

CONTENTS

Preface	xix
How to use this book	xxv
Acknowledgements	xxx
Dedication	xxxiii
Symbols used in this book	xxxiv
Some maths revision	xxxvi
1 Why is my evil lecturer forcing me to learn statistics?	1
1.1. What will this chapter tell me? ①	1
1.2. What the hell am I doing here? I don't belong here ①	2
1.2.1. The research process ①	3
1.3. Initial observation: finding something that needs explaining ①	4
1.4. Generating theories and testing them ①	4
1.5. Collect data to test your theory ①	7
1.5.1. Variables ①	7
1.5.2. Measurement error ①	11
1.5.3. Validity and reliability ①	12
1.5.4. Correlational research methods ①	13
1.5.5. Experimental research methods ①	14
1.5.6. Randomization ①	18
1.6. Analysing data ①	19
1.6.1. Frequency distributions ①	19
1.6.2. The centre of a distribution ①	21
1.6.3. The dispersion in a distribution ①	24
1.6.4. Using a frequency distribution to go beyond the data ①	28
1.6.5. Fitting statistical models to the data ①	32
1.7. Reporting data ①	34
1.7.1. Dissemination of research ①	34
1.7.2. Knowing how to report data ①	35
1.7.3. Some initial guiding principles ①	35
1.8. Brian's attempt to woo Jane ①	37
1.9. What next? ①	37
1.10. Key terms that I've discovered	38
1.11. Smart Alex's tasks	38
1.12. Further reading	39

2	Everything you never wanted to know about statistics	40
2.1.	What will this chapter tell me? ①	40
2.2.	Building statistical models ①	41
2.3.	Populations and samples ①	42
2.4.	Statistical models ①	44
2.4.1.	The mean as a statistical model ①	46
2.4.2.	Assessing the fit of a model: sums of squares and variance revisited ①	46
2.4.3.	Estimating parameters ①	50
2.5.	Going beyond the data ①	51
2.5.1.	The standard error ①	52
2.5.2.	Confidence intervals ②	54
2.6.	Using statistical models to test research questions ①	60
2.6.1.	Null hypothesis significance testing ①	60
2.6.2.	Problems with NHST ②	74
2.7.	Modern approaches to theory testing ②	78
2.7.1.	Effect sizes ②	79
2.7.2.	Meta-analysis ②	83
2.8.	Reporting statistical models ②	84
2.9.	Brian's attempt to woo Jane ①	85
2.10.	What next? ①	86
2.11.	Key terms that I've discovered	87
2.12.	Smart Alex's tasks	87
2.13.	Further reading	88
3	The IBM SPSS Statistics environment	89
3.1.	What will this chapter tell me? ①	89
3.2.	Versions of IBM SPSS Statistics ①	90
3.3.	Windows versus MacOS ①	90
3.4.	Getting started ①	90
3.5.	The data editor ①	91
3.5.1.	Entering data into the data editor ①	98
3.5.2.	The variable view ①	99
3.5.3.	Missing values ①	107
3.6.	Importing data ①	109
3.7.	The SPSS viewer ①	109
3.8.	Exporting SPSS output ①	113
3.9.	The syntax editor ③	113
3.10.	Saving files ①	115
3.11.	Retrieving a file ①	115
3.12.	Brian's attempt to woo Jane ①	116
3.13.	What next? ①	117
3.14.	Key terms that I've discovered	117
3.15.	Smart Alex's tasks	117
3.16.	Further reading	120
4	Exploring data with graphs	121
4.1.	What will this chapter tell me? ①	121
4.2.	The art of presenting data ①	122
4.2.1.	What makes a good graph? ①	122
4.2.2.	Lies, damned lies, and ... erm ... graphs ①	123

4.3.	The SPSS chart builder ①	125
4.4.	Histograms ①	127
4.5.	Boxplots (box-whisker diagrams) ①	131
4.6.	Graphing means: bar charts and error bars ①	135
4.6.1.	Simple bar charts for independent means ①	136
4.6.2.	Clustered bar charts for independent means ①	137
4.6.3.	Simple bar charts for related means ①	140
4.6.4.	Clustered bar charts for related means ①	143
4.6.5.	Clustered bar charts for 'mixed' designs ①	145
4.7.	Line charts ①	148
4.8.	Graphing relationships: the scatterplot ①	148
4.8.1.	Simple scatterplot ①	149
4.8.2.	Grouped scatterplot ①	151
4.8.3.	Simple and grouped 3-D scatterplots ①	153
4.8.4.	Matrix scatterplot ①	154
4.8.5.	Simple dot plot or density plot ①	157
4.8.6.	Drop-line graph ①	157
4.9.	Editing graphs ①	158
4.10.	Brian's attempt to woo Jane ①	161
4.11.	What next? ①	161
4.12.	Key terms that I've discovered	161
4.13.	Smart Alex's tasks	162
4.14.	Further reading	162
5	The beast of bias	163
5.1.	What will this chapter tell me? ①	163
5.2.	What is bias? ①	164
5.2.1.	Assumptions ①	165
5.2.2.	Outliers ①	165
5.2.3.	Additivity and linearity ①	167
5.2.4.	Normally distributed something or other ①	168
5.2.5.	Homoscedasticity/homogeneity of variance ②	172
5.2.6.	Independence ②	176
5.3.	Spotting bias ②	176
5.3.1.	Spotting outliers ②	176
5.3.2.	Spotting normality ①	179
5.3.3.	Spotting linearity and heteroscedasticity/heterogeneity of variance ②	192
5.4.	Reducing bias ②	196
5.4.1.	Trimming the data ②	196
5.4.2.	Winsorizing ①	198
5.4.3.	Robust methods ③	198
5.4.4.	Transforming data ②	201
5.5.	Brian's attempt to woo Jane ①	210
5.6.	What next? ①	210
5.7.	Key terms that I've discovered	211
5.8.	Smart Alex's tasks	211
5.9.	Further reading	212
6	Non-parametric models	213
6.1.	What will this chapter tell me? ①	213
6.2.	When to use non-parametric tests ①	214

6.3.	General procedure of non-parametric tests in SPSS ①	215
6.4.	Comparing two independent conditions: the Wilcoxon rank-sum test and Mann–Whitney test ①	217
6.4.1.	Theory ②	219
6.4.2.	Inputting data and provisional analysis ①	221
6.4.3.	The Mann–Whitney test using SPSS ①	223
6.4.4.	Output from the Mann–Whitney test ①	224
6.4.5.	Calculating an effect size ②	227
6.4.6.	Writing the results ①	227
6.5.	Comparing two related conditions: the Wilcoxon signed-rank test ①	228
6.5.1.	Theory of the Wilcoxon signed-rank test ②	228
6.5.2.	Running the analysis ①	230
6.5.3.	Output for the ecstasy group ①	231
6.5.4.	Output for the alcohol group ①	233
6.5.5.	Calculating an effect size ②	234
6.5.6.	Writing the results ①	234
6.6.	Differences between several independent groups: the Kruskal–Wallis test ①	236
6.6.1.	Theory of the Kruskal–Wallis test ②	236
6.6.2.	Follow-up analysis ②	238
6.6.3.	Inputting data and provisional analysis ①	239
6.6.4.	Doing the Kruskal–Wallis test in SPSS ①	241
6.6.5.	Output from the Kruskal–Wallis test ①	242
6.6.6.	Testing for trends: the Jonckheere–Terpstra test ②	246
6.6.7.	Calculating an effect size ②	248
6.6.8.	Writing and interpreting the results ①	249
6.7.	Differences between several related groups: Friedman's ANOVA ①	249
6.7.1.	Theory of Friedman's ANOVA ②	251
6.7.2.	Inputting data and provisional analysis ①	252
6.7.3.	Doing Friedman's ANOVA in SPSS ①	253
6.7.4.	Output from Friedman's ANOVA ①	254
6.7.5.	Following-up Friedman's ANOVA ②	256
6.7.6.	Calculating an effect size ②	256
6.7.7.	Writing and interpreting the results ①	257
6.8.	Brian's attempt to woo Jane ①	258
6.9.	What next? ①	259
6.10.	Key terms that I've discovered	259
6.11.	Smart Alex's tasks	259
6.12.	Further reading	261
7	Correlation	262
7.1.	What will this chapter tell me? ①	262
7.2.	Modelling relationships ①	263
7.2.1.	A detour into the murky world of covariance ①	264
7.2.2.	Standardization and the correlation coefficient ①	266
7.2.3.	The significance of the correlation coefficient ③	268
7.2.4.	Confidence intervals for r ③	269
7.2.5.	A word of warning about interpretation: causality ①	270
7.3.	Data entry for correlation analysis using SPSS ①	270
7.4.	Bivariate correlation ①	271
7.4.1.	General procedure for running correlations in SPSS ①	272
7.4.2.	Pearson's correlation coefficient ①	274
7.4.3.	Spearman's correlation coefficient ①	276

7.4.4.	Kendall's tau (non-parametric) ①	278
7.4.5.	Biserial and point-biserial correlations ③	279
7.5.	Partial correlation ②	281
7.5.1.	The theory behind part and partial correlation ③	281
7.5.2.	Partial correlation in SPSS ③	283
7.5.3.	Semi-partial (or part) correlations ②	285
7.6.	Comparing correlations ③	285
7.6.1.	Comparing independent r s ③	285
7.6.2.	Comparing dependent r s ③	286
7.7.	Calculating the effect size ①	287
7.8.	How to report correlation coefficients ①	288
7.9.	Brian's attempt to woo Jane ①	290
7.10.	What next? ①	290
7.11.	Key terms that I've discovered	291
7.12.	Smart Alex's tasks	291
7.13.	Further reading	292

8 Regression 293

8.1.	What will this chapter tell me? ①	293
8.2.	An introduction to regression ①	294
8.2.1.	The simple linear model ①	294
8.2.2.	The linear model with several predictors ②	296
8.2.3.	Estimating the model ②	298
8.2.4.	Assessing the goodness of fit, sums of squares, R and R^2 ①	300
8.2.5.	Assessing individual predictors ①	303
8.3.	Bias in regression models? ②	304
8.3.1.	Is the model biased by unusual cases? ②	304
8.3.2.	Generalizing the model ②	309
8.3.3.	Sample size in regression ③	313
8.4.	Regression using SPSS: One Predictor ①	314
8.4.1.	Regression: the general procedure ①	315
8.4.2.	Running a simple regression using SPSS ①	316
8.4.3.	Interpreting a simple regression ①	318
8.4.4.	Using the model ①	320
8.5.	Multiple regression ②	321
8.5.1.	Methods of regression ②	321
8.5.2.	Comparing models ②	324
8.5.3.	Multicollinearity ②	324
8.6.	Regression with several predictors using SPSS ②	326
8.6.1.	Main options ②	327
8.6.2.	Statistics ②	328
8.6.3.	Regression plots ②	329
8.6.4.	Saving regression diagnostics ②	331
8.6.5.	Further options ②	332
8.6.6.	Robust regression ②	333
8.7.	Interpreting multiple regression ②	334
8.7.1.	Descriptives ②	334
8.7.2.	Summary of model ②	335
8.7.3.	Model parameters ②	338
8.7.4.	Excluded variables ②	342
8.7.5.	Assessing multicollinearity ②	342
8.7.6.	Bias in the model: casewise diagnostics ②	345
8.7.7.	Bias in the model: assumptions ②	348

8.8.	What if I violate an assumption? Robust regression ②	350
8.9.	How to report multiple regression ②	352
8.10.	Brian's attempt to woo Jane ①	353
8.11.	What next? ①	354
8.12.	Key terms that I've discovered	354
8.13.	Smart Alex's tasks	354
8.14.	Further reading	356
9	Comparing two means	357
9.1.	What will this chapter tell me? ①	357
9.2.	Looking at differences ①	358
9.2.1.	An example: are invisible people mischievous? ①	359
9.2.2.	Categorical predictors in the linear model ①	362
9.3.	The <i>t</i> -test ①	364
9.3.1.	Rationale for the <i>t</i> -test ①	364
9.3.2.	The independent <i>t</i> -test equation explained ①	365
9.3.3.	The paired-samples <i>t</i> -test equation explained ①	368
9.4.	Assumptions of the <i>t</i> -test ①	371
9.5.	The independent <i>t</i> -test using SPSS ①	371
9.5.1.	The general procedure ①	371
9.5.2.	Exploring data and testing assumptions ①	372
9.5.3.	Compute the independent <i>t</i> -test ①	372
9.5.4.	Output from the independent <i>t</i> -test ①	373
9.5.5.	Calculating the effect size ②	376
9.5.6.	Reporting the independent <i>t</i> -test ①	377
9.6.	Paired-samples <i>t</i> -test using SPSS ①	378
9.6.1.	Entering data ①	378
9.6.2.	Exploring data and testing assumptions ①	378
9.6.3.	Computing the paired-samples <i>t</i> -test ①	383
9.6.4.	Calculating the effect size ①	386
9.6.5.	Reporting the paired-samples <i>t</i> -test ①	387
9.7.	Between groups or repeated measures? ①	388
9.8.	What if I violate the test assumptions? ②	388
9.9.	Brian's attempt to woo Jane ①	389
9.10.	What next? ①	389
9.11.	Key terms that I've discovered	389
9.12.	Smart Alex's tasks	390
9.13.	Further reading	391
10	Moderation, mediation and more regression	392
10.1.	What will this chapter tell me? ①	392
10.2.	Installing custom dialog boxes in SPSS ②	393
10.3.	Moderation: interactions in regression ③	395
10.3.1.	The conceptual model ③	395
10.3.2.	The statistical model ②	397
10.3.3.	Centring variables ②	398
10.3.4.	Creating interaction variables ②	400
10.3.5.	Following up an interaction effect ②	400
10.3.6.	Running the analysis ②	401
10.3.7.	Output from moderation analysis ②	402
10.3.8.	Reporting moderation analysis ②	407
10.4.	Mediation ②	408

10.4.1.	The conceptual model ②	408
10.4.2.	The statistical model ②	409
10.4.3.	Effect sizes of mediation ③	411
10.4.4.	Running the analysis ②	413
10.4.5.	Output from mediation analysis ②	414
10.4.6.	Reporting mediation analysis ②	418
10.5.	Categorical predictors in regression ③	419
10.5.1.	Dummy coding ③	419
10.5.2.	SPSS output for dummy variables ③	422
10.6.	Brian's attempt to woo Jane ①	426
10.7.	What next? ①	427
10.8.	Key terms that I've discovered	427
10.9.	Smart Alex's tasks	427
10.10.	Further reading	428
11	Comparing several means: ANOVA (GLM 1)	429
11.1.	What will this chapter tell me? ①	429
11.2.	The theory behind ANOVA ②	430
11.2.1.	Using a linear model to compare means ②	430
11.2.2.	Logic of the F -ratio ②	434
11.2.3.	Total sum of squares (SS_T) ②	436
11.2.4.	Model sum of squares (SS_M) ②	438
11.2.5.	Residual sum of squares (SS_R) ②	439
11.2.6.	Mean squares ②	440
11.2.7.	The F -ratio ②	441
11.2.8.	Interpreting F ②	442
11.3.	Assumptions of ANOVA ③	442
11.3.1.	Homogeneity of variance ②	442
11.3.2.	Is ANOVA robust? ③	444
11.3.3.	What to do when assumptions are violated ②	445
11.4.	Planned contrasts ②	445
11.4.1.	Choosing which contrasts to do ②	446
11.4.2.	Defining contrasts using weights ②	449
11.4.3.	Non-orthogonal comparisons ②	454
11.4.4.	Standard contrasts ②	456
11.4.5.	Polynomial contrasts: trend analysis ②	457
11.5.	<i>Post hoc</i> procedures ②	458
11.5.1.	Type I and Type II error rates for <i>post hoc</i> tests ②	458
11.5.2.	Are <i>post hoc</i> procedures robust? ②	459
11.5.3.	Summary of <i>post hoc</i> procedures ②	459
11.6.	Running one-way ANOVA in SPSS ②	460
11.6.1.	General procedure of one-way ANOVA ②	460
11.6.2.	Planned comparisons using SPSS ②	462
11.6.3.	<i>Post hoc</i> tests in SPSS ②	463
11.6.4.	Options ②	464
11.6.5.	Bootstrapping ②	465
11.7.	Output from one-way ANOVA ②	466
11.7.1.	Output for the main analysis ②	466
11.7.2.	Output for planned comparisons ②	469
11.7.3.	Output for <i>post hoc</i> tests ②	470
11.8.	Calculating the effect size ②	472
11.9.	Reporting results from one-way independent ANOVA ②	474
11.10.	Key terms that I've discovered	475

11.11. Brian's attempt to woo Jane ①	475
11.12. What next? ①	476
11.13. Smart Alex's tasks	476
11.14. Further reading	477
12 Analysis of covariance, ANCOVA (GLM 2)	478
12.1. What will this chapter tell me? ②	478
12.2. What is ANCOVA? ②	479
12.3. Assumptions and issues in ANCOVA ③	484
12.3.1. Independence of the covariate and treatment effect ③	484
12.3.2. Homogeneity of regression slopes ③	485
12.3.3. What to do when assumptions are violated ②	488
12.4. Conducting ANCOVA in SPSS ②	488
12.4.1. General procedure ①	488
12.4.2. Inputting data ①	488
12.4.3. Testing the independence of the treatment variable and covariate ②	488
12.4.4. The main analysis ②	490
12.4.5. Contrasts	490
12.4.6. Other options ②	491
12.4.7. Bootstrapping and plots ②	493
12.5. Interpreting the output from ANCOVA ②	493
12.5.1. What happens when the covariate is excluded? ②	493
12.5.2. The main analysis ②	494
12.5.3. Contrasts ②	497
12.5.4. Interpreting the covariate ②	497
12.6. Testing the assumption of homogeneity of regression slopes ③	499
12.7. Calculating the effect size ②	500
12.8. Reporting results ②	503
12.9. Brian's attempt to woo Jane ①	504
12.10. What next? ②	504
12.11. Key terms that I've discovered	505
12.12. Smart Alex's tasks	505
12.13. Further reading	506
13 Factorial ANOVA (GLM 3)	507
13.1. What will this chapter tell me? ②	507
13.2. Theory of factorial ANOVA (independent designs) ②	508
13.2.1. Factorial designs ②	508
13.2.2. Guess what? Factorial ANOVA is a linear model ③	509
13.2.3. Two-way ANOVA: behind the scenes ②	514
13.2.4. Total sums of squares (SS_T) ②	515
13.2.5. Model sum of squares, SS_M ②	516
13.2.6. The residual sum of squares, SS_R ②	519
13.2.7. The F -ratios ②	519
13.3. Assumptions of factorial ANOVA ③	520
13.4. Factorial ANOVA using SPSS ②	520
13.4.1. General procedure for factorial ANOVA ①	520
13.4.2. Entering the data and accessing the main dialog box ②	521
13.4.3. Graphing interactions ②	522
13.4.4. Contrasts ②	523
13.4.5. <i>Post hoc</i> tests ②	524
13.4.6. Bootstrapping and other options ②	524

13.5. Output from factorial ANOVA ②	526
13.5.1. Levene's test ②	526
13.5.2. The main ANOVA table ②	526
13.5.3. Contrasts ②	529
13.5.4. Simple effects analysis ③	530
13.5.5. <i>Post hoc</i> analysis ②	532
13.6. Interpreting interaction graphs ②	533
13.7. Calculating effect sizes ③	537
13.8. Reporting the results of two-way ANOVA ②	539
13.9. Brian's attempt to woo Jane ①	540
13.10. What next? ②	541
13.11. Key terms that I've discovered	541
13.12. Smart Alex's tasks	541
13.13. Further reading	542
14 Repeated-measures designs (GLM 4)	543
14.1. What will this chapter tell me? ②	543
14.2. Introduction to repeated-measures designs ②	544
14.2.1. The assumption of sphericity ②	545
14.2.2. How is sphericity measured? ②	545
14.2.3. Assessing the severity of departures from sphericity ②	546
14.2.4. What is the effect of violating the assumption of sphericity? ③	546
14.2.5. What do you do if you violate sphericity? ②	548
14.3. Theory of one-way repeated-measures ANOVA ②	548
14.3.1. The total sum of squares, SS_T ②	551
14.3.2. The within-participant sum of squares, SS_W ②	551
14.3.3. The model sum of squares, SS_M ②	552
14.3.4. The residual sum of squares, SS_R ②	553
14.3.5. The mean squares ②	553
14.3.6. The <i>F</i> -ratio ②	554
14.3.7. The between-participants sum of squares ②	554
14.4. Assumptions in repeated-measures ANOVA ③	555
14.5. One-way repeated-measures ANOVA using SPSS ②	555
14.5.1. Repeated-measures ANOVA: the general procedure ②	555
14.5.2. The main analysis ②	555
14.5.3. Defining contrasts for repeated measures ②	557
14.5.4. <i>Post hoc</i> tests and additional options ③	558
14.6. Output for one-way repeated-measures ANOVA ②	559
14.6.1. Descriptives and other diagnostics ①	559
14.6.2. Assessing and correcting for sphericity: Mauchly's test ②	560
14.6.3. The main ANOVA ②	560
14.6.4. Contrasts ②	563
14.6.5. <i>Post hoc</i> tests ②	565
14.7. Effect sizes for repeated-measures ANOVA ③	566
14.8. Reporting one-way repeated-measures ANOVA ②	568
14.9. Factorial repeated-measures designs ②	568
14.9.1. The main analysis ②	570
14.9.2. Contrasts ②	573
14.9.3. Simple effects analysis ③	573
14.9.4. Graphing interactions ②	574
14.9.5. Other options ②	574
14.10. Output for factorial repeated-measures ANOVA ②	576

14.10.1.	Descriptives and main analysis ②	576
14.10.2.	Contrasts for repeated-measures variables ②	581
14.11.	Effect sizes for factorial repeated-measures ANOVA ③	586
14.12.	Reporting the results from factorial repeated-measures ANOVA ②	587
14.13.	Brian's attempt to woo Jane ①	588
14.14.	What next? ②	589
14.15.	Key terms that I've discovered	589
14.16.	Smart Alex's tasks	589
14.17.	Further reading	590
15	Mixed design ANOVA (GLM 5)	591
15.1	What will this chapter tell me? ①	591
15.2.	Mixed designs ②	592
15.3.	Assumptions in mixed designs ②	593
15.4.	What do men and women look for in a partner? ②	593
15.5.	Mixed ANOVA in SPSS ②	594
15.5.1.	Mixed ANOVA: the general procedure ②	594
15.5.2.	Entering data ②	594
15.5.3.	The main analysis ②	596
15.5.4.	Other options ②	598
15.6.	Output for mixed factorial ANOVA ③	600
15.6.1.	The main effect of gender ②	602
15.6.2.	The main effect of looks ②	603
15.6.3.	The main effect of charisma ②	605
15.6.4.	The interaction between gender and looks ②	606
15.6.5.	The interaction between gender and charisma ②	607
15.6.6.	The interaction between attractiveness and charisma ②	608
15.6.7.	The interaction between looks, charisma and gender ③	611
15.6.8.	Conclusions ③	614
15.7.	Calculating effect sizes ③	615
15.8.	Reporting the results of mixed ANOVA ②	617
15.9.	Brian's attempt to woo Jane ①	620
15.10.	What next? ②	621
15.11.	Key terms that I've discovered	621
15.12.	Smart Alex's tasks	621
15.13.	Further reading	622
16	Multivariate analysis of variance (MANOVA)	623
16.1.	What will this chapter tell me? ②	623
16.2.	When to use MANOVA ②	624
16.3.	Introduction	624
16.3.1.	Similarities to and differences from ANOVA ②	624
16.3.2.	Choosing outcomes ②	625
16.3.3.	The example for this chapter ②	626
16.4.	Theory of MANOVA ③	626
16.4.1.	Introduction to matrices ③	626
16.4.2.	Some important matrices and their functions ③	628
16.4.3.	Calculating MANOVA by hand: a worked example ③	629
16.4.4.	Principle of the MANOVA test statistic ④	637
16.5.	Practical issues when conducting MANOVA ③	642
16.5.1.	Assumptions and how to check them ③	642

16.5.2.	What to do when assumptions are violated ③	643
16.5.3.	Choosing a test statistic ③	643
16.5.4.	Follow-up analysis ③	644
16.6.	MANOVA using SPSS ②	644
16.6.1.	General procedure of one-way ANOVA ②	644
16.6.2.	The main analysis ②	645
16.6.3.	Multiple comparisons in MANOVA ②	646
16.6.4.	Additional options ③	646
16.7.	Output from MANOVA ③	647
16.7.1.	Preliminary analysis and testing assumptions ③	647
16.7.2.	MANOVA test statistics ③	648
16.7.3.	Univariate test statistics ②	649
16.7.4.	SSCP matrices ③	650
16.7.5.	Contrasts ③	652
16.8.	Reporting results from MANOVA ②	652
16.9.	Following up MANOVA with discriminant analysis ③	654
16.10.	Output from the discriminant analysis ④	656
16.11.	Reporting results from discriminant analysis ②	660
16.12.	The final interpretation ④	660
16.13.	Brian's attempt to woo Jane ①	662
16.14.	What next? ②	663
16.15.	Key terms that I've discovered	663
16.16.	Smart Alex's tasks	664
16.17.	Further reading	664
17	Exploratory factor analysis	665
17.1.	What will this chapter tell me? ①	665
17.2.	When to use factor analysis ②	666
17.3.	Factors and components ②	667
17.3.1.	Graphical representation ②	668
17.3.2.	Mathematical representation ②	669
17.3.3.	Factor scores ②	671
17.4.	Discovering factors ②	674
17.4.1.	Choosing a method ②	674
17.4.2.	Communality ②	675
17.4.3.	Factor analysis or PCA? ②	675
17.4.4.	Theory behind PCA ③	676
17.4.5.	Factor extraction: eigenvalues and the scree plot ②	677
17.4.6.	Improving interpretation: factor rotation ③	678
17.5.	Research example ②	682
17.5.1.	General procedure ①	682
17.5.2.	Before you begin ②	683
17.6.	Running the analysis ②	686
17.6.1.	Factor extraction in SPSS ②	688
17.6.2.	Rotation ②	689
17.6.3.	Scores ②	691
17.6.4.	Options ②	691
17.7.	Interpreting output from SPSS ②	692
17.7.1.	Preliminary analysis ②	693
17.7.2.	Factor extraction ②	696
17.7.3.	Factor rotation ②	701
17.7.4.	Factor scores ②	704
17.7.5.	Summary ②	705

17.8.	How to report factor analysis ①	706
17.9.	Reliability analysis ②	706
17.9.1.	Measures of reliability ③	706
17.9.2.	Interpreting Cronbach's α (some cautionary tales) ②	709
17.9.3.	Reliability analysis in SPSS ②	710
17.9.4.	Reliability analysis output ②	712
17.10.	How to report reliability analysis ②	716
17.11.	Brian's attempt to woo Jane ①	716
17.12.	What next? ②	717
17.13.	Key terms that I've discovered	717
17.14.	Smart Alex's tasks	717
17.15.	Further reading	719
18	Categorical data	720
18.1.	What will this chapter tell me? ①	720
18.2.	Analysing categorical data ①	721
18.3.	Theory of analysing categorical data ①	721
18.3.1.	Pearson's chi-square test ①	721
18.3.2.	Fisher's exact test ①	723
18.3.3.	The likelihood ratio ②	724
18.3.4.	Yates's correction ②	724
18.3.5.	Other measures of association ①	725
18.3.6.	Several categorical variables: loglinear analysis ③	725
18.4.	Assumptions when analysing categorical data ①	735
18.4.1.	Independence ①	735
18.4.2.	Expected frequencies ①	735
18.4.3.	More doom and gloom ①	736
18.5.	Doing chi-square in SPSS ①	736
18.5.1.	General procedure for analysing categorical outcomes ①	736
18.5.2.	Entering data ①	736
18.5.3.	Running the analysis ①	738
18.5.4.	Output for the chi-square test ①	740
18.5.5.	Breaking down a significant chi-square test with standardized residuals ②	743
18.5.6.	Calculating an effect size ②	744
18.5.7.	Reporting the results of chi-square ①	746
18.6.	Loglinear analysis using SPSS ②	746
18.6.1.	Initial considerations ②	746
18.6.2.	Running loglinear analysis ②	748
18.6.3.	Output from loglinear analysis ③	750
18.6.4.	Following up loglinear analysis ②	753
18.7.	Effect sizes in loglinear analysis ②	755
18.8.	Reporting the results of loglinear analysis ②	756
18.9.	Brian's attempt to woo Jane ①	757
18.10.	What next? ①	757
18.11.	Key terms that I've discovered	758
18.12.	Smart Alex's tasks	758
18.13.	Further reading	759
19	Logistic regression	760
19.1.	What will this chapter tell me? ①	760
19.2.	Background to logistic regression ①	761

19.3. What are the principles behind logistic regression? ③	762
19.3.1. Assessing the model: the log-likelihood statistic ③	763
19.3.2. Assessing the model: the deviance statistic ③	763
19.3.3. Assessing the model: R and R^2 ③	764
19.3.4. Assessing the contribution of predictors: the Wald statistic ②	766
19.3.5. The odds ratio: $\exp(B)$ ③	766
19.3.6. Model building and parsimony ②	767
19.4. Sources of bias and common problems ④	768
19.4.1. Assumptions ②	768
19.4.2. Incomplete information from the predictors ④	769
19.4.3. Complete separation ④	770
19.4.4. Overdispersion ④	772
19.5. Binary logistic regression: an example that will make you feel eel ②	773
19.5.1. Building a model ①	774
19.5.2. Logistic regression: the general procedure ①	775
19.5.3. Data entry ①	775
19.5.4. Building the models in SPSS ②	775
19.5.5. Method of regression ②	776
19.5.6. Categorical predictors ②	776
19.5.7. Comparing the models ②	778
19.5.8. Rerunning the model ①	780
19.5.9. Obtaining residuals ②	781
19.5.10. Further options ②	781
19.5.11. Bootstrapping ②	782
19.6. Interpreting logistic regression ②	783
19.6.1. Block 0 ②	783
19.6.2. Model summary ②	783
19.6.3. Listing predicted probabilities ②	789
19.6.4. Interpreting residuals ②	789
19.6.5. Calculating the effect size ②	792
19.7. How to report logistic regression ②	792
19.8. Testing assumptions: another example ②	792
19.8.1. Testing for linearity of the logit ③	794
19.8.2. Testing for multicollinearity ③	794
19.9. Predicting several categories: multinomial logistic regression ③	797
19.9.1. Running multinomial logistic regression in SPSS ③	799
19.9.2. Statistics ③	802
19.9.3. Other options ③	803
19.9.4. Interpreting the multinomial logistic regression output ③	804
19.9.5. Reporting the results ②	811
19.10. Brian's attempt to woo Jane ①	811
19.11. What next? ①	811
19.12. Key terms that I've discovered	812
19.13. Smart Alex's tasks	812
19.14. Further reading	813
20 Multilevel linear models	814
20.1. What will this chapter tell me? ①	814
20.2. Hierarchical data ②	815
20.2.1. The intraclass correlation ②	816
20.2.2. Benefits of multilevel models ②	818

20.3	Theory of multilevel linear models ③	819
20.3.1.	An example ②	819
20.3.2.	Fixed and random coefficients ③	820
20.4	The multilevel model ④	823
20.4.1.	Assessing the fit and comparing multilevel models ④	825
20.4.2.	Types of covariance structures ④	826
20.5	Some practical issues ③	827
20.5.1.	Assumptions ③	827
20.5.2.	Robust multilevel models ③	828
20.5.3.	Sample size and power ③	829
20.5.4.	Centring predictors ③	829
20.6	Multilevel modelling using SPSS ④	830
20.6.1.	Entering the data ②	831
20.6.2.	Ignoring the data structure: ANOVA ②	831
20.6.3.	Ignoring the data structure: ANCOVA ②	836
20.6.4.	Factoring in the data structure: random intercepts ③	837
20.6.5.	Factoring in the data structure: random intercepts and slopes ④	841
20.6.6.	Adding an interaction to the model ④	845
20.7.	Growth models ④	849
20.7.1.	Growth curves (polynomials) ④	850
20.7.2.	An example: the honeymoon period ②	851
20.7.3.	Restructuring the data ③	853
20.7.4.	Running a growth model on SPSS ④	854
20.7.5.	Further analysis ④	860
20.8.	How to report a multilevel model ③	862
20.9.	A message from the octopus of inescapable despair ①	863
20.10.	Brian's attempt to woo Jane ①	864
20.11.	What next? ②	864
20.12.	Key terms that I've discovered	865
20.13.	Smart Alex's tasks	865
20.14.	Further reading	866
21	Epilogue: life after discovering statistics	867
21.1.	Nice emails	867
21.2.	Everybody thinks that I'm a statistician	868
21.3.	Craziness on a grand scale	868
21.3.1.	Statistics	868
21.3.2.	Cult of underlying numerical truths	869
21.3.3.	And then it got really weird	869
	Glossary	870
	Appendix	887
	References	899
	Index	908