

Chapter 14

Caio Geraldes

Generative model

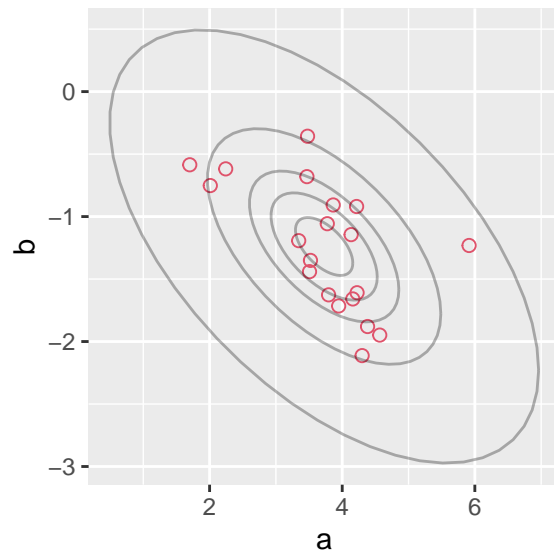
```
a <- 3.5
b <- (-1)
sigma_a <- 1
sigma_b <- 0.5
rho <- (-0.7)

Mu <- c(a, b)
sigmas <- c(sigma_a, sigma_b)
Rho <- matrix(c(1, rho, rho, 1), nrow=2) # correlation matrix
Sigma <- diag(sigmas) %*% Rho %*% diag(sigmas)

N_cafes <- 20

set.seed(5)
vary_effects <- mvrnorm(N_cafes, Mu, Sigma)

a_cafe <- vary_effects[,1]
b_cafe <- vary_effects[,2]
```



Simulating observations

```
set.seed(22)
N_visits <- 10
```

```

afternoon <- rep(0:1, N_visits*N_cafes/2)
cafe_id <- rep(1:N_cafes, each = N_visits)
mu <- a_cafe[cafe_id] + b_cafe[cafe_id]*afternoon
sigma <- 0.5
wait <- rnorm(N_visits*N_cafes, mu, sigma)
d <- tibble(cafe = cafe_id, afternoon = afternoon, wait = wait)

d %>% sample_n(10)

## # A tibble: 10 x 3
##   cafe afternoon wait
##   <int>      <int> <dbl>
## 1     2         1  1.22
## 2    14         1  2.98
## 3    10         0  3.67
## 4    20         1  3.63
## 5     4         0  3.61
## 6    13         1  1.21
## 7     5         0  1.59
## 8    10         0  3.69
## 9     1         1  2.76
## 10   17         0  4.08

```

Varying slopes model

$$\begin{aligned}
 W_i &\sim \text{Normal}(\mu_i, \sigma) \\
 \mu_i &= \alpha_{C_i} + \beta_{C_i} A_i \\
 \begin{bmatrix} \alpha_C \\ \beta_C \end{bmatrix} &\sim \text{MVNormal} \left(\begin{bmatrix} \alpha \\ \beta \end{bmatrix}, \mathbf{S} \right) \\
 \mathbf{S} &= \begin{pmatrix} \sigma_\alpha & 0 \\ 0 & \sigma_\beta \end{pmatrix} \mathbf{R} \begin{pmatrix} \sigma_\alpha & 0 \\ 0 & \sigma_\beta \end{pmatrix} \\
 \alpha &\sim \text{Normal}(5, 2) \\
 \beta &\sim \text{Normal}(-1, 0.5) \\
 \sigma &\sim \text{Exponential}(1) \\
 \sigma_\alpha &\sim \text{Exponential}(1) \\
 \sigma_\beta &\sim \text{Exponential}(1) \\
 \mathbf{R} &\sim \text{LKJcorr}(2)
 \end{aligned}$$

```

set.seed(867530)

f.14.1 <- alist(
  wait ~ normal(mu, sigma),
  mu <- a_cafe[cafe] + b_cafe[cafe]*afternoon,

  # adaptative priors
  c(a_cafe, b_cafe)[cafe] ~ multi_normal(c(a, b), Rho, sigma_cafe),

  # fixed priors
  a ~ normal(5, 2),
  b ~ normal(-1, 0.5),
  sigma_cafe ~ exponential(1),

```

```

sigma ~ exponential(1),
Rho ~ lkj_corr(2)
)

m14.1 <- ulam(
  flist = f.14.1,
  data = d,
  chains = 4,
  cores = 4
)

```

```

## Warning in '/tmp/RtmpoMvR2s/model-511a4d321072.stan', line 3, column 4: Declaration
##   of arrays by placing brackets after a variable name is deprecated and
##   will be removed in Stan 2.32.0. Instead use the array keyword before the
##   type. This can be changed automatically using the auto-format flag to
##   stanc

```

```

## Warning in '/tmp/RtmpoMvR2s/model-511a4d321072.stan', line 4, column 4: Declaration
##   of arrays by placing brackets after a variable name is deprecated and
##   will be removed in Stan 2.32.0. Instead use the array keyword before the
##   type. This can be changed automatically using the auto-format flag to
##   stanc

```

```

## Warning in '/tmp/RtmpoMvR2s/model-511a4d321072.stan', line 23, column 4: Declaration
##   of arrays by placing brackets after a variable name is deprecated and
##   will be removed in Stan 2.32.0. Instead use the array keyword before the
##   type. This can be changed automatically using the auto-format flag to
##   stanc

```

```

## Chain 1 Informational Message: The current Metropolis proposal is about to be rejected because of the

```

```

## Chain 1 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/model-511a4d321072.stan', line 4, column 4)

```

```

## Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like covariance matrices, then the sampler is ok,

```

```

## Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or misspecified.

```

```

## Chain 1

```

```

## Chain 1 Informational Message: The current Metropolis proposal is about to be rejected because of the

```

```

## Chain 1 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/model-511a4d321072.stan', line 4, column 4)

```

```

## Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like covariance matrices, then the sampler is ok,

```

```

## Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or misspecified.

```

```

## Chain 1

```

```

## Chain 1 Informational Message: The current Metropolis proposal is about to be rejected because of the

```

```

## Chain 1 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/model-511a4d321072.stan', line 4, column 4)

```

```

## Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like covariance matrices, then the sampler is ok,

```

```

## Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or misspecified.

```

```

## Chain 1

```

```

## Chain 1 Informational Message: The current Metropolis proposal is about to be rejected because of the

```

```

## Chain 1 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/model-511a4d321072.stan', line 4, column 4)

```

```

## Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like covariance matrices, then the sampler is ok,

```

```

## Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or m
## Chain 1
## Chain 1 Informational Message: The current Metropolis proposal is about to be rejected because of the
## Chain 1 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/l
## Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like covar
## Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or m
## Chain 1
## Chain 1 Informational Message: The current Metropolis proposal is about to be rejected because of the
## Chain 1 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/l
## Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like covar
## Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or m
## Chain 1
## Chain 1 Informational Message: The current Metropolis proposal is about to be rejected because of the
## Chain 1 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/l
## Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like covar
## Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or m
## Chain 1
## Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the
## Chain 2 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/l
## Chain 2 If this warning occurs sporadically, such as for highly constrained variable types like covar
## Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or m
## Chain 2
## Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the
## Chain 2 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/l
## Chain 2 If this warning occurs sporadically, such as for highly constrained variable types like covar
## Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or m
## Chain 2
## Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the
## Chain 2 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/l
## Chain 2 If this warning occurs sporadically, such as for highly constrained variable types like covar
## Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or m
## Chain 2
## Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the
## Chain 2 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/l
## Chain 2 If this warning occurs sporadically, such as for highly constrained variable types like covar
## Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or m

```

```

## Chain 2
## Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because of th
## Chain 3 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/1
## Chain 3 If this warning occurs sporadically, such as for highly constrained variable types like cova
## Chain 3 but if this warning occurs often then your model may be either severely ill-conditioned or m
## Chain 3
## Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of th
## Chain 4 Exception: lkj_corr_lpdf: Correlation matrix is not positive definite. (in '/tmp/RtmpoMvR2s/1
## Chain 4 If this warning occurs sporadically, such as for highly constrained variable types like cova
## Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned or m
## Chain 4

```