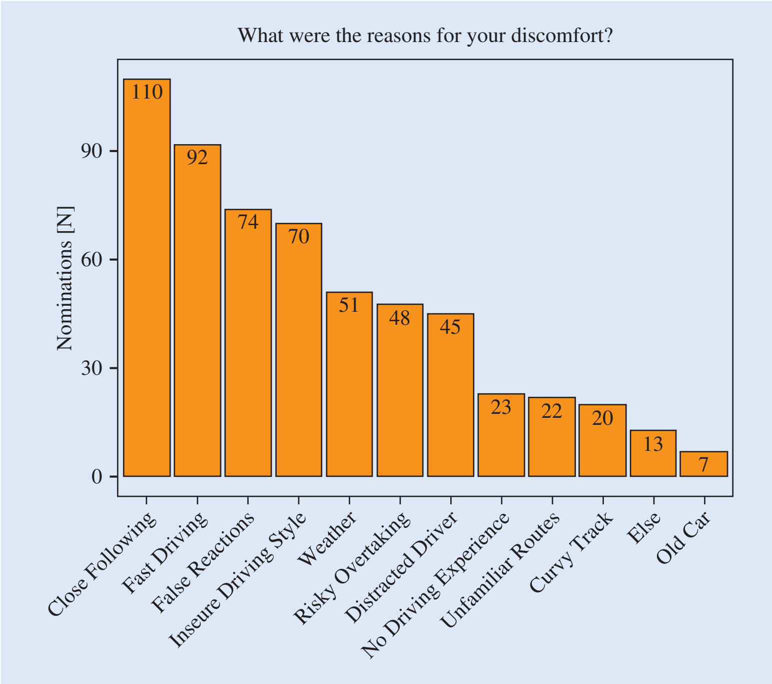
As mentioned earlier, histograms are even more rare in research articles (except in articles about statistics). Instead, histograms are often used by researchers to better understand the distribution of their scores before conducting more complex statistical analyses. Bar graphs, in contrast, often appear in research articles. For example, Ittner and colleagues (2020) conducted

Table 1–8 Demographic Variables for Three Studies of Adolescent Participants

	Study 1 (N = 613)	Study 2 (N = 145)	Study 3 (N = 579)
M_{age} (SD)	14.3 (0.70)	14.8 (0.55)	15.3 (0.40)
Gender			
% Boys	45.0	48.6	50.3
% Girls	55.0	51.4	49.7
Race/ethnicity			
% White/European American	44.9	57.6	53.5
% Hispanic/Latinx	31.8	19.4	32.5
% Black/African American	3.5	1.4	3.8
% Asian/Pacific Islander	12.3	14.6	6.5
% Native American Indian	0.3	0.0	0.2
% Multi-racial/other	6.8	6.9	3.5
Maternal education			
% No high school degree	15.4	2.0	5.6
% High school degree	23.1	14.3	19.3
% 2-year associate degree	5.5	5.1	5.1
% 4-year college degree	25.5	36.7	32.7
% Master's degree or above	20.9	35.7	23.4
% Participant did not know	9.5	6.1	14.0

SOURCE: Data from Lee, H.Y., et. al. (2020). Getting fewer "likes" than others on social media elicits emotional distress among victimized adolescents. *Child Development*, 91(6), 2141–2159.

Figure 1–13 Reasons for co-driver discomfort.



SOURCE: Ittner, S., Mühlbacher, D., & Weisswange, T. H. (2020). The discomfort of riding shotgun—why many people don't like to be codriver. *Frontiers in Psychology*. Published by Frontiers Media. Reprinted with permission.

a study on the reasons for the discomfort that many people feel when riding as a passenger—or as a codriver—in a car. As shown in Figure 1–13, the researchers created a bar graph—from a frequency table—to display their results. Note that they used a bar graph rather than a histogram because they were displaying the frequencies for a nominal variable. Note: When codrivers were asked why they were uncomfortable being a passenger, the most frequent response was that the driver was closely following another car. The next most frequent response was that the driver was driving too fast and the least frequent response was that the car was old. You can also see that although nominal variables don't have any particular order, the researchers chose to sort the categories from the most frequent response on the left to the least frequent response on the right. This decision helps the reader quickly glean which responses are most and least common.

Learning Aids

Summary

1. Psychologists use descriptive statistics to describe and summarize a group of numbers from a research study.
2. A value is a number or category; a variable is a characteristic that can have different values; a score is a particular person's value on the variable.
3. Most variables in psychology research are numeric with approximately equal intervals. However, some numeric variables are rank-ordered (the values are ranks), and some variables are not numeric at all (the values are categories).
4. A frequency table organizes the scores into a table of each of the possible values with the frequency and percentage of scores with that value.
5. When there are many different values, a grouped frequency table is useful. It is like an ordinary frequency table except that the frequencies are given for intervals that include a range of values.

6. The pattern of frequencies in a distribution can be shown visually with a histogram (or bar graph for a nominal variable), in which the height of each bar is the frequency for a particular value.
7. The general shape of a histogram can be unimodal (having a single peak), bimodal (having two peaks), multimodal (including bimodal), or rectangular (having no peak); it can be symmetrical or skewed (having a long tail) to the right or the left; and, compared to the bell-shaped normal curve, it can be kurtotic (having a peaked or flat distribution).
8. One important decision that researchers must make is how to measure the variables they are interested in. For example, they may have to decide whether to measure variables such as race or gender as nominal/categorical or as continuous. These decisions have statistical, and sometimes social consequences.
9. Frequency tables, histograms, and bar graphs are very important for researchers in the process of interpreting their results, but are rarely shown in published research articles. When they are, they often follow nonstandard formats or involve frequencies (or percentages) for a nominal variable. The shapes of distributions (normal, skewed, and so on) are more often described.

Key Terms

statistics (p. 1)
descriptive statistics (p. 2)
inferential statistics (p. 2)
variable (p. 3)
values (p. 3)
score (p. 3)
numeric variable (p. 3)
equal-interval variable (p. 3)
rank-order variable (p. 4)
nominal variable (p. 4)
levels of measurement (p. 4)
discrete variable (p. 5)
continuous variable (p. 5)
frequency table (p. 6)
interval (p. 9)
grouped frequency table (p. 9)
histogram (p. 11)
frequency distribution (p. 15)
unimodal distribution (p. 15)
bimodal distribution (p. 15)
multimodal distribution (p. 15)
rectangular distribution (p. 15)
symmetrical distribution (p. 16)
skewed distribution (p. 16)
floor effect (p. 17)
ceiling effect (p. 17)
normal curve (p. 17)
kurtosis (p. 18)

Example Worked-Out Problems

Ten first-year university students rated their interest in graduate school on a scale from 1 = no interest at all to 6 = high interest. Their scores were as follows: 2, 4, 5, 5, 1, 3, 6, 3, 6, 6.

Making a Frequency Table

See Figure 1–14.

Figure 1–14 Answer to Example Worked-Out Problem for making a frequency table. ❶ Make a list down the page of each possible value, from lowest to highest. ❷ Go one by one through the scores, making a mark for each next to its value on your list. ❸ Make a table showing how many times each value on your list is used. ❹ Figure the percentage of scores for each value.

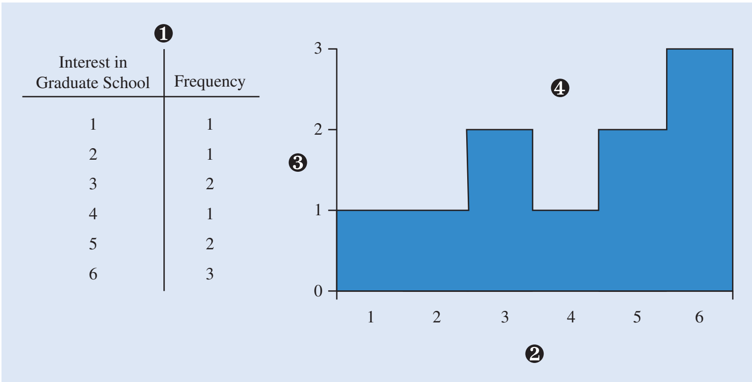
❶ Interest in Graduate School	❸ Frequency	❹ Percent	❷
1	1	10	/
2	1	10	/
3	2	20	//
4	1	10	/
5	2	20	//
6	3	30	///

2, 4, 5, 5, 1, 3, 6, 3, 6, 6

Making a Histogram

See Figure 1–15.

Figure 1–15 Answer to Example Worked-Out Problem for making a histogram. ❶ Make a frequency table. ❷ Put the values along the bottom of the page (from left to right, from lowest to highest). ❸ Make a scale of frequencies along the left edge of the page (going from 0 at the bottom to the highest frequency for any value). ❹ Make a bar for each value (with a height for the frequency of that value).



Practice Problems

These problems involve tabulation and making graphs. Most real-life statistics problems are done with special statistical software. Even if you have such software, do these problems by hand to ingrain the method in your mind. To learn how to use a computer to solve statistics problems like those in this chapter, refer to the Using SPSS section at the end of this chapter.

All data are fictional unless an actual citation is given.

Practice Set 1–1

(for Answers to Set I Problems, see pp. 615–616)

1. A client rates her satisfaction with her vocational counselor as a 3 on a 4-point scale from 1 = not at all satisfied to 4 = very satisfied. What is the (a) variable, (b) possible values, and (c) this client's score?

2. Give the level of measurement for each of the following variables: (a) ethnic group to which a person belongs, (b) number of times a mouse makes a wrong turn in a laboratory maze, and (c) position a runner finishes in a race.

3. A particular block in a suburban neighborhood has 20 households. The number of children in these households is as follows:

   2, 4, 2, 1, 0, 3, 6, 0, 1, 1, 2, 3, 2, 0, 1, 2, 1, 0, 2, 2

   Make (a) a frequency table and (b) a histogram. Then (c) describe the general shape of the distribution.

4. Fifty students were asked how many hours they studied this weekend. Here are their answers:

   11, 2, 0, 13, 5, 7, 1, 8, 12, 11, 7, 8, 9, 10, 7, 4, 6, 10, 4, 7, 8, 6, 7, 10, 7, 3, 11, 18, 2, 9, 7, 3, 8, 7, 3, 13, 9, 8, 7, 7, 10, 4, 15, 3, 5, 6, 9, 7, 10, 6

   Make (a) a frequency table and (b) a histogram. Then (c) describe the general shape of the distribution.

5. These are the scores on a test of sensitivity to smell taken by 25 chefs attending a national conference:

   96, 83, 59, 64, 73, 74, 80, 68, 87, 67, 64, 92, 76, 71, 68, 50, 85, 75, 81, 70, 76, 91, 69, 83, 75

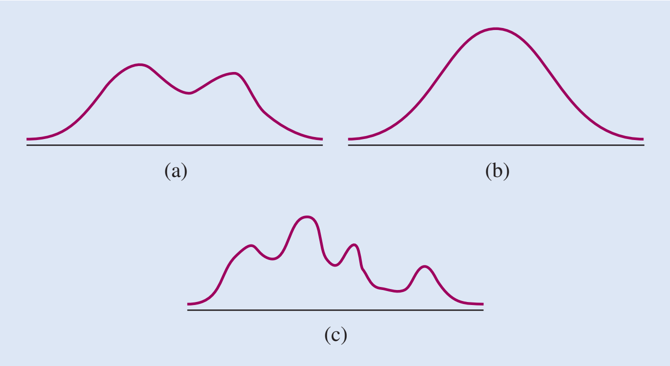
   Make (a) a frequency table and (b) histogram. (c) Make a grouped frequency table using intervals of 50–59, 60–69, 70–79, 80–89, and 90–99. Based on the grouped frequency table, (d) make a histogram and (e) describe the general shape of the distribution.

6. The following data are the number of minutes it took each of a group of 34 10-year-olds to do a series of abstract puzzles:

   24, 83, 36, 22, 81, 39, 60, 62, 38, 66, 38, 36, 45, 20, 20, 67, 41, 87, 41, 82, 35, 82, 28, 80, 80, 68, 40, 27, 43, 80, 31, 89, 83, 24

   Make (a) a frequency table and (b) a grouped frequency table using intervals of 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, and 80–89. Based on the grouped frequency table, (c) make a histogram and (d) describe the general shape of the distribution.

7. Describe the shapes of the three distributions illustrated.



8. Make up and draw an example of each of the following distributions: (a) symmetrical, (b) rectangular, and (c) skewed to the right.
9. Explain to a person who has never had a course in statistics what is meant by (a) a symmetrical unimodal distribution and (b) a negatively skewed unimodal distribution. (Be sure to include in your first answer an explanation of what *distribution* means.)
10. Gillihan and colleagues (2013) interviewed 90 adolescent girls who were receiving treatment for post-traumatic stress disorder (PTSD) after a sexual trauma. Table 1–9 shows data from Gillihan and colleagues' (2013) study. In particular, the table shows the extent to which the girls were diagnosed with "comorbid" (that is, in addition to PTSD) psychological disorders. (a) Using this table as an example, explain the idea of a frequency table to a person who has never had a course in statistics. (b) Explain the general meaning of the pattern of results.

Practice Set 1–2

11. A participant in a cognitive psychology study is given 50 words to remember and later asked to recall as many of the words as she can. She recalls 17 words. What is the (a) variable, (b) possible values, and (c) score?

Table 1–9 Comorbid Diagnoses in Girls with PTSD

Diagnosis	*n*	%
Panic disorder	1	1.1
Attention-deficit/hyperactivity disorder	5	5.5
Oppositional defiant disorder	5	5.5
Social anxiety disorder	6	6.6
Specific phobia	9	9.9
Obsessive compulsive disorder	10	11.0
Generalized anxiety disorder	11	12.1
Major depressive disorder	43	47.3

SOURCE: Data from Gillihan, S. J., et al. (2013).

12. Explain and give an example for each of the following types of variables: (a) equal-interval, (b) rank-order, (c) nominal, (d) ratio scale, (e) continuous, (f) discrete.
13. An organizational psychologist asks 20 employees in a company to rate their job satisfaction on a 5-point scale from 1 = very unsatisfied to 5 = very satisfied. The ratings are as follows:

    3, 2, 3, 4, 1, 3, 3, 4, 5, 2, 3, 5, 2, 3, 3, 4, 1, 3, 2, 4

    Make (a) a frequency table and (b) a histogram. Then (c) describe the general shape of the distribution.
14. A social psychologist asked 15 university students how many times they fell in love before they were 11 years old. The numbers of times were as follows:

    2, 0, 6, 0, 3, 1, 0, 4, 9, 0, 5, 6, 1, 0, 2

    Make (a) a frequency table and (b) a histogram. Then (c) describe the general shape of the distribution.
15. Following are the speeds of 40 cars clocked by radar on a particular road in a 35-mph zone on a particular afternoon:

    30, 36, 42, 36, 30, 52, 36, 34, 36, 33, 30, 32, 35, 32,
    37, 34, 36, 31, 35, 20, 24, 46, 23, 31, 32, 45, 34, 37,
    28, 40, 34, 38, 40, 52, 31, 33, 15, 27, 36, 40

    Make (a) a grouped frequency table and (b) a histogram based on the grouped frequency table. Then (c) describe the general shape of the distribution.
16. Here are the number of holiday gifts purchased by 25 families randomly interviewed at a local mall at the end of the holiday season:

    22, 18, 22, 26, 19, 14, 23, 27, 2, 18, 28, 28, 11,
    16, 34, 28, 13, 21, 32, 17, 6, 29, 23, 22, 19

    Make (a) a frequency table and (b) a grouped frequency table using intervals of 0–4, 5–9, 10–14, 15–19, 20–24, 25–29, and 30–34. Based on the grouped frequency table, (c) make a histogram and (d) describe the general shape of the distribution.
17. Pick a book and a page number of your choice. (Select a page with at least 30 lines; *do not pick a textbook or any book with tables or illustrations*.) Make a list of the number of words on each line; use that list as your group of scores. Make (a) a frequency table and (b) a histogram. Then (c) describe the general shape of the distribution. (Be sure to give the name, author, publisher, and year of the book you used, along with the page number, with your answer.)
18. Explain to a person who has never taken a course in statistics the meaning of a grouped frequency table.
19. Make up and draw an example of each of the following distributions: (a) bimodal, (b) approximately rectangular, and (c) skewed to the right. Do not use an example given in this text or in class.

20. Choose a variable that you might be interested in measuring (e.g., stress, love, religion, and so on). How would you measure this variable and what is your reasoning?

21. Raskauskas and Stoltz (2007) asked a group of 84 adolescents about their involvement in traditional and electronic bullying. The researchers defined electronic bullying as "a means of bullying in which peers use electronics [such as text messages, emails, and defaming Web sites] to taunt, threaten, harass, and/or intimidate a peer" (p. 565). Table 1–10 reflects data from 84 participants from Raskauskas and Stoltz (2007). In particular, you can see a frequency table showing the adolescents' reported incidence of being victims or perpetrators of traditional and electronic bullying. (a) Using this table as an example, explain the idea of a frequency table to a person who has never had a course in statistics. (b) Explain the general meaning of the pattern of results.

Table 1–10 Bullying and Victimization

Form of Bullying	*N*	%
Electronic victims	41	48.8
Traditional victims	60	71.4
Electronic bullies	18	21.4
Traditional bullies	54	64.3

SOURCE: Data from Raskauskas, J., & Stoltz, A. D. (2007).

22. Kärnä and colleagues (2013) tested the effects of a new antibullying program, called KiVa, among students in grades 1–3 and grades 7–9 in 147 schools in Finland. The schools were randomly assigned to receive the new antibullying program or no program. At the beginning, middle, and end of the school year, all of the students completed a number of questionnaires, which included the following two questions: "How often have you been bullied at school in the last couple of months?" and "How often have you bullied others at school in the last couple of months?" Table 1–11 is data from Kärnä and colleagues (2013). In particular, you can see a frequency table that shows students' responses to these two questions at the end of the school year. Note that the table shows the results combined for all of the students in the study. In the table, "victimization" refers to students' reports of being bullied and "bullying" is students' reports of bullying other students. (a) Using this table as an example, explain the idea of a frequency table to a person who has never had a course in statistics. (b) Explain the general meaning of the pattern of results. (You may be interested to know that the KiVa intervention program successfully reduced victimization and bullying among students in grades 1–3 but the results were mixed with regards to the effectiveness of the program among those in grades 7–9.).

Table 1–11 Frequencies of Self-Reported Bullying and Victimization at End of School Year

	Grades 7–9				Grades 1–3			
	Victimization		Bullying		Victimization		Bullying	
Variable	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Incidence								
Not at all	10,660	77.4	10,880	79.5	3,203	53.6	4,296	72.0
Only once or twice	2,031	14.7	1,987	14.5	1,745	29.2	1,333	22.3
2 or 3 times a month	402	2.9	344	2.5	446	7.5	197	3.3
About once a week	312	2.3	196	1.4	297	5.0	90	1.5
Several times a week	375	2.7	279	2.0	281	4.7	49	0.8
Participants								
Respondents *n*	13,780	100.0	13,686	100.0	5,972	100.0	5,965	100.0

SOURCE: Data from Kärnä, A., et. al. (2013). Effectiveness of the KiVa Antibullying Program: Grades 1–3 and 7–9. *Journal of Educational Psychology*, 105, 535–551.

Using SPSS

The in the following steps indicates a mouse click. (We used SPSS version 27.0 to carry out these analyses. The steps and output may be slightly different for other versions of SPSS.)

Creating a Frequency Table

❶ Enter the scores from your distribution in one column of the data window and the name of your variable in "variable view." To access "variable view," click the tab labeled "variable view" at the bottom of the screen. (For reference, this tab appears on the bottom of Figure 1–16.) If you click this tab, you can enter your variable name of "social_int" in the first row. Then return to "data view" by clicking the associated tab and you should now see your variable name at the top of the column, above your entered scores.

❷ ✎ *Analyze.*

❸ ✎ *Descriptive statistics.*

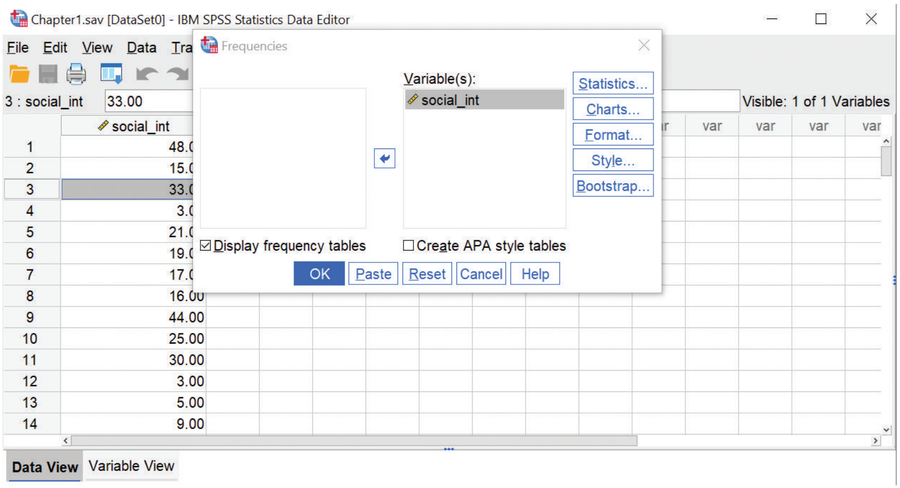
❹ ✎ *Frequencies.*

❺ ✎ the variable you want to make a frequency table of and then ✎ the arrow.

❻ ✎ *OK.*

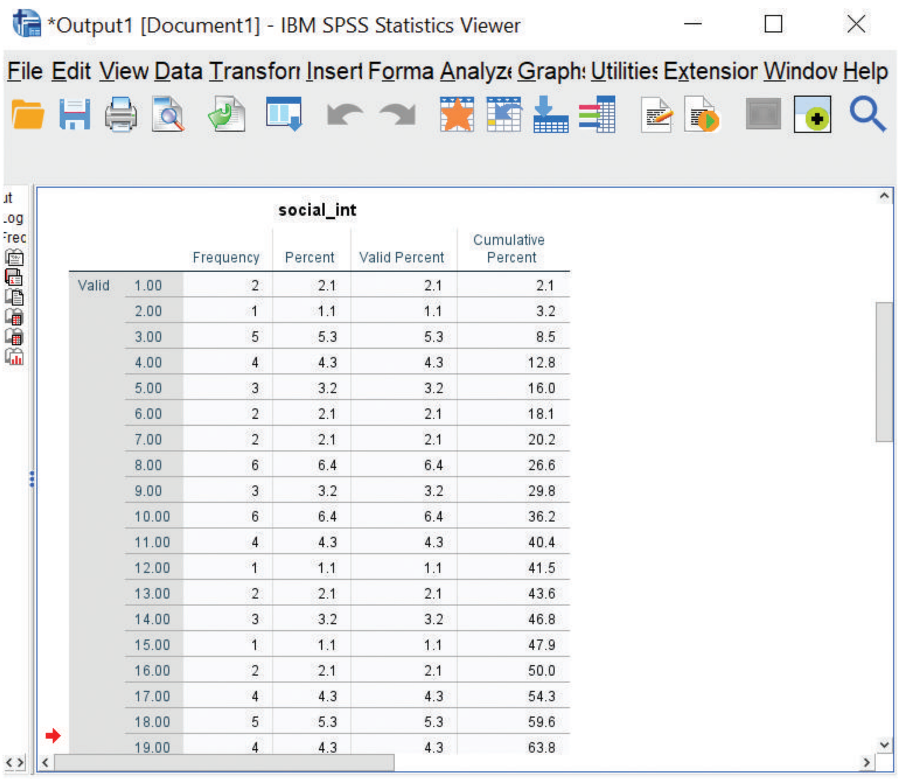
Practice the preceding steps by creating a frequency table for the social interactions example in this chapter (the scores are listed on p. 8). After Step ❺, your screen should look like Figure 1–16. Your output window (which appears after you ✎ *OK* in Step ❻) should look like Figure 1–17.

Figure 1–16 SPSS data window and frequencies window for the social interactions example.



SOURCE: Reprint Courtesy of IBM Corporation ©

Figure 1–17 SPSS frequency table for the social interactions example.



social_int

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	2	2.1	2.1	2.1
	2.00	1	1.1	1.1	3.2
	3.00	5	5.3	5.3	8.5
	4.00	4	4.3	4.3	12.8
	5.00	3	3.2	3.2	16.0
	6.00	2	2.1	2.1	18.1
	7.00	2	2.1	2.1	20.2
	8.00	6	6.4	6.4	26.6
	9.00	3	3.2	3.2	29.8
	10.00	6	6.4	6.4	36.2
	11.00	4	4.3	4.3	40.4
	12.00	1	1.1	1.1	41.5
	13.00	2	2.1	2.1	43.6
	14.00	3	3.2	3.2	46.8
	15.00	1	1.1	1.1	47.9
	16.00	2	2.1	2.1	50.0
	17.00	4	4.3	4.3	54.3
	18.00	5	5.3	5.3	59.6
	19.00	4	4.3	4.3	63.8

SOURCE: Reprint Courtesy of IBM Corporation ©

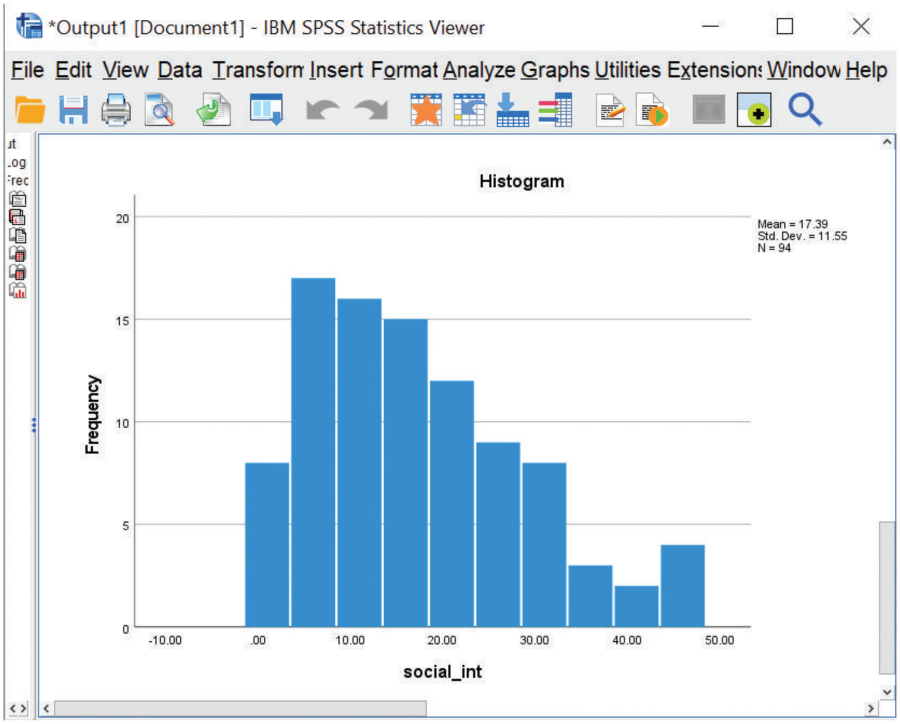
As you will see, SPSS automatically produces a column with the cumulative percentage (or percentile) for each value. (Note: It is possible to create grouped frequency tables in SPSS, but since it is not a straightforward process, we do not cover it here.)

Creating a Histogram

1. Enter the scores from your distribution in one column of the data window.
2. *Analyze*.
3. *Descriptive statistics*.
4. *Frequencies*.
5. the variable you want to make a histogram of and then the arrow.
6. *Charts*, *Histograms*, *Continue*.
7. Optional: To instruct SPSS *not* to produce a frequency table, the box labeled *Display frequency tables* (this *un*checks the box).
8. *OK*.

Practice these steps by creating a histogram for the social interactions example in this chapter (the scores are listed on p. 8). Your output window should look like Figure 1–18. Notice that SPSS automatically creates a histogram based on a grouped frequency table. (Should you wish, you can change the number of intervals or the interval size for the histogram by doing the following: Place your mouse cursor on the histogram and double to bring up a Chart Editor window; place your mouse cursor over one of the bars in the histogram and double to bring up a Properties window; *Binning*; *Custom*; *Number of intervals* or *Interval Width*; then enter the number of intervals or the interval size you want; *Apply*. If you want a nongrouped histogram, type in "1" for the interval width.)

Figure 1–18 SPSS histogram for the social interactions example.



SOURCE: Reprint Courtesy of IBM Corporation ©

Chapter Note

1. Most research articles follow the procedure we recommend here: Going from lowest at the top to highest at the bottom. However, some statistics authorities recommend going from highest at the top to lowest at the bottom.

Answers to "How are you doing?"

1–1 Answers

1. (a) crankiness, (b) 2, (c) 1 to 7.
2. A numeric variable has values that are numbers that tell you the degree or extent of what the variable measures; a nominal variable has values that are different categories and have no particular numerical order.
3. (a) nominal, (b) equal-interval, (c) rank-order.
4. A discrete variable has specific values and has no values between the specific values. A continuous variable has, in theory, an infinite number of values between any two values.

1–2 Answers

1. A frequency table is a systematic listing of the number of scores (the frequency) of each value in the group studied.
2. A frequency table makes it easy to see the pattern in a large group of scores.
3.

Value	Frequency	Percent
4	2	28.6
5	3	42.9
6	1	14.3
7	1	14.3

4. A grouped frequency table groups the frequencies of adjacent values into intervals.
5. Nominal variables are categories, they do not have a meaningful order. Cumulative frequencies refer to frequencies of values at or below a particular value, which is necessary for having an order.

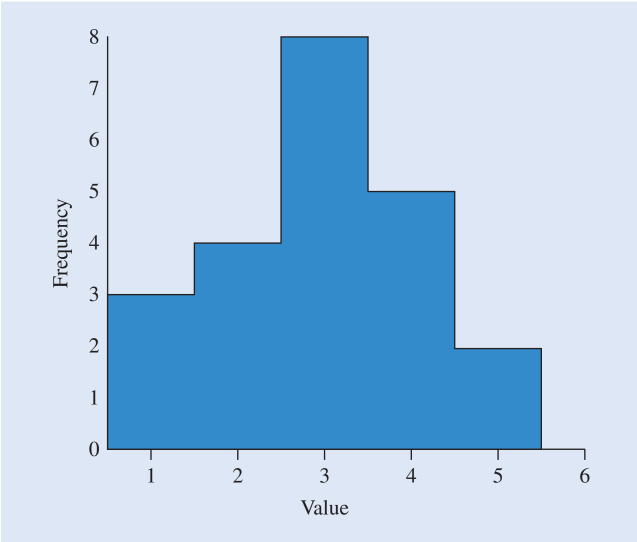
1–3 Answers

1. Researchers make histograms to show the pattern visually in a frequency table.
2. (a) The values, from lowest to highest go along the bottom; (b) the frequencies from 0 at the bottom to the highest frequency of any value at the top go along the left edge; (c) above each value is a bar with a height of the frequency for that value.
3. See Figure 1–19.
4. A histogram based on a nominal variable has gaps between the bars and is called a bar graph.

1–4 Answers

1. (a) A unimodal distribution has one main high point; a multimodal distribution has more than one main high point. (b) A unimodal distribution has one value with a higher frequency than all the other frequencies; a multimodal distribution has more than one value with large frequencies compared to the values around it.
2. When a distribution is skewed to the left, fewer scores have low values than have high values.
3. (a) A floor effect creates a distribution that is skewed to the right; (b) a ceiling effect creates a distribution that is skewed to the left.
4. The distribution is being compared to a normal curve.

Figure 1–19 Histogram for "How are you doing?" question 3.



Chapter 2
Central Tendency and Variability

Learning Objectives

2–1 Calculate the three representative measures of a group of scores

2–2 Calculate two standard measures of the variability of a group of scores

2–3 Consider the limitations of summarizing many different scores by their mean

2–4 Interpret research data based on standard indicators of central tendency and variability

Several recent studies have asked students to record their dreams each morning for a week or two (e.g., Mikulincer, Shaver, & Avihou-Kanza, 2011; Plailly, Villalba, Vallat, Nicolas, & Ruby, 2019; Selterman, Apetroaia, Reila, & Aron, 2014). In a typical study, the total number of dreams per week for 10 students might be as follows: 7, 8, 8, 7, 3, 1, 6, 9, 3, 8. How might you make this group of scores more understandable?

Tip for Success Before beginning this chapter, you should be sure that you are comfortable with the key terms **VARIABLE, SCORE,** *and* **VALUE** that we considered in chapter *Displaying the Order in a Group of Numbers Using Tables and Graphs*.

One way to gain that understanding is to use the tables and graphs you learned about in chapter *Displaying the Order in a Group of Numbers Using Tables and Graphs*. Another way, which you will learn in this chapter, is to use numbers to describe and summarize a group of scores such as this.

First, you can describe a group of scores in terms of a *representative* (or *typical*) *value*, such as an average. A representative value gives the *central tendency* of a group of scores. A representative value is a simple way, with a single number, to describe a group of scores (and there may be hundreds—or even thousands—of scores). The main representative value we consider is the *mean*. Next, we focus on ways of describing how the numbers are spread out in a group of scores. In other words, we consider the amount of variation, or *variability*, among the scores. The two measures of variability you will learn about are called the *variance* and *standard deviation*.

In this chapter, for the first time in this text, you will use statistical formulas. Such formulas are not here to confuse you. Hopefully, you will come to see that they actually simplify things and provide a very straightforward, concise way of describing statistical procedures. To help you grasp what such formulas mean in words, whenever we present formulas in this text, we always also give the "translation" in ordinary English.

2.1 Central Tendency

2–1 Calculate the three representative measures of a group of scores

central tendency
typical or most representative value of a group of scores.

The **central tendency** of a group of scores (a distribution) refers to the middle of the group of scores. You will learn about three measures of central tendency: *mean*, *mode*, and *median*. Each measure of central tendency uses its own method to come up with a single number describing the middle of a group of scores. We start with the mean, the most commonly used measure of central tendency. Understanding the mean is also an important foundation for much of what you learn in later chapters.

2.1.1 The Mean

mean
arithmetic average of a group of scores; sum of the scores divided by the number of scores.

Usually the best measure of central tendency is the ordinary average, the sum of all the scores divided by the number of scores. In statistics, this is called the **mean**. The average, or mean, of a group of scores is a representative value. Consider again the example from the start of the chapter, in which 10 students recorded their total number of dreams during the last weeks. The mean of the 10 scores $(7, 8, 8, 7, 3, 1, 6, 9, 3, 8)$ is 6 (the sum of 60 dreams divided by 10 students). That is, on the average, each student had 6 dreams in the past week. The information for the 10 students is thus summarized by the single number 6.

You can think of the mean as a kind of balancing point for the distribution of scores. Try it by visualizing a board balanced over a log, like a rudimentary teeter-totter. Imagine piles of blocks set along the board according to their values, one for each score in the distribution (like a bar graph made of blocks). The mean is the point on the board where the weight of the blocks on one side balances exactly with the weight on the other side. Figure 2–1 shows this for the number of dreams for the 10 students.

Mathematically, you can think of the mean as the point at which the total distance to all the scores above that point equals the total distance to all the scores below that point. Let's first figure the total distance from the mean to all the scores above the mean for the dreams example shown in Figure 2–1. There are two scores of 7, each of which is 1 unit above 6 (the mean). There are three scores of 8, each of which is 2 units above 6. And, there is one score of 9, which is 3 units above 6. This gives a total distance of 11 units $(1 + 1 + 2 + 2 + 2 + 3)$ from the mean to all the scores above the mean. Now, let's look at the scores below the mean. There are two scores of 3, each of which is 3 units below 6 (the mean). And there is one score of 1, which is 5 units below 6. This gives a total distance of 11 units $(3 + 3 + 5)$ from the mean to all of the scores below the mean. Thus, you can see that the total distance from the mean to the scores above the mean is the same as the total distance from the mean to the scores below the mean. The scores above the mean balance out the scores below the mean (and vice-versa).

Some other examples are shown in Figure 2–2. Notice that there doesn't have to be a block right at the balance point. That is, the mean doesn't have to be a score actually in the distribution. The mean is the average of the scores, the balance point. The mean can be a decimal number, even if all the scores in the distribution have to be whole numbers (a mean of 2.30 children, for example). For each distribution in Figure 2–2, the total distance from the mean to the scores above the mean is

Figure 2–1 Mean of the distribution of the number of dreams during a week for 10 students, illustrated using blocks on a board balanced on a log.

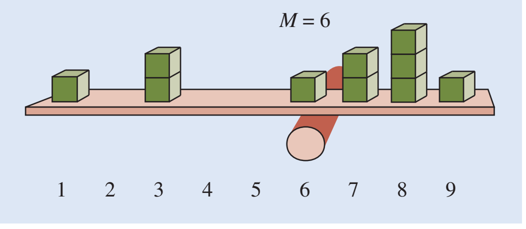
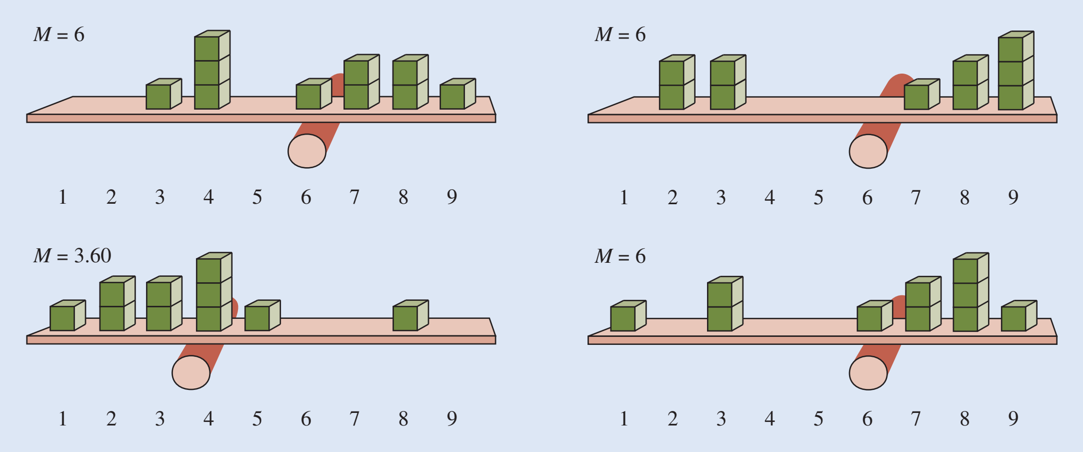


Figure 2–2 Means of various distributions illustrated with blocks on a board balanced on a log.



the same as the total distance from the mean to the scores below the mean. (By the way, this analogy to blocks on a board, in reality, works out precisely only if the board has no weight of its own.)

Formula for the Mean and Statistical Symbols The rule for figuring the mean is to add up all the scores and divide by the number of scores. Here is how this rule is written as a formula:

$$M = \frac{\sum X}{N} \quad \text{(2–1)}$$

The mean is the sum of the scores divided by the number of scores.

M is a symbol for the mean. An alternative symbol, $\bar{X}$ ("X-bar"), is sometimes used. However, M is almost always used in published research articles, as recommended by the style guidelines of the American Psychological Association (2020). You will see $\bar{X}$ used mostly in advanced statistics texts and in articles *about* statistics. In fact, there is not a standard agreement for many of the symbols used in statistics. (In this text we generally use the symbols most widely found in psychology research articles.)

M
mean.

Tip for Success Think of each formula as a statistical recipe, with statistical symbols as ingredients. Before you use each formula, be sure you know what each symbol stands for. Then carefully follow the formula to come up with the end result.

Σ, the capital Greek letter sigma, is the symbol for "sum of." It means "add up all the numbers for whatever follows." It is the most common special arithmetic symbol used in statistics.

X stands for the scores in the distribution of the variable X. We could have picked any letter. However, if there is only one variable, it is usually called X. In later chapters we use formulas with more than one variable. In those formulas, we use a second letter along with X (usually Y) or subscripts (such as X_1 and X_2).

$\sum X$ is "the sum of X." This tells you to add up all the scores in the distribution of the variable X. Suppose X is the number of dreams of our 10 students: $\sum X$ is $7 + 8 + 8 + 7 + 3 + 1 + 6 + 9 + 3 + 8$, which is 60.

Σ
sum of; add up all the scores following this symbol.

X
scores in the distribution of the variable *X*.

N stands for number—the number of scores in a distribution. In our example, there are 10 scores. Thus, N equals 10.[1]

N
number of scores in a distribution.

Overall, the formula says to divide the sum of all the scores in the distribution of the variable X by the total number of scores, N. In the dreams example, this means you divide 60 by 10. Put in terms of the formula,

$$M = \frac{\sum X}{N} = \frac{60}{10} = 6$$

Additional Examples of Figuring the Mean Consider the examples from chapter *Displaying the Order in a Group of Numbers Using Tables and Graphs*. The stress ratings of the 30 students in the first week of their statistics class were:

8, 7, 4, 10, 8, 6, 8, 9, 9, 7, 3, 7, 6, 5, 0, 9, 10, 7, 7, 3, 6, 7, 5, 2, 1, 6, 7, 10, 8, 8

In this previous chapter, we summarized all of these numbers into a frequency table (Table 1–3). Now, you can summarize all of this information as a single number by figuring the mean. Figure the mean by adding up all the stress ratings and dividing by the number of stress ratings. That is, you add up the 30 stress ratings: $8 + 7 + 4 + 10 + 8 + 6 + 8 + 9 + 9 + 7 + 3 + 7 + 6 + 5 + 0 + 9 + 10 + 7 + 7 + 3 + 6 + 7 + 5 + 2 + 1 + 6 + 7 + 10 + 8 + 8$, for a total of 193. Then you divide this total by the number of scores, 30. In terms of the formula,

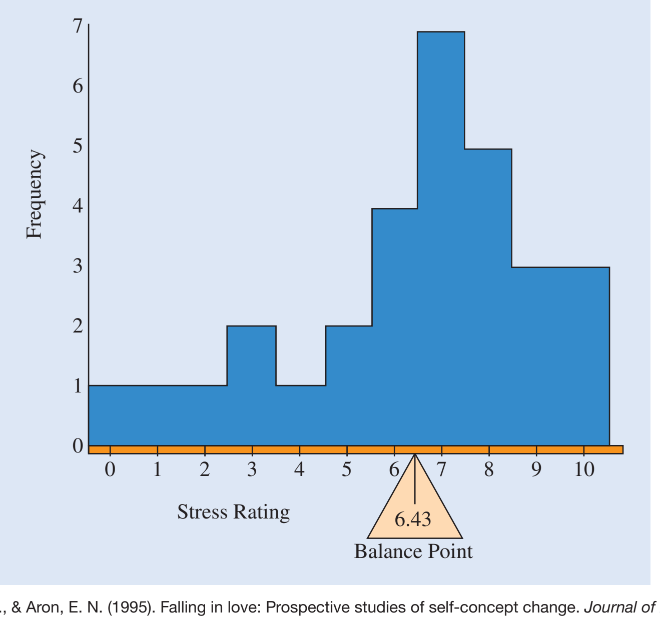
$$M = \frac{\sum X}{N} = \frac{193}{30} = 6.43$$

Tip for Success When an answer is not a whole number, we suggest that you use two more decimal places in the answer than for the original numbers. In this example, the original numbers did not use decimals, so we rounded the answer to two decimal places.

This tells you that the average stress rating was 6.43 (after rounding off). This is clearly higher than the middle of the 0–10 scale. You can also see this on a graph. Think again of the histogram as a pile of blocks on a board and the mean of 6.43 as the point where the board balances on the fulcrum (see Figure 2–3). This single representative value simplifies the information in the 30 stress scores.

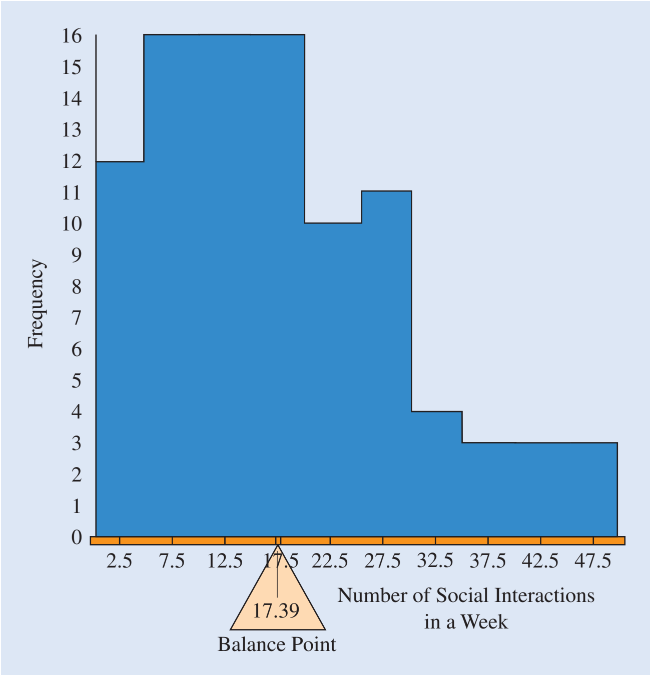
Similarly, consider the example of students' social interactions (Boykin et al., 2021) described in chapter *Displaying the Order in a Group of Numbers Using Tables and Graphs*. The actual number of interactions over a week for the 94 students are listed on page 9. In this previous chapter, we organized the original scores into a frequency table (see Table 1–5). We can now take those same 94 scores, add them up, and divide by 94 to figure the mean:

Figure 2–3 Analogy of blocks on a board balanced on a fulcrum showing the means for 30 statistics students' ratings of their stress level.



SOURCE: Aron, A., Paris, M., & Aron, E. N. (1995). Falling in love: Prospective studies of self-concept change. *Journal of Personality and Social Psychology*, 69, 1102–1112.

Figure 2–4 Analogy of blocks on a board balanced on a fulcrum illustrating the mean for number of social interactions during a week for 94 college students. (Data from Boykin et al., 2021)



$$M = \frac{\sum X}{N} = \frac{1,635}{94} = 17.39$$

This tells us that during this week these students had an average of 17.39 social interactions. Figure 2–4 shows the mean of 17.39 as the balance point for the 94 social interaction scores.

Steps for Figuring the Mean Figure the mean in two steps.

❶ **Add up all the scores.** That is, figure $\sum X$.

❷ **Divide this sum by the number of scores.** That is, divide $\sum X$ by N.

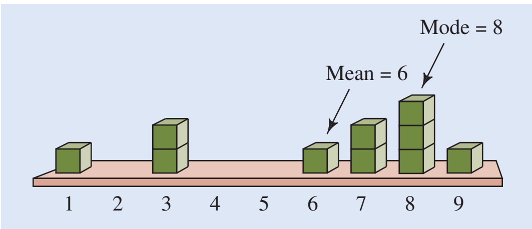
2.1.2 The Mode

The **mode** is another measure of central tendency. The mode is the most common single value in a distribution. In our dreams example, the mode is 8. This is because there are three students with 8 dreams and no other particular number of dreams with as many students. Another way to think of the mode is that it is the particular value with the largest frequency in a frequency table, the high point or peak of a distribution's histogram (as shown in Figure 2–5).

mode value with the greatest frequency in a distribution.

In a perfectly symmetrical unimodal distribution, the mode is the same as the mean. However, what happens when the mean and the mode are not the same? In that situation, the mode is

Figure 2–5 Mode as the high point in a distribution's histogram, using the example of the number of dreams during a week for 10 students.



usually not a very good way of describing the central tendency of the scores in the distribution. In fact, sometimes researchers compare the mode to the mean to show that the distribution is *not* perfectly symmetrical. Also, the mode can be a particularly poor representative value because it does not reflect many aspects of the distribution. For example, you can change some of the scores in a distribution without affecting the mode—but this is not true of the mean, which is affected by any changes in the scores in the distribution (see Figure 2–6).

On the other hand, the mode *is* the usual way of describing the central tendency for a nominal variable. In fact, the mode is the only measure of central tendency that would be appropriate for a nominal variable given that categories cannot be meaningfully added together (as needed to calculate the mean); nor can they be ordered (as needed to calculate the median). For example, if you know the religions of a particular group of people, the mode tells you for this group which religion has the most people in it. However, when it comes to figuring central tendency for numerical variables in psychology research, the mode is rarely used.

2.1.3 The Median

median
middle score when all the scores in a distribution are arranged from lowest to highest.

Another alternative to the mean is the **median**. If you line up all the scores from lowest to highest, the middle score is the median. Figure 2–7 shows the scores for the number of dreams lined up from lowest to highest. In this example, the fifth and sixth scores (the two middle ones) are both 7s. Either way, the median is 7.

> **Tip for Success** When figuring the median, remember that the first step is to line up the scores from lowest to highest. Forgetting to do this is the most common mistake students make when figuring the median.

When you have an even number of scores, the median can be between two different scores. In that situation, the median is the average (the mean) of those two scores.

Figure 2–6 Effect on the mean and on the mode of changing some scores, using the example of the number of dreams during a week for 10 students.

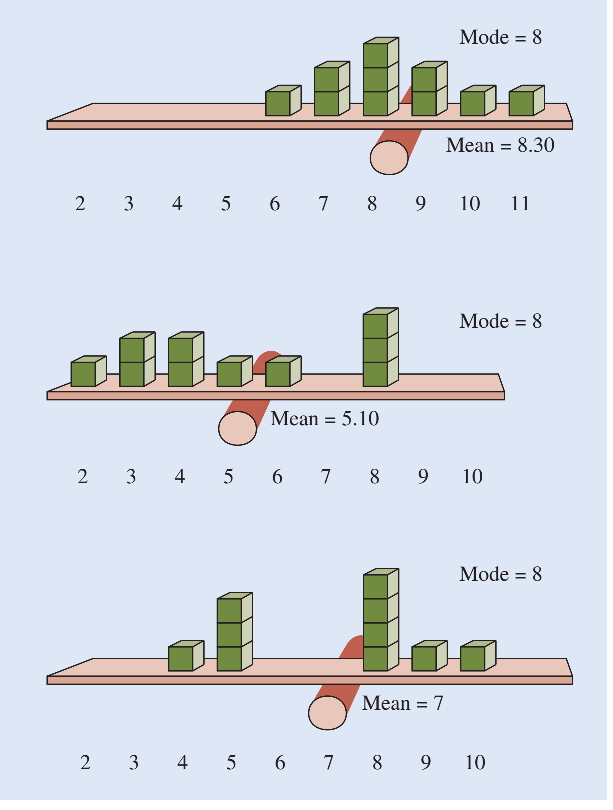
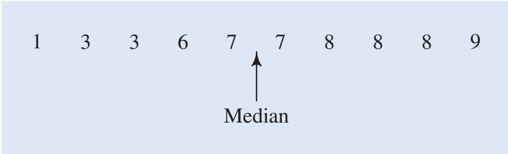


Figure 2–7 The median is the middle score when scores are lined up from lowest to highest, using the example of the number of dreams during a week for 10 students.



Steps for Finding the Median Finding the median takes three steps.

❶ **Line up all the scores from lowest to highest.**

❷ **Figure how many scores there are to the middle score by adding 1 to the number of scores and dividing by 2.** For example, with 29 scores, adding 1 and dividing by 2 gives you 15. The 15th score is the middle score. If there are 50 scores, adding 1 and dividing by 2 gives you 25.5. Because there are no half scores, the 25th and 26th scores (the scores on either side of 25.5) are the middle scores.

❸ **Count up to the middle score or scores.** If you have one middle score, this is the median. If you have two middle scores, the median is the average (the mean) of these two scores.

2.1.4 Comparing the Mean, Mode, and Median

Sometimes, the median is better than the mean (or mode) as a representative value for a group of scores. This happens when a few extreme scores would strongly affect the mean but would not affect the median. Reaction time scores are a common example in psychology research. Suppose you are asked to press a key as quickly as possible when a picture of a particular political candidate is shown on the computer screen. On five showings of the candidate, your times (in seconds) to respond are .74, .86, 2.32, .79, and .81. The mean of these five scores is 1.1040: that is, $(\sum X)/N = 5.52/5 = 1.1040$. However, this mean is very much influenced by the one very long time (2.32 seconds). (Perhaps you were distracted just when the candidate's picture was shown.) The median is much less affected by the extreme score. The median of these five scores is .81—a value that is much more representative of most of the scores. Thus, using the median deemphasizes the one extreme time, which is probably appropriate. An extreme score like this is called an **outlier**. In this example, the outlier was much higher than the other scores, but in other cases an outlier may be much lower than the other scores in the distribution.

outlier
score with an extreme value (very high or very low) in relation to the other scores in the distribution.

The importance of whether you use the mean, mode, or median can be seen in a long-standing controversy among psychologists studying the evolutionary basis of human mate choice. One classic set of theorists (e.g., Buss & Schmitt, 1993) argued that over their lives, men should prefer to have many partners, but women should prefer to have just one reliable partner. This is because a woman can have only a small number of children in a lifetime and her genes are most likely to survive if those few children are well taken care of. Men, however, can have a great many children in a lifetime. Therefore, according to the theory, a shotgun approach is best for men, because their genes are most likely to survive if they have a great many partners. Consistent with this assumption, evolutionary psychologists have found that men report wanting far more partners than do women.

Other theorists, from early on (e.g., Miller & Fishkin, 1997), however, have questioned this view. They argue that women and men should prefer about the same number of partners. This is because individuals with a basic predisposition to seek a strong intimate bond are most likely to have babies that survive infancy. This desire for strong bonds, they argue, remains in adulthood. These theorists also asked a sample of women and men how many partners they wanted. They found the same result as the previous researchers when using the mean: Women wanted a mean of 2.8 partners, men a mean of 64.3 partners. However, the situation looks drastically different if you look at the median or mode (see Table 2–1). Table 2–2, based on the data in their article, shows why. Most women and most men want just one partner. A few want more, some

Table 2–1 Responses of a Sample of Women and Men to the Question, "How many partners would you ideally desire in the next 30 years?"

	Mean	Median	Mode
Women	2.8	1	1
Men	64.3	1	1

SOURCE: Data from Miller, L. C., & Fishkin, S. A. (1997). On the dynamics of human bonding and reproductive success: Seeking windows on the adapted-for human-environmental interface, In J. Simpson & D. T. Kenrick (Eds.) *Evolutionary social psychology*. Mahwah, NJ: Erlbaum.

Table 2–2 Ideal Number of Partners Desired in the Next 30 Years

Number of Partners Desired in the Next 30 Years	Men %	Women %
0	5	1
1	47	64
2	4	6
3	4	5
4	8	1
5	4	5
6	4	4
7	1	2
8	1	6
9	2	1
10	2	2
11 to 20	10	2
21 to 30	3	1
31 to 40	1	0
41 to 50	1	0
51 to 60	0	0
61 to 70	0	0
71 to 80	0	0
81 to 90	0	0
91 to 100	0	0
100 to 1000	2	0
1001 to 10000	1	0

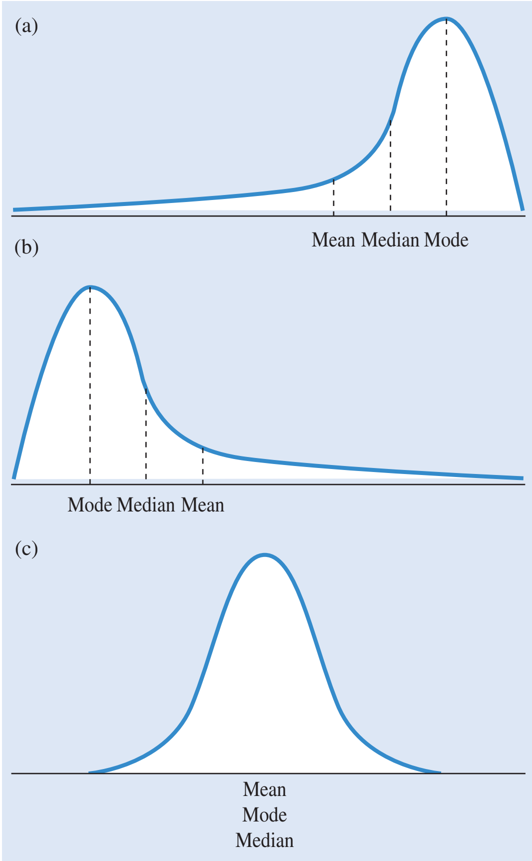
NOTE: Numbers are based on graphed data reported in Miller & Fishkin (1997).

SOURCE: Based on J. Simpson & D. T. Kenrick (Eds.), *Evolutionary social psychology 1997* (pp. 197–235). Mahwah, NJ: Erlbaum. (Published by Taylor and Francis).

many more. The big difference is that there are a lot more men in the small group that want many more than one partner. Similar results have also been found in some subsequent studies (e.g., Pedersen et al., 2002).

So, which theory is right? You could argue either way from these results. (For a more recent discussion of this controversy regarding both theoretical and statistical issues, see Mitchell et al., 2019.) The point is that focusing just on the mean can clearly misrepresent the reality of the distribution. As this example shows, the median is most likely to be used when a few extreme scores would make the mean unrepresentative of the main body of scores. Figure 2–8 illustrates this point, by showing the relative location of the mean, mode, and median for three types of distribution that you learned about in chapter *Displaying the Order in a Group of Numbers Using Tables and Graphs*. The distribution in Figure 2–8a is skewed to the left (negatively skewed); the long tail of the distribution points to the left. The mode in this distribution is the highest point of the distribution, which is on the far right-hand side of the distribution. The median is the point at which half of the scores are above that point and

Figure 2–8 Locations of the mean, mode, and median on (a) a distribution skewed to the left, (b) a distribution skewed to the right, and (c) a normal curve.



half are below. As you can see, for that to happen, the median must be a lower value than the mode. Finally, the mean is strongly influenced by the very low scores in the long tail of the distribution and is thus a lower value than the median. Figure 2–8b shows the location of the mean, mode, and median for a distribution that is skewed to the right (positively skewed). In this case, the mean is a higher value than either the mode or median because the mean is strongly influenced by the very *high* scores in the long tail of the distribution. Again, the mode is the highest point of the distribution, and the median is between the mode and the mean. In Figures 2–8a and 2–8b, the mean is not a good representative value of the scores, because it is overly influenced by the extreme scores.

Figure 2–8c shows a normal curve. As for any distribution, the mode is the highest point in the distribution. For a normal curve, the highest point falls exactly at the midpoint of the distribution. This midpoint is the median value, since half of the scores in the distribution are below that point and half are above it. The mean also falls at the same point because the normal curve is symmetrical about the midpoint, and every score in the left-hand side of the curve has a matching score on the right-hand side. So, for a perfect normal curve, the mean, mode, and median are always the same value.

In some situations, psychologists use the median as part of more complex statistical methods. Also, the median is the usual way of describing the central tendency for a rank-order variable. Otherwise, unless there are extreme scores, psychologists almost always use the mean as the representative value of a group of scores. In fact, as you will learn, the mean is a fundamental building block for most other statistical techniques.

A summary of the mean, mode, and median as measures of central tendency is shown in Table 2–3.

Table 2–3 Summary of Measures of Central Tendency

Measure	Definition	When Used
Mean	Sum of the scores divided by the number of scores	• With equal-interval variables • Most commonly used in psychology research
Mode	Value with the greatest frequency in a distribution	• With nominal variables • Rarely used in psychology research
Median	Middle score when all the scores in a distribution are arranged from lowest to highest	• With rank-ordered variables • When a distribution has one or more outliers • Less frequently used in psychology research

2–1 How are you doing?

1. Name and define three measures of central tendency.
2. Write the formula for the mean and define each of the symbols.
3. Figure the mean of the following scores: 2, 3, 3, 6, and 6.
4. For the following scores, find (a) the mean, (b) the mode, and (c) the median: 5, 3, 2, 13, 2. (d) Why is the mean different from the median?

2.2 Variability

2–2 Calculate two standard measures of the variability of a group of scores

Researchers also want to know how spread out the scores are in a distribution. This tells you the amount of variability in the distribution. For example, suppose you were asked, "How old are the students in your statistics class?" At a city-based university with many returning and part-time students, the mean age might be 29 years. You could answer, "The average age of the students in my class is 29." However, this would not tell the whole story. You could have a mean of 29 because every student in the class was exactly 29 years old. If this is the case, the scores in the distribution are not spread out at all. In other words, there is no variation, or *variability*, among the scores. You could also have a mean of 29 because exactly half the class members were 19 and the other half 39. In this situation, the distribution is much more spread out; there is considerable variability among the scores in the distribution.

You can think of the variability of a distribution as the amount of spread of the scores around the mean. In other words, how close or far from the mean are the scores in a distribution? If the scores are mostly quite close to the mean, then the distribution has less variability than if the scores are further from the mean. Distributions with the same mean can have very different amounts of spread around the mean; Figure 2–9a shows histograms for three different frequency distributions with the same mean but different amounts of spread around the mean. A possible real-life example of this is shown in Figure 2–10, which shows the distributions of the housing prices in two neighborhoods: one with diverse housing types and the other with a consistent type of housing. As with Figure 2–10a, the mean housing price is the same in each neighborhood. However, the distribution for the neighborhood with diverse housing types is much more spread out around the mean than the distribution for the neighborhood that has a consistent type of housing. This tells you that there is much greater variability in the prices of housing in the neighborhood with diverse types of housing than in the neighborhood with a consistent housing type. Also, distributions with different means can have the same amount of spread around the mean. Figure 2–9b shows three different distributions with different means but the same amount of spread. So, although the mean provides a representative value of a group of scores, it doesn't tell you about the variability of the scores. You will now learn about two measures of the variability of a group of scores: the *variance* and *standard deviation*.[2]