# **An Introduction to Statistical Thinking**

#### Dan Schafer

## **Table of Contents**

### PART I: STATISTICAL CONCLUSIONS AND THEIR UNCERTAINTY

| CHAPTER                               | STATISTICS  | STATISTICAL   | NUMERICAL                    | CRITICAL-                         | ELEMENTS |
|---------------------------------------|---|---|------------------------------|-----------------------------------|----------|
|                                       | STORIES   | IDEAS   | AND                          | THINKING                          | OF DATA  |
|                                       |   |   | GRAPHICAL                    | TOOLS                             | ANALYSIS |
|                                       |   |   | SKILLS                       |                                   |          |
| Chapter1<br>Statistics as a Branch of | John Arbuthnott's<br>Use of a New<br>Reasoning Device | An Introduction to<br>Statistics and Statistical<br>Reasoning | Interpreting<br>Scatterplots | Identify the Parts of an Argument |          |
| Human Reasoning                       | 21048024449   | 210480211119  | Interpreting Bar             | Do the W's of the                 |          |
|                                       | Weighing the  | <b>Numerical Evidence</b>                                     | Charts                       | <b>Conclusion Match</b>           |          |
|                                       | Evidence on Weight and Death                          |   |                              | the W's of the Data?              |          |
|                                       |   |   |                              | Are Alternative                   |          |
|                                       |   |   |                              | Explanations                      |          |
|                                       | _   |   |                              | Overlooked?<br>Was the Product    | _        |
| Chapter 2                             | You Are More Likely                                   | Probability   | The Probability That         | Rule Misused?                     |          |
| What You Should Know                  | to Be Struck by                                       | 1 1 Obability   | All of Several Events        | Ruic Misuscu.                     |          |
| about Probability                     | Lightning Than  | <b>Conditional Probability</b>                                | Occur                        | Was a Conditional                 |          |
|                                       |   | and Independent Events  |                              | Probability                       |          |
|                                       | Probability and Sally                                 |   | The Probability That         | Confused?                         |          |
|                                       | Clark's Murder Trial                                  |   | at Least One of Two          | T 4 4 41                          |          |
|                                       |   |   | <b>Events Occurs</b>         | Interpreting the<br>Results of a  |          |
|                                       |   |   |                              | Screening Test                    |          |

### PART II: STATISTICAL REASONING: PROPORTIONS OR PERCENTAGES

| CHAPTER   | STATISTICS<br>STORIES   | STATISTICAL<br>IDEAS  | NUMERICAL & GRAPHICAL | CRITICAL-<br>THINKING   | ELEMENTS OF<br>DATA   |
|---|---|---|-----------------------|---|---|
|   |   |   | SKILLS                | TOOLS   | ANALYSIS  |
| CHAPTER 3 Understanding Statistical Significance from Randomized Experiments  | Echinacea for Cold<br>Prevention<br>Acupuncture for<br>Smoking Cessation                                  | Hypothesis Testing— Something you Already Do  Randomized Experiments  Uncertain Conclusions from Randomized Experiments |                       | The Fallacy of Accepting the Null Hypothesis  Statistical Significance is Not Practical Significance  Evaluating Conclusions from Medical Experiments | Entering Data In a<br>Spreadsheet<br>Making a Bar Chart<br>with a Computer<br>Program |
| CHAPTER 4<br>Understanding Statistical<br>Significance from Random<br>Samples | Racial Profiling  A Public Opinion Poll about Racial Profiling  | Observational Studies Random Samples Uncertain Conclusions from Random Samples  |                       | Anecdotal Evidence The Volvo Fallacy  |   |
| CHAPTER 5<br>Understanding Confidence<br>Intervals                            | The Kinsey Reports<br>on Sexual Behavior<br>Exit Poll Errors in<br>the 2004 U.S.<br>Presidential Election | Confidence Interval Reasoning Interpreting Confidence Intervals A Confidence Interval for a Single Proportion           |                       | Evaluating Statistical Conclusions from Non-Random Samples  Questions to Ask of Public Opinion Polls  |   |

## PART III: STATISTICAL REASONING: QUANTITATIVE VARIABLES

| CHAPTER  | STATISTICS  | STATISTICAL   | NUMERICAL &  | CRITICAL-  | ELEMENTS OF  |
|--|---|---|--|--|--|
|  | STORIES   | IDEAS   | GRAPHICAL  | THINKING   | DATA   |
|  |   |   | SKILLS   | TOOLS  | ANALYSIS   |
| CHAPTER 6 Population Distributions and Their Characteristics                     | Karl Pearson's Contribution to Human Reasoning The Changing Distribution of Household Incomes | Visualizing the<br>Distribution of a<br>Quantitative Variable<br>Summarizing a<br>Population Distribution | Reading Box Plots<br>and Histograms<br>Sample Mean and<br>Standard Deviation | When Can Populations be Compared by their Centers?  Which is Better, the Mean or the Median? | Getting Summary Statistics with a Computer  Making Histograms with a Computer                          |
| CHAPTER 7 Statistical Significance and Confidence Intervals for Population Means | Gender Differences<br>in Intelligence Test<br>Scores<br>Gender Differences<br>in SAT Scores   | Sampling Distributions<br>of Sample Means<br>Statistical Conclusions<br>about a Single<br>Population Mean | Reading Normal Probabilities  Percentage of Variability Explained            |  | A Fundamental Tool:<br>the Two-Sample t-<br>Test<br>What Can Go Wrong<br>with the Two-Sample<br>t-Test |
|  |   | Statistical Conclusions<br>about the Difference<br>between Two Means                                      |  |  | _  |
| CHAPTER 8<br>Statistical Significance and<br>Confidence Intervals for            | The Clever Hans<br>Effect   | Reasoning from<br>Random Assignment, II   |  | The Accumulation of Scientific Evidence  | A Multi-Purpose<br>Tool: the<br>Randomization Test   |
| Treatment Effects  | The Pygmalion Effect  | Using Tools Devised for<br>Random Samples on<br>Data from Randomized<br>Experiments                       |  | Publication Bias   | The Two-Sample t-<br>Test for Randomized<br>Experiments  |

## PART IV: STATISTICAL CONCLUSIONS ABOUT CAUSATION

| CHAPTER                              | STATISTICS<br>STORIES  | STATISTICAL<br>IDEAS  | NUMERICAL &<br>GRAPHICAL<br>SKILLS                                 | CRITICAL-<br>THINKING<br>TOOLS  | ELEMENTS OF<br>DATA<br>ANALYSIS   |
|--------------------------------------|--|---|--|---|---|
| CHAPTER 9 Causation and Probability  | Ronald Fisher's Contribution to Reasoning about Causation  Ronald Fisher, Smoking, and Lung Cancer | Causation and Confounding Variables  Statistical Conclusions of Causation from Randomized Experiments |  | Association is not Causation!  Is There a Downside to Randomized Experiments? | The Randomization Test for Categorical Response  Fundamental Tools for 2x2 Tables of Counts |
| CHAPTER 10 Causation and Correlation | Sex Discrimination  Cloud Seeding and  Rainfall  | Causation and Quantitative Responses  Correlation  Dose-Response Relationships                        | Properties of<br>Logarithms<br>Multiplicative<br>Treatment Effects | Simpson's Paradox<br>Are There Lurking<br>Variables?                          | Two Sample Analysis after Log Transformation Comparing Medians                              |

### PART V: WHAT YOU SHOULD KNOW ABOUT STATISTICAL MODELING

| CILA DEED  |  | CT A TICTLO A I   | NILIMEDICAL  | CDITICAL   | EL EMENIES OF   |
|--|--|---|--|--|---|
| CHAPTER  | STATISTICS   | STATISTICAL   | NUMERICAL &  | CRITICAL-  | ELEMENTS OF   |
|  | STORIES  | IDEAS   | GRAPHICAL  | THINKING   | DATA  |
|  |  |   | SKILLS   | TOOLS  | ANALYSIS  |
| CHAPTER 11 Statistical Modeling                                      | Heights of Fathers<br>and Sons in Galton's<br>Biological<br>Measurement<br>Laboratory<br>Percentiles of Weight<br>and Height | Models for Conditional<br>Means<br>Statistical Modeling                                       | Correlation<br>Coefficient<br>Interpolation and<br>Extrapolation | The Regression<br>Effect Fallacy<br>Critical Thinking<br>About Extrapolation                       | Simple Linear<br>Regression  What Can go Wrong<br>with Simple Linear<br>Regression? |
| CHAPTER 12 Association,<br>and Prediction with<br>Statistical Models | Trends in Standard<br>of Living<br>Internet Disease Risk<br>Calculators  | Multiple Regression<br>Models<br>Questions That May be<br>Answered with<br>Statistical Models | Linear and<br>Exponential<br>Relationships<br>Rate of Change     | Multiplicity<br>The Data Dredging<br>Fallacy   | Customizing<br>Scatterplots<br>Scatterplots and<br>Logarithms                       |
| Chapter 13 Comparing Two Groups after Accounting for Other Variables | The Bell Curve Predicting Future Salaries of Eighth Graders (NYLS)   | Full and Reduced<br>Models<br>What You Should<br>Know about Interaction                       | Coded Scatterplots  The Arithmetic of Analysis of Variance       | The Texas Sharp<br>Shooter Fallacy and<br>the Clustering<br>Illusion<br>The Role of Sample<br>Size | Making a Coded<br>Scatterplot<br>Analysis of Variance<br>from a Computer            |

| Chapter 14 Special Types of Statistical Models | Were Donner Party Females More Likely to Survive Than Males? Risk Factors for Breast Cancer | Regression and<br>Regression-Like<br>Methods<br>What you Should Know<br>About Statistical<br>Theory |  | What You Should Know About Statistical Assumptions What Can Go Wrong with a Statistical Analysis? | Finding Your Way in<br>a Statistical<br>Computer Package<br>What Statistical<br>Analyses You Can Do<br>On Your Own |
|--|---|---|--|---|--|
|--|---|---|--|---|--|

#### **APPENDIXES**

| APPENDIX A What Statisticians Do | Education of Statisticians             |  |  |
|----------------------------------|--|--|--|
| What Statisticians Do            | Statistical Careers                    |  |  |
| APPENDIX B                       | Medical and Health                     |  |  |
| Key Ideas and Tools,             | Information                            |  |  |
| by Application Topic             | Surveys and Public<br>Opinion Polls    |  |  |
|                                  | Statistical Evidence in<br>Legal Cases |  |  |
|                                  | Consumer Information                   |  |  |
|                                  | Statistics in the News                 |  |  |
| APPENDIX C A<br>Summary of       |  |  |  |

| Fundamental<br>Statistical Tools<br>APPENDIX D<br>Glossary |  |  |  |
|--|--|--|--|
|  |  |  |  |