Contents

Preface	xv
Acknowledgments	xxv
Part I: Organization and description of data	
Tare i. Organization and description of data	
1 The organization of data	2
The meaning of data	3
Quantitative data	3
Types of quantitative data	3 3
Representations of data	4
Tabular representation	
Graphic representation	10
Exercises 1.1	13
Summary	16
2 Describing distributions	18
Descriptive statistics	19
Desirable properties of descriptive statistics	20
Statistical shorthand	21
Exercises 2.1	24
Describing the location of a distribution	26
The mode: Mo.	27
The median: \widetilde{x}	28
Exercises 2.2	37
The mean: \bar{x}	39
Exercises 2.3	44
Describing the dispersion of a distribution	48
The range	49
The mean difference among observations	50
The mean deviation from the mean	51

Part

The variance and standard deviation	52
Exercises 2.4	59
Describing the shape of a distribution Skewness	62
Kurtosis	63 68
Exercises 2.5	71
Summary	73
3 Describing individuals in distributions	78
•	
Percentile ranks and percentiles A special case: the median	79 82
Percentiles with ungrouped scores	83
Exercises 3.1	84
Standardization	85
Measurement in the sciences	86
Establishing common scales of measurement	87
The standard score, z	92
Exercises 3.2	95
Summary	96
4 Describing joint distributions of data	98
The scatter diagram	99
The concept of a statistical relation	101
Exercises 4.1	104
Quantitative description of a statistical relation	106
The covariance C_{XY}	107
Exercises 4.2	110
The correlation coefficient r_{XY}	110
Exercises 4.3	121
Linear regression	125
The regression equation: prediction and error	126
Interpreting regression Exercises 4.4	131
Summary	134
Summary	137
Postscript to Part I	140
Graphs and statistics: two sides of a coin	140
Outliers	142
Intervals and scales	143
Statistical description as data exploration	147
II: Probability	
5 Introduction to probability	150
The classical approach to probability	152
The probability of E_1 and E_2 : the multiplication theorem	
one manapheanon meorem	156

The probability of E_1 or E_2 : the addition theorem Exercises 5.1	160 163
Counting results of more complicated experiments Exercises 5.2	165 177
	180
Other approaches to probability The relative frequency approach to probability	180
The relative frequency approach to probability The mathematical definition of probability	182
Summary	184
Summary	10-
6 Discrete probability distributions	186
Introduction: the notion of a probability distribution	187
Discrete and continuous random variables	187
The uniform distribution	189
Describing probability distributions	189
Standardized random variables	198
Exercises 6.1	200
The binomial distribution	203
The binomial experiment	204
The expected value and variance of a binomial	209
random variable The standardized binomial random variable	20s 21s
Exercises 6.2	214
Representation of probability distributions	
of discrete random variables	217
Tabular representation	217
Graphic representation	218
Functional representation	220
Exercises 6.3	220
Summary	221
7 Continuous probability distributions	224
The uniform distribution revisited: probability	
as area and the notion of probability density ϕ	225
Cumulative probability P	231 231
Exercises 7.1	
The normal distribution	232
The effects of sample size on the histogram for the binomial distribution	234
The probability histogram for the standardized	20-
binomial random variable	238
The standard normal random variable	240
The standard normal restaurance of the table of cumulative probabilities	
for the standard normal curve	244
Exercises 7.2	250
The normal approximation to the binomial	25.
The nonstandard normal random variable	260
Exercises 7.3	264

Representation of probability distributions	
of continuous random variables	268
Tabular representation	268
Graphic representation	268
Functional representation	269
Summary	269
art III: Introduction to statistical inference	
8 Sampling distributions and estimation	274
Populations and samples	275
Sampling as a random experiment	278
Statistics as random variables	279
Exercises 8.1	281
Sampling distributions	281
The sampling distribution of the mean $ \overline{\! X} $	282
Exercises 8.2	292
Estimation	295
Point estimation	296
Interval estimation	305
Exercises 8.3	318
Summary	321
9 Hypothesis testing	326
Outline and example of hypothesis testing	327
Formulation	328
Decisions	329
Data collection	330
Conclusions	330
Foundations of hypothesis testing	330
Formulation	330
Decisions	334
Exercises 9.1	341
Data collection	352
Conclusions	356
Exercises 9.2	360
Evaluation of the statistical test	363
The concept of power	363
The power of a test against a composite alternative	004
hypothesis Scientific versus statistical significance	364 366
Postscript: decisions concerning hypotheses	900
	000
about proportions Test statistics: Z and Z	368
Test statistics: Z_X and $Z_{X/N}$ Upper-tailed tests, lower-tailed tests,	368
and two-tailed tests	369
THE CHARGE BODD	600

	Contents	Хİ
Significance level and adjustments for continuity		370
Exercises 9.3		372
Summary		375
10 Testing hypotheses about population means	,	380
A "textbook" example: the Neanderthal problem		382
Formulation		383
Decisions		384
Data collection		386
Conclusions		387
The power of the statistical test		387
Testing hypotheses about one population mean μ		388
Large samples $(N \ge 30)$		389
Exercises 10.1		398
Small samples ($N < 30$): Student's t		401
Exercises 10.2		408
Exercises 10.3		413
Testing hypotheses about two population means μ_1		
and μ_2		417
Formulation		418 419
Decisions		419 424
Exercises 10.4 Data collection		436
Testing hypotheses about two population		100
		439
proportions p_1 and p_2 Exercises 10.5		441
		448
Summary		110
11 Testing hypotheses about population variances		454
The χ^2 family of distributions		455
Expected value and expected variance of $\chi^2(\nu)$		456
Properties of χ^2 distributions		457
The addition and subtraction of χ^2 random		
variables		460
Testing hypotheses about one population		
variance σ^2		461
Formulation		461
Decisions		462
Exercises 11.1		467
Fisher's F distribution		470
Testing hypotheses about two population variances		
σ_1^2 and σ_2^2		471
Formulation		471
Decisions		471
Exercises 11.2		474
Summary		478

12 Testing hypotheses about many population means	
$\mu_1, \mu_1, \dots, \mu_J$: introduction to analysis of variance	482
Double summation notation	483
The algebra of double summations	486
Exercises 12.1	487
Logic and overview of analysis of variance (ANOVA)	488 488
Formulation Decisions	490
Exercises 12.2	495
Foundations of analysis of variance	498
Assumptions underlying analysis of variance	498
The linear model for analysis of variance	500
Variability as sums of squares	504
Decisions: test statistic and rejection rule for ANOVA	509
Mean squares	509
Rejection rule for ANOVA	513 514
Results: the ANOVA summary table Exercises 12.3	514
Evaluation of analysis of variance: post hoc	010
comparisons	524
Formulation: hypotheses about contrasts	524
Scheffé's test statistic	526
Exercises 12.4	528
Summary	532
Part IV: Hypothesis testing: intermediate techniques	
13 More complex analyses of variance	538
Two-way analysis of variance	539
Interaction and the linear model for two-way	
ANOVA	542
Fixed effects and random effects Hypotheses and test statistics for two-way ANOVA	544
Analysis of variance for one experimental treatment	544
with repeated measures	554
Exercises 13.1	55 4
Summary	565
14 Testing hypotheses about covariance: correlation	
and regression	570
The joint distribution of two variables	571
Joint discrete probability distributions	571
Jointly distributed continuous random variables	577
Exercises 14.1	580

	Contents	XIII
The population correlation coefficient ρ		583
Testing hypotheses about ρ		583
Testing hypotheses about ρ_1 and ρ_2		588
Interpreting tests about ρ : linearity, reduction		
of uncertainty, and independence		590
Exercises 14.2		593
Regression		596
The population regression equation		596
Formulating hypotheses about regression		597
Test statistics: analysis of variance for regression		598
Exercises 14.3		607
Summary		609
15 Testing hypotheses about entire distributions:		
Pearson's <i>chi</i> -square		616
·		020
Testing hypotheses about one distribution:		
goodness-of-fit tests		619
Goodness of fit as a test of proportions		626
Exercises 15.1		628
Testing hypotheses about two or more distributions:		
tests of association		635
Tests of homogeneity		636
Tests of independence		644
The fourfold table		647
Exercises 15.2		649
Assumptions underlying Pearson's <i>chi</i> -square		656
Special applications of Pearson's chi-square		657
Goodness-of-fit test for normality		657
The median test		661
Fourfold point correlation: the phi coefficient		663
A test for correlated proportions		667
A test of homogeneity when expected frequencies		
are small		668
Exercises 15.3		670
Summary		674
Appendices		
I. The algebra of summations		682
-		686
II. Linear interpolation		688
III. Regression coefficients		692
IV. Scales of measurement		
V. The algebra of expectations		696
VI. Fundamentals of research design		704
VII. Sums of squares		708

xiv Contents

VIII.	Tables	716
	1. Uniformly distributed random numbers	716
	2. The binomial probability distribution	716
	3. Cumulative probabilities for the standard	
	normal random variable	724
	4. Student's <i>t</i> -values for selected	
	cumulative probabilities	726
	5. Chi-square values for selected cumulative	
	probabilities	727
	6. Fisher's <i>F</i> -values for selected cumulative	
	probabilities	729
	7. The Poisson probability distribution	
	for selected values of μ	744
IX.	Solutions to odd-numbered exercises	746
Inde	x	840