

# ERRATUM (FOR THE FIRST PRINTING OF “BAYESIAN MODELING USING WINBUGS”)

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The following corrections were spotted in the first printing of the book and corrected to the second one.

## **Acknowledgements**

I would like to express my gratitude to Dimitris Fouskakis (National Technical University of Athens, Greece), Louis Kates (Canada), MaryAnn Morgan-Cox (Baylor University, USA), Hao Liya (China) and Stefanos Dimitrakopoulos (University of Warwick, UK) for their corrections and comments on the first printing of the book.

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**Major corrections****Chapter 2**

1. **Page 44, last line:** Change equation to

$$\log f(\boldsymbol{\theta}|\mathbf{y}) = \text{constant} + \log f(\mathbf{y}|\boldsymbol{\theta}) + \log f(\boldsymbol{\theta})$$

**Chapter 3**

1. **Page 102, R output above section 3.4.6.3 (in grey):** Must be replaced by

```

, , 1
  [,1] [,2] [,3]
[1,]   1   3   5
[2,]   7   9  11
[3,]  13  15  17
[4,]  19  21  23
[5,]  25  27  29

, , 2
  [,1] [,2] [,3]
[1,]   2   4   6
[2,]   8  10  12
[3,]  14  16  18
[4,]  20  22  24
[5,]  26  28  30

```

**Chapter 5**

1. **Page 161, 4th line of section 5.3.1:** The correct code is

```
mu[i] <- beta0 + beta[1] * x[i,1] + ... + beta[p]*x[i,p]
```

2. **Page 163, line 8 of Section 5.3.3:** The code must be replaced by the following

```
precision <- tau/c2
for (j in 1:P){ beta[j] ~ dnorm( beta0[j], precision ) }
```

3. **Page 164, line 7 from the bottom of the page:** “x” must be replaced by “X” (capital) twice.

**Chapter 7**

1. **Page 236, line 4:** Equation must be changed to

$$g(\pi) = \frac{\pi^{\lambda_1 - \lambda_2} - 1}{\lambda_1 - \lambda_2} - \frac{(1 - \pi)^{\lambda_1 + \lambda_2} - 1}{\lambda_1 + \lambda_2},$$

[equal must be replaced by minus sign].

2. **Page 238, 6th line from the bottom:** Equation must be changed to

$$E(Y|X = x + 1) = \beta_0 + \beta_1(x + 1) = \beta_0 + \beta_1x + \beta_1 = E(Y|X = x) + \beta_1 \Leftrightarrow$$

[ $E(y|X = x + 1)$  and  $\mu(x)$  was changed to  $E(Y|X = x + 1)$  and  $E(Y|X = x)$  respectively].

## Chapter 8

1. **Pages 279–280, last 3 lines of p.279 and 3 first lines of p.280:** WinBUGS code must be replaced by

```
for (i in 1:n){
  y[i] ~ dgamma( a[i], tau )
  a[i] <- mu[i]*tau
  log(mu[i]) <- eta[i]
}
s2 <- 1/tau
```

2. **Page 285, last paragraph:** Must be replaced by

Note that  $\lambda_j$  (i.e. the expected counts) have similar posterior means under both Poisson and negative binomial models, but have different posterior variance since the dispersion of the sampling distribution is larger for the NB model. This leads to posterior distributions with wider 95% posterior intervals for the  $\lambda_j$  of the NB model.

3. **Page 292, 1st line of code:** Delete the first line of the code.
4. **Page 293, line 7:** Add the following line of code

```
miny[i] <- min(y1[i], y2[i]) + 1
```

## Chapter 10

1. **Page 349, last line:** The correct equation is

$$T[i-L] = T_i = \sum_{a=1}^L Y.T_{i-L,a}$$

2. **Page 350, lines 2–3:** The correct equations are

$$\sum_{a=1}^L Y.T_{i-L,a} = \sum_{a=1}^{i-L} Y.T_{i-L,a} + \sum_{a=i-L+1}^L Y.T_{i-L,a} = \sum_{a=i-L+1}^L Y_{a,i+1-a}$$

and  $\sum_{a=1}^{i-L} Y.T_{i-L,a} = 0$ .

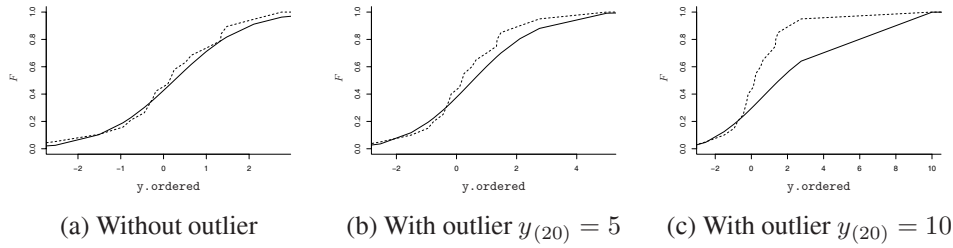
3. **Page 361, in both WinBUGS code bits:** The sign before  $0.5 \cdot \log(\tau)$  must change to plus (+). Also Figures 10.8 and 10.9 in page 362 must be updated with the correct ones which follow

(see also [http://stat-athens.aueb.gr/~jbn/winbugs\\_book/home.html](http://stat-athens.aueb.gr/~jbn/winbugs_book/home.html)).

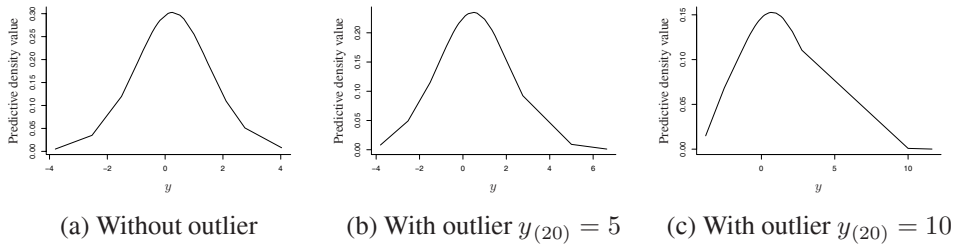
## Chapter 11

1. **Page 423, 3rd line of section 11.10.1:** Equation

$$f(\mathbf{y}|\mathbf{y}, m) = \int f(\mathbf{y}|\boldsymbol{\theta}_m, m) f(\boldsymbol{\theta}_m|m) d\boldsymbol{\theta}_m$$



**Figure 10.8** Observed (dashed line) and estimated predictive (solid line) cumulative distribution for Example 10.3.



**Figure 10.9** Estimated predictive density function for Example 10.3.

must be replaced by

$$f(\mathbf{y}|\mathbf{y}, m) = \int f(\mathbf{y}|\boldsymbol{\theta}_m, m) f(\boldsymbol{\theta}_m|\mathbf{y}, m) d\boldsymbol{\theta}_m$$

2. **Page 428, 3rd paragraph of section 11.11.4:** The paragraph must be changed to the following:

Another estimate of of the minimum deviance (and hence of AIC and BIC) can be obtained via calculation of the posterior Bayes factor. As we have described in Section 11.10, the PBF is simply given as a ratio of the posterior predictive densities of two competing models which can be estimated by the posterior mean of the likelihood  $f(\mathbf{y}|\boldsymbol{\theta}_m, m)$  from MCMC outputs. Hence we may obtain an estimate of the minimum deviance by

$$\widetilde{\text{min}}D(\boldsymbol{\theta}_m, m) = -2 \log \overline{f(\mathbf{y}|\boldsymbol{\theta}_m, m)} - d_m \log(2)$$

using the result of O'Hagan (1995) which expresses the PBF as an information criterion with penalty equal to  $\log(2)$ . Then an information criterion of type (11.37) can be estimated by

$$\widetilde{\text{IC}}(m) = \widetilde{\text{min}}D(\boldsymbol{\theta}_m, m) + d_m F .$$

## Minor corrections

### Table of Contents

1. Page xiii: “11.9 ~~R~~Reversible jump MCMC (RJMCMC)”

### Chapter 1

1. Page 3, Section 1.2, 2nd paragraph, 3rd line: Delete comma and add “is” after  $\mathcal{V}$ .
2. Page 6, 2nd paragraph, step 5: “select between using ~~a~~ a noninformative prior or incorporating ~~prior~~ preceding known information and/or experts’ opinion in our prior distribution).”
3. Page 8, 2nd line:  $x$  must be replaced by  $\lambda$ .
4. Page 8, 3rd line:  $\lambda^{n\bar{y}+a}$  must be replaced by  $\lambda^{n\bar{y}+a-1}$ .
5. Page 8, 1st line after equation (1.1):  $\tilde{a} \rightarrow \tilde{\alpha}$ .
6. Page 9, last line:  $\sqrt{2\pi\sigma^2} \rightarrow \sqrt{2\Pi\sigma^2}$ .
7. Page 10, line 7:  $(2\pi\sigma^{-2})^{-n/2} \rightarrow (2\Pi\sigma^2)^{-n/2}$
8. Pages 9–11 and 14:  $\pi$  must be replaced by  $\Pi$ .
9. Page 13, 2nd line from the bottom: “. . . an inverse gamma distributions- . . .”
10. Page 18, line 8: “. . . firstis . . .”.
11. Page 29, Problem 1.10: change the lines referring to data to the following format  

0.671	1.412	-2.119	1.224	-1.168	-0.860	1.936	3.396	4.808	-1.259
0.275	1.820	2.417	2.929	7.020	0.483	6.483	2.966	0.942	-3.398
2.846	3.840	6.640	1.018	2.747	1.857	7.270	2.734	4.325	-1.222

### Chapter 2

1. Page 38, line 4 of 2nd paragraph: “. . . sufficient . . .”  $\rightarrow$  “. . . insufficient . . .”.
2. Page 43, lines 10–12: “Nevertheless, in practice, the choice of the proposal is important~~ee~~ since poor choices will considerably delay convergence towards the equilibrium distribution.”
3. Page 53, 6th line from the bottom:  $b o \rightarrow b \times o$
4. Page 81, Problem 2.2.c: “Of winning”.

### Chapter 3

1. **Page 86, 2nd bullet:** Must be replaced by
  - Update the chain (Update)
  - Monitor the acceptance rate of the Metropolis–Hastings algorithm (Monitor Met)
2. **Page 86, last two lines:** “The Inference menu is also a valuable ~~menu~~ since, with its available set of operations, ~~that~~ we can ”.
3. **Page 87, line 9:** “The menu item Samples is the most frequently used ~~tool~~. ~~With Using~~ this tool, ...”
4. **Page 87, 9th line from the bottom of the page:** “... conceive ~~of~~ the structure ...”.
5. **Page 92, line 6:** “... with  $i = 1, 2, \dots$ ” [*add a space*].
6. **Page 99, 4th line from the bottom of the page:** “...  $\theta = (a, b, \sigma^2) \dots$ ” → “...  $\theta = (\alpha, \beta, \sigma^2) \dots$ ” [*change a and b to greek letters*].
7. **Page 101, line of code after Vectors:** Remove the curly bracket at the end of the code.
8. **Page 107, Section 3.4.6.8, line 4:** “... recommend ~~to~~ defining a simple model ...”.
9. **Page 108, 1st line of 2nd paragraph of Section 3.4.8:** “From the WinBUGS team, ~~we it is~~ recommended specifying any transformations ...”.
10. **Page 115, lines 6–7 of 6-b:** “... ~~that~~ we recommend using large refresh values ...”.
11. **Page 117, 2nd line:** “... this procedure is ~~called~~ “setting the monitored parameters.””.

### Chapter 4

1. **Page 126, 2nd line:** “... to the ~~previous~~ season.”.
2. **Page 140, 1st line of Section 4.2.5:** Delete the word “deviance”.
3. **Page 141, 1st line:** “... and possible problems ~~s~~ ...”
4. **Page 142, lines 2-3 of Section 4.3.2:** “... are visually separated ~~ly~~ ...”
5. **Page 146, 1st line after bullets:** “see Figure ...” → “See Figure ...”

### Chapter 5

1. **Page 153, 1st line above WinBUGS code:** Delete the word “commands”.
2. **Page 156, lines 5–6 of the 1st paragraph after Table 5.1:** “~~Frequently~~ ~~In such cases~~, direct interpretation of  $\beta_0$  ~~does may~~ not lead to realistic and sensible interpretation.”
3. **Page 160, lines 1–2 after Figure 5.1:** “Concerning the posterior distribution of  $\sigma$ , we observe that with the current model we can predict the expected delivery time with ~~with~~ an a-posteriori ~~expectation~~ ~~expected error~~ of 3.4 minutes.”

4. **Page 162, line 5:**  $\mu_i = \beta X_{(i)} \rightarrow \mu_i = X_{(i)}\beta$ .
5. **Page 162, line 8:** The code `mu[i] <- inprod( beta[], X[i,] )` can be optionally replaced by `mu[i] <- inprod( X[i,], beta[] )`. [*The old syntax is also correct. The change was made to be in concordance with the linear predictor in line 5*].
6. **Page 162, line 5 of Section 5.3.2:** Move “ $P = p + 1$ ” here from 2nd line above equation (5.6).
7. **Page 168, line 3:** “...effects of  $\ell$  ~~it~~ level ...”.
8. **Page 168, Equations 5.9 and 5.10:**  $y$  must be changed to capital.
9. **Page 169, 2nd line from the end of Section 5.4.2.2:** change “effects” to “values”.
10. **Page 175, 4th line after Equation 5.15:** “...denote ~~to~~ the mean ...”.
11. **Page 184, 2nd line of Section 5.4.6:** “... interpretation is ~~has~~ similar ...”.

## Chapter 6

1. **Page 192, lines 4–5 of 3rd paragraph:** “... indicating ~~the likelihood~~ that ~~we may remove~~ parameters of this term ~~can be eliminated from the model~~.”
2. **Page 192, line 3 of 4th paragraph:** “... (1) ~~both~~ all interactions ...”
3. **Page 196, caption of Figure 6.1** must change to “Boxplots of parameters for interaction models for Example 6.1; asterisk indicates that all lower interaction terms are also included in the model.”
4. **Page 199, line 5 of 2nd paragraph:**  $\ell > 2 \rightarrow \ell \geq 2$ .
5. **Page 209, 2nd line of 2nd (unnumbered) Equation:** The minus sign must change to plus.
6. **Page 209, lines 3–4 of last paragraph:** “This comparison might be misleading since the ~~generated values~~ for the two ~~variables~~ ~~parameters~~ are highly correlated (see Figure 6.7).”
7. **Pages 209 and 210, lines 5–6 of last paragraph of page 209 and 1st line of page 210:** “Indeed, from the posterior density of the difference (see Figure 6.8), we observe the zero value (equal intercepts) lying at the right tail area of the ~~posterior~~ distribution ~~of the difference~~.”
8. **Page 213, lines 5–6 after Equation 6.10:** Delete “ $\beta_0$  and  $\beta'_0$ ”.
9. **Page 213, line 8 after Equation 6.10:** “while for STZ ~~the slopes are equal to~~  ~~$\beta_0 = \beta_1 - \delta_2$~~  and  ~~$\beta'_0 = \beta_1 + \delta_2$~~  with relative potency given by”
10. **Page 216, line 5:** Delete full stop between the words “used” and “but”.
11. **Page 217, 2nd line of last paragraph:** “... indicates that ~~do~~ the models ...”.
12. **Page 223, 2nd line in “Results”:** “saturated”  $\rightarrow$  “full”.
13. **Page 226, 1st line:** “these parameters”  $\rightarrow$  “ $\beta_1, \beta_2$  and  $\beta_4$ ”.

## Chapter 7

1. **Page 229, line 7:** "They can ...".
2. **Page 236, 2nd line from the bottom:** "...but we might ~~ignore~~**be ignorant** of the exact time of failure."
3. **Page 237, lines 1–2:** "Binary (zero–one) data (**i.e.**,  $y \in \{0, 1\}$ ) can be modeled using the Bernoulli distribution ~~(i.e.,  $y \in \{0, 1\}$ )~~."
4. **Page 241, last line before Section 7.3:** " $i = 1, \dots, N$ "  $\rightarrow$  " $i = 1, \dots, n$ "
5. **Page 250, line 3:** "Concerning the Poisson assumption, slight overdispersion **has been reported** in literature."
6. **Page 257, line 3:** "... binomial."  $\rightarrow$  "... Bernoulli."
7. **Page 259, line 8:** "These two facts ~~findings~~**founded** odds ratios ...".
8. **Page 259, 4th line from the bottom:** "... the effect of ~~every~~**each** covariate ...".
9. **Page 261, 6th line after equation 7.9:** " $\pi = \frac{1}{2}$ "  $\rightarrow$  " $\pi_0 = \frac{1}{2}$ ".
10. **Page 262, line 13:** "To be more specific,  $\varepsilon_i$  follows the Gumbel ..."  $\rightarrow$  "To be more specific,  $-\varepsilon_i$  follows the Gumbel ..." ( $\varepsilon_i$  must change to  $-\varepsilon_i$ ).
11. **Page 263, 12th line of Section 7.5.2.1:** "... without **any** problem."
12. **Page 265, 6th line of the computational note:** " $\xi \geq 4$ "  $\rightarrow$  " $\xi \geq 5$ ".
13. **Page 268, line 8:**  $3 - -9 \rightarrow 3-9$ .

## Chapter 8

1. **Page 280, 3rd paragraph of Section 8.2.2, first line:** Delete the word "Finally".
2. **Page 280, 4th paragraph of Section 8.2.2, lines 1–4:** Must be replaced by the following:

Finally, the Weibull distribution is used with probability density function

$$f(y|\lambda, v) = v\lambda y^{v-1}e^{-\lambda y^v},$$

mean  $E(Y) = \lambda^{-1/v}\Gamma(1+v^{-1})$ , and variance  $V(Y) = \lambda^{-2/v}(\Gamma(1+2/v) - \Gamma(1+1/v)^2)$ .

3. **Page 282, Section 8.3, lines 4–5:** "... this extra (**or lower**) variability."
4. **Page 283, Section 8.3.1, 2nd line from the end of 2nd paragraph:** Add  $du$  at the end of the integral. The correct expression is the following:

$$f(y) = \int_0^\infty f(y|u)f(u)du = \frac{\Gamma(y+r)}{y!\Gamma(r)} \left(\frac{r}{r+\lambda}\right)^r \left(\frac{\lambda}{r+\lambda}\right)^y,$$

5. **Page 283, Section 8.3.1, 2nd line of 3rd paragraph:** "... [complementary log (**i.e.** clog) on  $\pi$ , ..."



6. **Page 283, Section 8.3.1, 4th line of 3rd paragraph:** "... [~~ie~~ which is equivalent to setting  $\text{logit}(\pi) = -r - \eta$ ] ..."
7. **Page 292, 2nd paragraph, line 2:** "... or directly ~~on~~with the marginal means  $\lambda_1 + \lambda_3$  and  $\lambda_2 + \lambda_3$ ."
8. **Page 292, equation in the middle of the page:** The probability function of the bivariate Poisson must be corrected to

$$f_{BP}(y_1, y_2) = \sum_{k=0}^{\min(y_1, y_2)} \frac{e^{-\lambda_1} \lambda_1^{y_1-k}}{(y_1 - k)!} \frac{e^{-\lambda_2} \lambda_2^{y_2-k}}{(y_2 - k)!} \frac{e^{-\lambda_3} \lambda_3^k}{k!}$$

[ $y_1 - k$  must be replaced by  $y_2 - k$  in the second term of the summation].

9. **Page 297, Section 8.4.1, 2nd paragraph, line 7:** Replace equation with the following correct expression:

$$h(y) = \lim_{\delta y \rightarrow 0} \frac{P(y \leq Y < y + \delta y | Y > y)}{\delta y}.$$

10. **Page 297, below equation in the 5th line from the bottom:** Add "for right censored data" after the equation.
11. **Page 297, last line:** Delete "In WinBUGS,".
12. **Page 298, 3rd paragraph, line 4:** Delete right parenthesis after  $x_{(i)}$ .
13. **Page 301, 2nd paragraph, line 5:** "For ~~an~~a smooth ...".
14. **Page 302, line 1:** "Use a normal distribution ~~of~~for the logarithms of the data above."
15. **Page 302, line 5 of Problem 8.3:** "I(a,)" → "I(,)"
16. **Page 302, line 5 of Problem 8.4:** "I(a,)" → "I(,)"

## Chapter 9

1. **Page 305, line 2:** "... can be considered ~~as~~ one level of hierarchy."
2. **Page 305, Caption of Figure 9.1:** Change comma (,) to period (.) after word "model".
3. **Page 310, line 3:**  $I_2 \rightarrow I_K$
4. **Page 310, 2nd line from the end of Section 9.2.1.2:** "... books ..." → "... book's ...".
5. **Page 312, line 1:** "The posterior distributions of ~~within-between-subject~~ and ~~between-within-subject~~ variabilities ( $\sigma_a^2$  and  $\sigma^2$ , respectively) ..."
6. **Page 313, Section 9.2.2.1, line 1:** "~~This~~ The model of Section 9.2.2 assumes that ..."
7. **Page 313, Section 9.2.2.1, line 3:** "... simple ..." → "... simply ..."
8. **Page 316, line 2:**  $u_i \rightarrow r_i$ .

9. **Page 325, Section 9.3.2, line 8:** "... within-patient ~~variability~~correlation."
10. **Page 327, 5th line from the bottom:** The index  $k$  should start from one ( $k = 1$ ) instead of zero.
11. **Page 330, 3rd line after Table 9.14:** "... which is lower than the corresponding ~~values for~~ models with ..."
12. **Page 338, 3rd paragraph, lines 2–7:** "Interesting ... (Draper, 1995)." must be replaced by

Interesting books on the subject include the more recent ones by Hedeker and Gibbons (2006), Brown and Prescott (2006), and de Leeuw and Meijer (2008), while a variety of papers on the topic can be found in the related special issue of the *Journal of Educational and Behavioral Statistics* (vol. 20, issue no. 2, 1995), including the fruitful critical review by Professor D. Draper (Draper, 1995).

## Chapter 10

1. **Page 342, line 11:** "... of ~~again~~reobserving ~~in the future~~each  $y_i$  ..."
2. **Page 342, 2nd line from the bottom:** "... is not clear ~~directly~~ which ..."
3. **Page 344, last two lines of Section 10.1.3:** Delete these two lines.
4. **Page 347, line 11 of Section 10.2.2:** "... in actuarial practice ~~to be able~~to precisely estimate such quantities in order to ..."
5. **Page 357, line 11:** "intervalus" → "intervals".
6. **Page 368, lines 8–9:** "Moreover, these ~~checks~~tests are useful ..."
7. **Page 378, 6th line from the bottom:** "schme" → "scheme".
8. **Page 387, 2nd paragraph, 1st line:** "A further interesting area for implementation of predictive inference ~~is can be found~~ in problems ..."

## Chapter 11

1. **Page 392, 3rd line of Section 11.3:** "... focus ~~on~~attention ~~to~~on the simpler ..."
2. **Page 392, 5th line of Section 11.3.1:** "... ~~where~~ with  $H_m(\tilde{\theta}_m)$  ~~is being~~ equal to ..."
3. **Page 406, 3rd paragraph, 2nd line:**  $\gamma_i \rightarrow \gamma_j$  (twice).
4. **Page 409, lines 3-4 from the bottom:** "... in the case where ~~a~~the data matrix  $X$  ~~with~~ has orthogonal columns  $X_j$  (appearing in (11.12) and the imposed priors are intended to be noninformative.
5. **Page 411, lines 3-4 from the bottom:** "... replace the pseudopriors required by ~~Carlin and Chib's (Carlin and Chib, 1995) GVS.~~"
6. **Page 413, line 2:** "... we ~~can~~ accurately estimate ..."

7. **Page 421, line 6 from the bottom of Section 11.9:** “The WinBUGS jump interface, ~~more~~ recently developed by Dave Lunn, . . .”
8. **Page 421, last line:** Delete comma after equal.
9. **Page 422, last line of 2nd paragraph:** “. . . see the appendix in ~~f~~Draper and Krnjajić (2006).”
10. **Page 424, line 2:** “Let us ~~again~~ reconsider Example 5.1.”
11. **Page 427, lines 2–3 of 4th paragraph:** “. . . (2) criteria that are asymptotically valid under the assumption that a true model does ~~not exist~~s.”
12. **Page 428, 1st line of 4th paragraph in section 11.11.4:** AIB → AIC.

## Appendix A

1. **Page 435, line 4:** Add a comma after “programming”.
2. **Page 435, last line:** Add a parenthesis after  $\sigma^2$ .
3. **Page 439, 1st paragraph, last line:** “Any node included in panels ~~will~~~~must~~ depend on the index of the surrounding panel.”

## Appendix C

1. **Page 448, line 3 of Section C.3:** “ordering” → “order”
2. **Page 453, paragraphs 1–2:**

~~is~~ The output of Example 1.4 as implemented in Section 4.1 is used in the following ~~we~~ to briefly illustrate the use of CODA for obtaining the diagnostics of Geweke (1992), Raftery and Lewis (1992) and Heidelberger and Welch (1992). Illustration of the Gelman–Rubin diagnostic (Gelman and Rubin, 1992) is omitted since it can be implemented in WinBUGS, as illustrated in Section 4.3.3. In the following we assume that we have generated one chain. \_\_\_\_\_  
 \_\_\_\_\_ The output file is saved under the name CODAoutput1.txt and the index file, under the name CODAoutputIndex.txt.