List of Examples

- 1. Page 18 Example of creating a completely randomized list of experiments for a bread dough rise experiment using base R commands, and storing it in an electronic data collection form.
- 2. Page 24 Calculation of least squares estimates from the bread dough rise experiment using R function 1m.
- 3. Page 25 Calculation of an estimable contrast of cell means from the bread dough rise experiment using the function fit.contrast from the R package gmodels.
- 4. Page 27 ANOVA table for bread dough rise experiment using R function aov.
- 5. Page 29 Creating graphs to verify the assumptions of the linear model fit to the bread dough rise experiment using R.
- 6. Page 32 R code to produce a Box-Cox plot for the bread dough rise experiment.
- 7. Page 33 Analysis of transformed data for the bread dough rise experiment using R.
- 8. Page 35 Weighted least squares analysis of data from the bread dough rise experiment using R.
- 9. Page 37 Generalized linear model fit to multinomial response data from a teaching experiment using the polr function in R package MASS.
- 10. Page 40 Power calculation for CRD model using R.
- 11. Page 42 Preplanned orthogonal comparisons using the function fit.contrast from the R package gmodels for data from the 1937 Rothamstead field experiment with sugar beets.
- 12. Page 43 Preplanned orthogonal polynomial contrasts for linear and quadratic trends in the bread dough rise experiment using R.
- 13. Page 44 Tukey's HSD multiple comparisons for data from the Rothamstead sugar beet experiment using R.
- 14. Page 45 Student Newman-Keuls multiple comparisons for data from the Rothamstead sugar beet experiment using the SNK.test function in R package agricolae.
- 15. Page 47 Dunnett's multiple comparisons for data from the Rothamstead sugar beet experiment using the glht function in R package multcomp.

- 16. Page 48 Hsu's MCB multiple comparisons with the best using the glht function in R package multcomp.
- 17. Page 60 Creating a randomized factorial plan in R for helicopter experiments.
- 18. Page 65 Analysis of a two-factor ANOVA of Hunter's CO emission data using R function aov.
- 19. Page 71 Power calculation for the two-factor factorial model using R.
- 20. Page 74 Analysis of a two-factor ANOVA of Hunter's CO emission data (with an unequal number of observations per cell) using function Anova from the R package car.
- 21. Page 77 Analysis of an unreplicated two-factor factorial with quantitative levels of the factors using R.
- 22. Page 80 Analysis of an unreplicated two-factor factorial with qualitative levels of the factors using the Tukey1df function in R package daewr.
- 23. Page 83 Analysis of a four-factor factorial with a binomial response.
- 24. Page 91 Analysis of a 2^3 design using R.
- 25. Page 97 Analysis of an unreplicated 2^4 design using the fullnormal function in R package daewr.
- 26. Page 99 Analysis of an unreplicated 2^4 design using a half-normal plot with the LGB function in the **daewr** package.
- 27. Page 100 Making an interaction plot with R.
- 28. Page 101 Making Lenth and Bayes plots of effects using the BsMD package.
- 29. Page 103 Detecting a single outlier in an unreplicated 2^k design using the Gaptest function in R package daewr.
- 30. Page 115 Creating an RCB design with R.
- 31. Page 115 Using the function design.rcbd in R package agricolae to create an RCB design with R.
- 32. Page 118 Analysis of an RCB design on the behavior of rats with R.
- 33. Page 121 Determining the number of blocks in an RCB design with R.
- 34. Page 123 Analysis of a factorial design in blocks using R.
- 35. Page 124 Example of a generalized complete block design.
- Page 130 Example of creating a Latin-square design using the design.lsd function in R package agricolae.
- 37. Page 131 Analysis of a Latin-square design in R.
- Page 147 Estimating variance components in a one-factor RSE using the method of moments with R.
- 39. Page 148 Calculating a confidence interval for variance components in a one-factor RSE.
- 40. Page 152 Estimating variance components in a one-factor RSE by REML using the lmer function in R package lme4.

xvi

- 41. Page 153 Asymptotic confidence interval for a variance component using the likelihood profile method using the profile function in R package lme4.
- 42. Page 154 Determining the sample size for a one-factor RSE with R.
- 43. Page 158 Estimating the variance components for a two-factor RSE using the method of moments with R.
- 44. Page 159 Estimating the variance components for a two-factor RSE by REML using the lmer function in R package lme4.
- 45. Page 160 Calculating a confidence interval for variance components in a two-factor RSE.
- 46. Page 163 Estimating the variance components for an unbalanced twofactor RSE using the lmer function in R package lme4.
- 47. Page 164 Calculating a confidence interval for variance components in an unbalanced two-factor RSE with R.
- 48. Page 166 Estimating the variance components for a nested sampling experiment (NSE) with R.
- 49. Page 170 Estimating the variance components for a staggered nested sampling experiment (SNSE).
- 50. Page 176 Analysis of a design with fixed and random factors.
- 51. Page 178 Analysis of a design with fixed and random factors using the lmer function in R package lme4.
- 52. Page 181 Graphical check of assumptions for a two-factor RSE with R.
- 53. Page 182 Gamma plot to check constant variance assumption in RSE with R.
- 54. Page 184 Half-normal plot to check constant variance assumption in a nested sampling experiment with R.
- 55. Page 187 Normal plot of estimated best linear predictors of random effects (EBLUPs) with R.
- 56. Page 195 Creating a half-fraction.
- 57. Page 198 Creating a half-fraction with R package FrF2.
- 58. Page 201 Analysis of the soup intermix half-fraction with R.
- 59. Page 205 Creating a $\frac{1}{4}$ fraction.
- 60. Page 206 Creating a $\frac{1}{8}$ fraction with R package FrF2.
- 61. Page 209 Creating a minimum abberation fractional factorial with R package FrF2.
- 62. Pages 211–212 Design and analysis of a $\frac{1}{16}$ fractional factorial fermentation experiment with R package FrF2.
- 63. Page 219 Augmenting a fractional factorial by foldover.
- 64. Page 220 Augmenting a fractional factorial with a mirror image using R package FrF2.

- 65. Page 223 Analysis of an augmented fractional factorial experiment on water purification.
- 66. Page 228 Augmenting a fractional factorial by optimal design using R package AlgDesign.
- 67. Page 230 Creating a Plackett-Burman design with R package FrF2.
- 68. Pages 231 and 234 Analysis of a Placktett-Burman experiment on weld repaired castings using R packages FrF2 and leaps.
- 69. Page 237 Making optimal column assignments in a Plackett-Burman design using the OptPB function in R package daewr.
- 70. Page 237 Retrieving one of Jones and Montgomery's (2010) alternative screening designs from a catalog using the Altscreen function in R package daewr.
- 71. Page 238 Retrieving one of Li and Nachtsheim's (2000) model robust factorial designs from a catalog using the ModelRobust function in R package daewr.
- 72. Page 239 Analyzing a screening design with complex aliasing using forward stepwise regression in R.
- 73. Page 240 Analyzing a screening design with complex aliasing using the HierAFS() function in R package daewr to ensure effect heredity.
- 74. Page 244 Finding an orthogonal array design with R package DoE.base.
- 75. Page 245 Finding a near orthogonal array design with R packages DoE.base and AlgDesign.
- 76. Page 247 Analysis of a main effects plan for a conjoint study using R.
- 77. Page 248 Recalling one of Jones and Nachtsheim's (2013) definitive screening designs using the DefScreen function in R package daewr.
- 78. Page 263 Checking for a possible BIB design using the **BIBsize** function in R package daewr.
- 79. Page 263 Creating a BIB design using the optBlock function in R package AlgDesign.
- 80. Page 266 Analysis of a BIB design using R.
- 81. Page 268 Analysis of a PBIB design using R.
- 82. Page 270 Creating a generalized cyclic PBIB design using the design.cyclic function in R package agricolae.
- 83. Page 272 Creating a row column design using the design.cyclic function in R package agricolae.
- 84. Page 273 Creating a confounded block 2^4 design using R package FrF2.
- 85. Page 275 Analysis of a confounded block 2^4 design using R.
- 86. Page 281 Creating a confounded block fractional factorial (2^{8-4}) design using R package FrF2.

xviii

- 87. Page 284 Creating a confounded block fractional factorial (2^{6-1}) design using R package FrF2.
- 88. Page 285 Creating a confounded block 3^2 design using the classical method.
- 89. Page 286 Creating a confounded block 3^4 design using the <code>optBlock</code> function in R package <code>AlgDesign</code>.
- 90. Page 288 Creating a confounded block $3^2 \times 2^2$ design using the classical method using the mod function in R package daewr.
- 91. Page 290 Creating a confounded block $3 \times 4 \times 6$ design using the classical method using the mod function in R package daewr.
- 92. Page 292 Creating a D-optimal confounded block $3 \times 4 \times 6$ design using the optBlock function in R package AlgDesign.
- 93. Page 294 Creating a blocked $4^1 \times 6^1 \times 2^3 \times 3^2$ orthogonal array design using the oa.design function in R package DoE.base.
- 94. Page 294 Creating a D-optimal blocked $4^1 \times 6^1 \times 2^3 \times 3^2$ orthogonal array design using the optBlock function in R package AlgDesign.
- 95. Page 296 Creating a partially confounded 2^2 design using the optBlock function in R package AlgDesign.
- 96. Page 297 Creating a partially confounded 3×2² design using the optBlock function in R package AlgDesign.
- 97. Page 298 Design and analysis of a partially confounded 4×3 design using gen.factorial and optBlock functions in R package AlgDesign.
- 98. Page 310 Design of a split-plot experiment with CRD in whole plots using R package AlgDesign.
- 99. Page 311 Design of a split-plot experiment with CRD in whole plots using R package ${\tt FrF2}.$
- 100. Page 313 ANOVA analysis of a balanced split-plot experiment with CRD in whole plots using R package GAD.
- 101. Page 314 REML analysis of a split-plot experiment with CRD in whole plots using R package lme4.
- 102. Page 318 Design of a split-plot experiment with RCB in whole plots using R package AlgDesign.
- 103. Page 320 Design and analysis of a split-plot experiment with RCB in whole plots using R packages FrF2 and 1me4.
- 104. Page 324 Analysis of an unreplicated split-plot experiment using R.
- 105. Page 330 Creating a fractional-factorial split-plot experiment using R package FrF2.
- 106. Pages 333–336 Creating a minimum aberration fractional-factorial splitplot experiment using R package FrF2.
- 107. Page 338 Design and analysis of a minimum aberration fractional-factorial split-plot experiment with R.

- 108. Page 353 Analysis of a two-period crossover study with R package car.
- 109. Page 355 Determining the sample size for a two-period crossover study with R.
- 110. Page 356 Analysis of a two-period crossover study to test carryover effects using the lmer function in R package lme4.
- 111. Page 360 Analysis of an extra-period crossover design with R.
- 112. Page 361 Calculating adjusted or least squares means of treatment effects from an extra-period crossover design using R package lsmeans.
- 113. Page 362 Creating a Williams's Latin-square crossover design using the williams function in the R package crossdes.
- 114. Page 364 Analysis of data from a Williams's Latin-square crossover design using R.
- 115. Page 368 Analysis of data from a repeated measures experiment using the R package GAD for a least-squares univariate split-plot analysis.
- 116. Page 369 Analysis of data from a repeated measures experiment using the R package lme4 for an REML univariate split-plot analysis.
- 117. Page 371 Testing the Huynh-Feldt condition using the Anova function in the R package car.
- 118. Page 372 Getting the Greenhouse-Geisser and Huynh-Feldt adjusted F-tests for a repeated measures design from the Anova function in the R package car.
- 119. Page 375 Calculating summary statistics over time for a repeated measures experiment using R.
- 120. Page 376 Conservative analysis of summary statistics for a repeated measures experiment using R.
- 121. Page 389 Creating a central composite with rsm package and making a variance dispersion graph with Vdgraph package R.
- 122. Page 395 Comparing small composite and central composite designs using the Vdgraph package.
- 123. Page 397 Creating a central composite design in coded units using rsm package.
- 124. Page 398 Creating a central composite design in actual units using rsm package.
- 125. Page 398 Creating a Box-Behnken design in actual units using rsm package.
- 126. Page 399 Recalling a hybrid design from a stored data frame in the Vdgraph package.
- 127. Page 400 Transforming a hybrid design from coded to actual factor levels.
- 128. Page 403 Creating a D-optimal design for fitting the general quadratic model using the AlgDesign package.

XX

- 129. Page 406 Creating a grid of candidate partial derivatives using R.
- 130. Page 407 Creating a D-optimal design for a nonlinear model using the AlgDesign package.
- 131. Page 408 Checking significance of pure quadratic terms using the rsm package.
- 132. Page 410 Fitting the general quadratic model using the rsm package.
- 133. Page 411 Fitting the general quadratic model with block terms using the rsm package.
- 134. Page 412 Fitting a nonlinear model using the R function nls.
- 135. Page 413 Making contour plots of a general quadratic model using the rsm package.
- 136. Page 414 Making 3D surface plots of a general quadratic model using the rsm package.
- 137. Page 415 Making contour plots and 3D surface plots of a general quadratic model at specified values of factors not on the axis, using the rsm package.
- 138. Page 417 Examining the stationary point of a general quadratic equation produced by the rsm package.
- 139. Page 418 Making contour plots or 3D surface plots at the stationary point using the rsm package.
- 140. Page 419 Using a ridge analysis to identify the maximum of a general quadratic model using the rsm package.
- 141. Page 421 Finding the maximum of a nonlinear model using R function constrOptim.
- 142. Page 424 Finding the maximum of a general quadratic model subject to a nonlinear constraint using R function constrOptim.
- 143. Page 426 Setting up desirability functions for multi-response optimization using the desirability package.
- 144. Page 427 Creating orthogonally blocked Box-Behnken designs using the rsm package.
- 145. Page 427 Creating orthogonally blocked central composite designs using the rsm package.
- 146. Page 428 Creating a blocked face-centered cube design using the optBlock function in the AlgDesign package.
- 147. Page 429 Blocking a subset of candidate points using the optBlock function in the AlgDesign package.
- 148. Page 430 Analyzing a blocked response surface design with more than two blocks using the rsm package.
- 149. Page 432 Fitting a general quadratic model to data from a split-plot experiment using REML in package lme4.

- 150. Page 438 Recalling a D-efficient estimation-equivalent split-plot response surface design using package daewr.
- 151. Page 456 Creating a simplex-lattice design and a simplex-centroid design with the mixexp package in R.
- 152. Page 457 Making a graphical representation of a simplex-lattice design with the mixexp package in R.
- 153. Page 459 Fitting the Scheffé special cubic model to data from a pesticide formulation experiment with R.
- 154. Page 460 Fitting the Scheffé quadratic model to data from a pesticide formulation experiment with R.
- 155. Page 461 Fitting the Scheffé quadratic model with the correct \mathbb{R}^2 statistic with R.
- 156. Page 462 Making a contour plot of a fitted Scheffé quadratic model in the simplex experimental region with the mixexp package in R.
- 157. Page 463 Making an effect plot a fitted Scheffé quadratic model with the mixexp package in R.
- 158. Page 468 Creating an extreme vertices design with the mixexp package in R.
- 159. Page 468 Creating a D-optimal subset of an extreme vertices design for fitting a Scheffé quadratic model with the mixexp and AlgDesign packages in R.
- 160. Page 470 Graphing the design points in the simplex of a D-optimal subset of an extreme vertices design for fitting a Scheffé quadratic model with the mixexp package in R.
- 161. Page 471 Fitting a Scheffé special cubic model to data from a D-optimal subset of an extreme vertices design with R.
- 162. Page 472 Making a contour plot of a fitted Scheffé quadratic model in pseudocomponent space with the mixexp package in R.
- 163. Page 474 Example of an orthogonally blocked mixture experiment.
- 164. Page 476 Flexible blocking of a simplex-lattice design with the mixexp and AlgDesign packages in R.
- 165. Page 477 Blocking an extreme-vertices design with the mixexp and AlgDesign packages in R.
- 166. Page 479 Creating a full-cross mixture process variable design with three mixture components and one process variable in R.
- 167. Page 481 Creating a full-cross mixture process variable design with three mixture components and two process variables in R.
- 168. Page 483 Creating a D-optimal design for a mixture process variable experiment with four mixture components and five process variables with the mixexp and AlgDesign packages in R.
- 169. Page 485 Analysis of a mixture process variable experiment with R.

xxii

- 170. Page 486 Finding the constrained optimum a model fit to a mixture experiment using R.
- 171. Page 488 Fitting a model to a split-plot mixture process variable experiment using R.
- 172. Page 507 A split-plot product-array parameter design experiment.
- 173. Page 509 Creating a product-array design using the oa.design and cross.design functions in R package DoE.base.
- 174. Page 509 A completely randomized product-array parameter design experiment.
- 175. Page 512 Creating an orthogonal array control factor design using the oa.design function in R package DoE.base.
- 176. Page 512 Use of a product-array parameter design experiment for a problem with a deterministic function.
- 177. Page 515 Loss model analysis of a product-array parameter design experiment using R.
- 178. Page 519 Loss model analysis of a product-array parameter design experiment for a deterministic function using R.
- 179. Page 523 Response model analysis of a split-plot product-array parameter design experiment using R.
- 180. Page 527 Creating orthonormal polynomial contrasts of a three-level factor in R.
- 181. Page 529 Response modeling analysis of a mixed two- and three-level product-array parameter-design experiment in R.
- 182. Page 532 A combined-array parameter design experiment.
- 183. Page 534 Analysis of a combined-array parameter design experiment using R.
- 184. Page 536 Analysis of a combined-array parameter design experiment involving a dispersion effect.
- 185. Page 543 Joint modeling of the mean and a dispersion effect in a product array parameter design experiment.
- 186. Page 564 An example of sequential experimentation and analysis of data from one of Jones and Nachtsheim's (2011) definitive screening designs using R.