

Contents

Preface to the Second Edition	ix
Preface	xi
Audience	xi
Teaching strategy	xii
How to use this book	xii
Installing the rethinking R package	xvi
Acknowledgments	xvi
Chapter 1. The Golem of Prague	1
1.1. Statistical golems	1
1.2. Statistical rethinking	4
1.3. Tools for golem engineering	10
1.4. Summary	17
Chapter 2. Small Worlds and Large Worlds	19
2.1. The garden of forking data	20
2.2. Building a model	28
2.3. Components of the model	32
2.4. Making the model go	36
2.5. Summary	46
2.6. Practice	46
Chapter 3. Sampling the Imaginary	49
3.1. Sampling from a grid-approximate posterior	52
3.2. Sampling to summarize	53
3.3. Sampling to simulate prediction	61
3.4. Summary	68
3.5. Practice	68
Chapter 4. Geocentric Models	71
4.1. Why normal distributions are normal	72
4.2. A language for describing models	77
4.3. Gaussian model of height	78
4.4. Linear prediction	91
4.5. Curves from lines	110
4.6. Summary	120
4.7. Practice	120
Chapter 5. The Many Variables & The Spurious Waffles	123
5.1. Spurious association	125
5.2. Masked relationship	144

5.3. Categorical variables	153
5.4. Summary	158
5.5. Practice	159
Chapter 6. The Haunted DAG & The Causal Terror	161
6.1. Multicollinearity	163
6.2. Post-treatment bias	170
6.3. Collider bias	176
6.4. Confronting confounding	183
6.5. Summary	189
6.6. Practice	189
Chapter 7. Ulysses' Compass	191
7.1. The problem with parameters	193
7.2. Entropy and accuracy	202
7.3. Golem taming: regularization	214
7.4. Predicting predictive accuracy	217
7.5. Model comparison	225
7.6. Summary	235
7.7. Practice	235
Chapter 8. Conditional Manatees	237
8.1. Building an interaction	239
8.2. Symmetry of interactions	250
8.3. Continuous interactions	252
8.4. Summary	260
8.5. Practice	260
Chapter 9. Markov Chain Monte Carlo	263
9.1. Good King Markov and his island kingdom	264
9.2. Metropolis algorithms	267
9.3. Hamiltonian Monte Carlo	270
9.4. Easy HMC: ulam	279
9.5. Care and feeding of your Markov chain	287
9.6. Summary	296
9.7. Practice	296
Chapter 10. Big Entropy and the Generalized Linear Model	299
10.1. Maximum entropy	300
10.2. Generalized linear models	312
10.3. Maximum entropy priors	321
10.4. Summary	321
Chapter 11. God Spiked the Integers	323
11.1. Binomial regression	324
11.2. Poisson regression	345
11.3. Multinomial and categorical models	359
11.4. Summary	365
11.5. Practice	366
Chapter 12. Monsters and Mixtures	369
12.1. Over-dispersed counts	369
12.2. Zero-inflated outcomes	376

12.3. Ordered categorical outcomes	380
12.4. Ordered categorical predictors	391
12.5. Summary	397
12.6. Practice	397
Chapter 13. Models With Memory	399
13.1. Example: Multilevel tadpoles	401
13.2. Varying effects and the underfitting/overfitting trade-off	408
13.3. More than one type of cluster	415
13.4. Divergent transitions and non-centered priors	420
13.5. Multilevel posterior predictions	426
13.6. Summary	431
13.7. Practice	431
Chapter 14. Adventures in Covariance	435
14.1. Varying slopes by construction	437
14.2. Advanced varying slopes	447
14.3. Instruments and causal designs	455
14.4. Social relations as correlated varying effects	462
14.5. Continuous categories and the Gaussian process	467
14.6. Summary	485
14.7. Practice	485
Chapter 15. Missing Data and Other Opportunities	489
15.1. Measurement error	491
15.2. Missing data	499
15.3. Categorical errors and discrete absences	516
15.4. Summary	521
15.5. Practice	521
Chapter 16. Generalized Linear Madness	525
16.1. Geometric people	526
16.2. Hidden minds and observed behavior	531
16.3. Ordinary differential nut cracking	536
16.4. Population dynamics	541
16.5. Summary	550
16.6. Practice	550
Chapter 17. Horoscopes	553
Endnotes	557
Bibliography	573
Citation index	585
Topic index	589