

# E3 alignment

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This notebook analyzes alignment values using a Bayesian approach.

```
set.seed(15000)
```

Load the data.

```
data <- read_csv('../data/E3/alignment_original.csv', show_col_types = FALSE)
#data <- read_csv('../data/E3/alignment.csv', show_col_types = FALSE)
```

Check number of subjects per group.

```
length(unique(filter(data, Musician == 'Yes')$sub))
## [1] 49
length(unique(filter(data, Musician == 'No')$sub))
## [1] 46
```

Make sure non-musicians and musicians are labelled with different numbers.

```
data %>% mutate(sub = ifelse(Musician == 'Yes', sub, sub + 49))
```

Pivot the data longer.

```
data %>% pivot_longer(cols = -c(Musician, sub, scramble),
                        names_to = 'level', values_to = 'value')
```

For comparisons across levels, look at nested structure only (levels 2, 4, 8, 16).

```
data_nested <- data %>%
  filter(!level %in% c(1,3,5))
```

Make group, scramble, and level into factors and set contrasts.

```
data %>% mutate(
  Musician = factor(Musician, levels = c('Yes', 'No')),
  scramble = factor(scramble, levels = c('Intact', '8B', '2B', '1B')),
  level = factor(level, levels = c(1,2,3,4,5,8,16), ordered = TRUE)
)

contrasts(data$scramble) <- contr.treatment(4) # Intact as reference
contrasts(data$level) <- contr.treatment(7, base = 6) # 8-bar as reference

data_nested %>% mutate(
  Musician = factor(Musician, levels = c('Yes', 'No')),
  scramble = factor(scramble, levels = c('Intact', '8B', '2B', '1B')),
  level = factor(level, levels = c(2,4,8,16), ordered = TRUE)
)
```

```
contrasts(data_nested$scramble) <- contr.treatment(4) # Intact as reference
contrasts(data_nested$level) <- contr.treatment(4, base = 3) # 8-bar as reference
```

Check normality of the data.

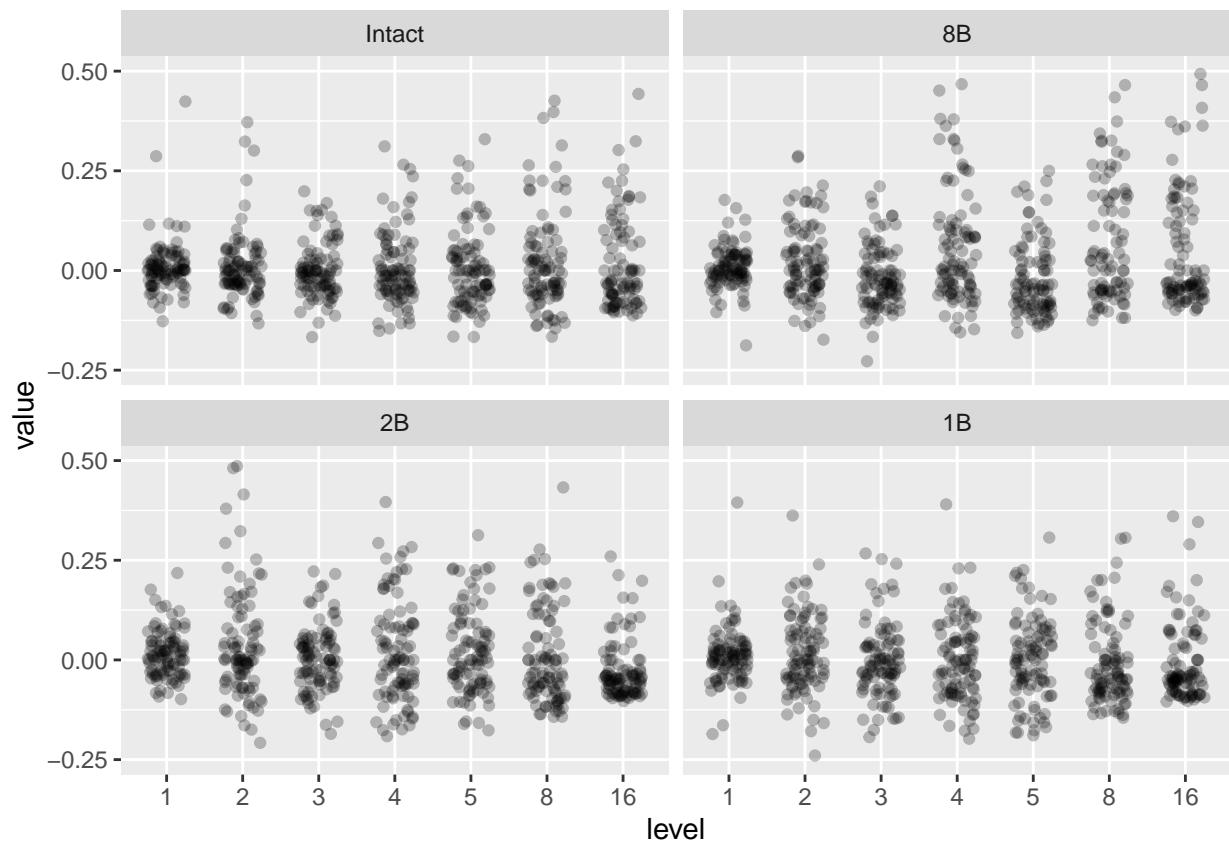
```
data %>%
  group_by(scramble, level) %>%
  shapiro_test(value)
```

```
## # A tibble: 28 x 5
##   scramble level variable statistic      p
##   <fct>    <ord>  <chr>     <dbl>    <dbl>
## 1 Intact    1     value     0.737 9.32e-12
## 2 Intact    2     value     0.812 1.15e- 9
## 3 Intact    3     value     0.952 1.48e- 3
## 4 Intact    4     value     0.922 2.96e- 5
## 5 Intact    5     value     0.930 7.38e- 5
## 6 Intact    8     value     0.898 1.99e- 6
## 7 Intact   16    value     0.852 2.69e- 8
## 8 8B        1     value     0.946 6.98e- 4
## 9 8B        2     value     0.964 9.62e- 3
## 10 8B       3     value     0.962 8.07e- 3
## # i 18 more rows
```

Visualize.

```
data %>%
  ggplot(aes(x = level, y = value)) +
  geom_jitter(width = 0.25, alpha = 0.25) +
  facet_wrap(vars(scramble)) +
  ylim(-0.25, 0.5)
```

```
## Warning: Removed 17 rows containing missing values or values outside the scale range
## (~geom_point()`).
```



## Main analysis

```
nested_3way <- brm(value ~ Musician + scramble + level + (1|sub), data = data_nested,
                     prior = c(
                       set_prior('normal(-0.1, 0.1)', coef = 'MusicianNo'),
                       set_prior('normal(0.1, 0.1)', coef = 'scramble2'),
                       set_prior('normal(-0.1, 0.1)', coef = 'scramble3'),
                       set_prior('normal(-0.1, 0.1)', coef = 'scramble4'),
                       set_prior('normal(-0.2, 0.1)', coef = 'level1'),
                       set_prior('normal(-0.1, 0.1)', coef = c('level2', 'level4'))
                     ),
                     save_pars = save_pars(all = TRUE), iter = 5000,
                     file = 'models/E3_alignment_3way_noInt')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       |           ^~~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000101 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.01 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 3.643 seconds (Warm-up)
```

```

## Chain 1:           1.668 seconds (Sampling)
## Chain 1:           5.311 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 4.5e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.45 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 3.885 seconds (Warm-up)
## Chain 2:           1.67 seconds (Sampling)
## Chain 2:           5.555 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 4.7e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.47 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 3.688 seconds (Warm-up)
## Chain 3:           1.666 seconds (Sampling)
## Chain 3:           5.354 seconds (Total)
## Chain 3:
##

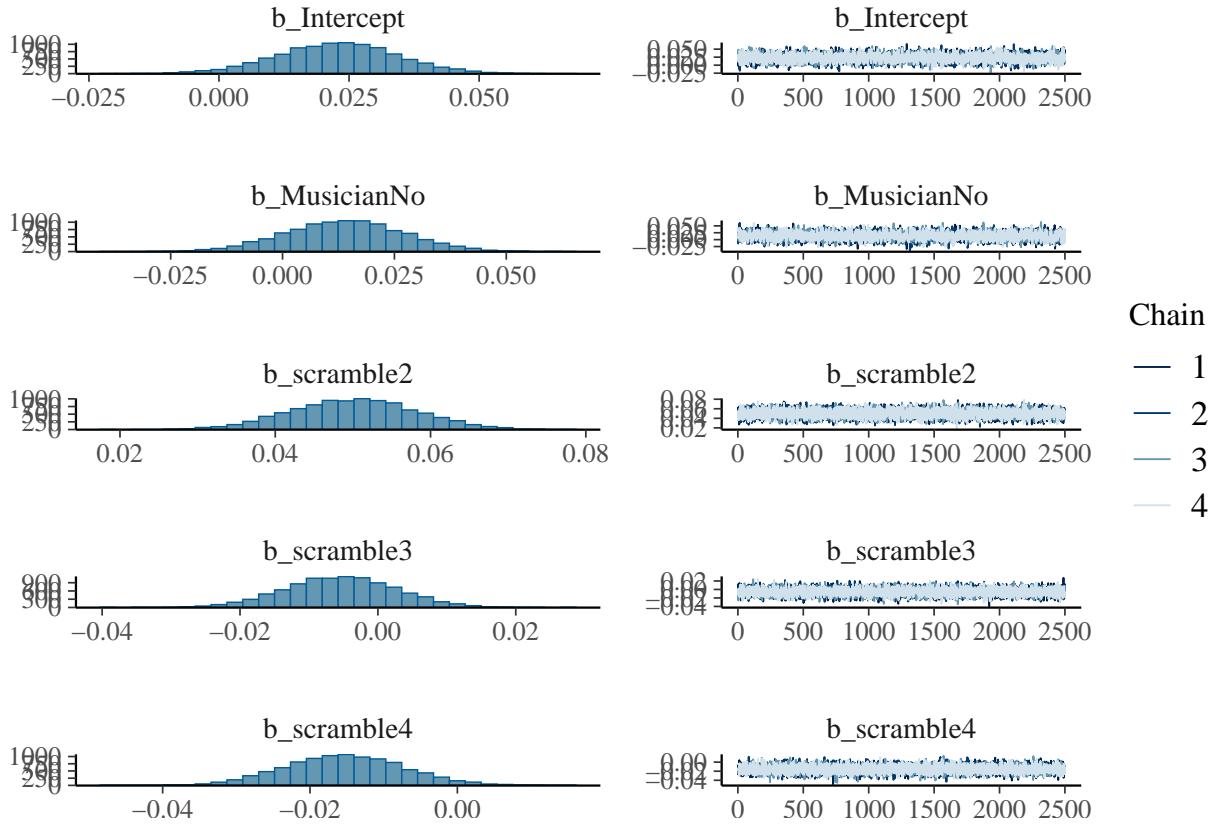
```

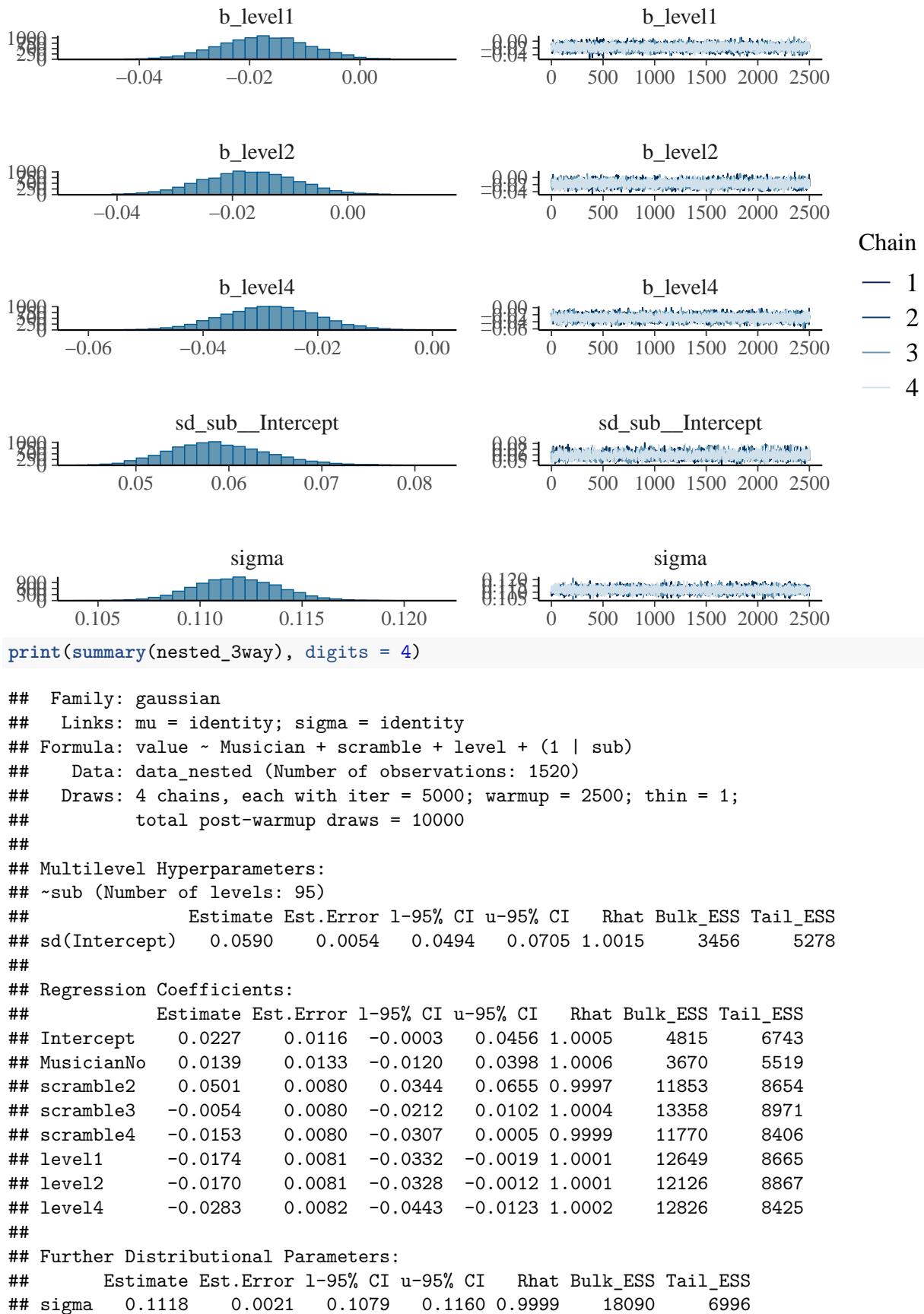
```

## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 4.2e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.42 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 3.943 seconds (Warm-up)
## Chain 4:                      1.668 seconds (Sampling)
## Chain 4:                      5.611 seconds (Total)
## Chain 4:

plot(nested_3way)

```





```
##  
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS  
## and Tail_ESS are effective sample size measures, and Rhat is the potential  
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

```

nested_noMus <- brm(value ~ scramble + level + (1|sub), data = data_nested,
                     prior = c(
                       set_prior('normal(0.1, 0.1)', coef = 'scramble2'),
                       set_prior('normal(-0.1, 0.1)', coef = 'scramble3'),
                       set_prior('normal(-0.1, 0.1)', coef = 'scramble4'),
                       set_prior('normal(-0.2, 0.1)', coef = 'level1'),
                       set_prior('normal(-0.1, 0.1)', coef = c('level2', 'level4'))
                     ),
                     save_pars = save_pars(all = TRUE), iter = 5000,
                     file = 'models/E3_alignment_2way_noMus')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       |           ^
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000114 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.14 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 3.589 seconds (Warm-up)
## Chain 1:                 1.615 seconds (Sampling)
## Chain 1:                 5.204 seconds (Total)
## Chain 1:

```

```

##  

## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).  

## Chain 2:  

## Chain 2: Gradient evaluation took 4e-05 seconds  

## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.4 seconds.  

## Chain 2: Adjust your expectations accordingly!  

## Chain 2:  

## Chain 2:  

## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)  

## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)  

## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)  

## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)  

## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)  

## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)  

## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)  

## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)  

## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)  

## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)  

## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)  

## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)  

## Chain 2:  

## Chain 2: Elapsed Time: 3.836 seconds (Warm-up)  

## Chain 2: 1.637 seconds (Sampling)  

## Chain 2: 5.473 seconds (Total)  

## Chain 2:  

##  

## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).  

## Chain 3:  

## Chain 3: Gradient evaluation took 4e-05 seconds  

## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.4 seconds.  

## Chain 3: Adjust your expectations accordingly!  

## Chain 3:  

## Chain 3:  

## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)  

## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)  

## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)  

## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)  

## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)  

## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)  

## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)  

## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)  

## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)  

## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)  

## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)  

## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)  

## Chain 3:  

## Chain 3: Elapsed Time: 3.464 seconds (Warm-up)  

## Chain 3: 1.614 seconds (Sampling)  

## Chain 3: 5.078 seconds (Total)  

## Chain 3:  

##  

## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).  

## Chain 4:  

## Chain 4: Gradient evaluation took 4.1e-05 seconds

```

```

## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.41 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 3.654 seconds (Warm-up)
## Chain 4:           1.66 seconds (Sampling)
## Chain 4:           5.314 seconds (Total)
## Chain 4:

nested_noScram <- brm(value ~ Musician + level + (1|sub), data = data_nested,
                       prior = c(
                         set_prior('normal(-0.1, 0.1)', coef = 'MusicianNo'),
                         set_prior('normal(-0.2, 0.1)', coef = 'level1'),
                         set_prior('normal(-0.1, 0.1)', coef = c('level2', 'level4'))
                       ),
                       save_pars = save_pars(all = TRUE), iter = 5000,
                       file = 'models/E3_alignment_2way_noScram')

## Compiling Stan program...
## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       |
##       ^~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000105 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.05 seconds.
## Chain 1: Adjust your expectations accordingly!

```

```

## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 3.633 seconds (Warm-up)
## Chain 1: 1.569 seconds (Sampling)
## Chain 1: 5.202 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 4e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.4 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 3.588 seconds (Warm-up)
## Chain 2: 1.583 seconds (Sampling)
## Chain 2: 5.171 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 3.9e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.39 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)

```

```

## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 3.687 seconds (Warm-up)
## Chain 3:           1.571 seconds (Sampling)
## Chain 3:           5.258 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 3.8e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.38 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration:    1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration:  500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 3.446 seconds (Warm-up)
## Chain 4:           1.573 seconds (Sampling)
## Chain 4:           5.019 seconds (Total)
## Chain 4:
nested_noLevel <- brm(value ~ Musician + scramble + (1|sub), data = data_nested,
                       prior = c(
                         set_prior('normal(-0.1, 0.1)', coef = 'MusicianNo'),
                         set_prior('normal(0.1, 0.1)', coef = 'scramble2'),
                         set_prior('normal(-0.1, 0.1)', coef = 'scramble3'),
                         set_prior('normal(-0.1, 0.1)', coef = 'scramble4')
                       ),
                       save_pars = save_pars(all = TRUE), iter = 5000,
                       file = 'models/E3_alignment_2way_noLevel')

## Compiling Stan program...
## Trying to compile a simple C file
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c

```

```

## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       |           ^~~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.0001 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 3.891 seconds (Warm-up)
## Chain 1:           1.574 seconds (Sampling)
## Chain 1:           5.465 seconds (Total)
## Chain 1:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 4.3e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.43 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)

```

```

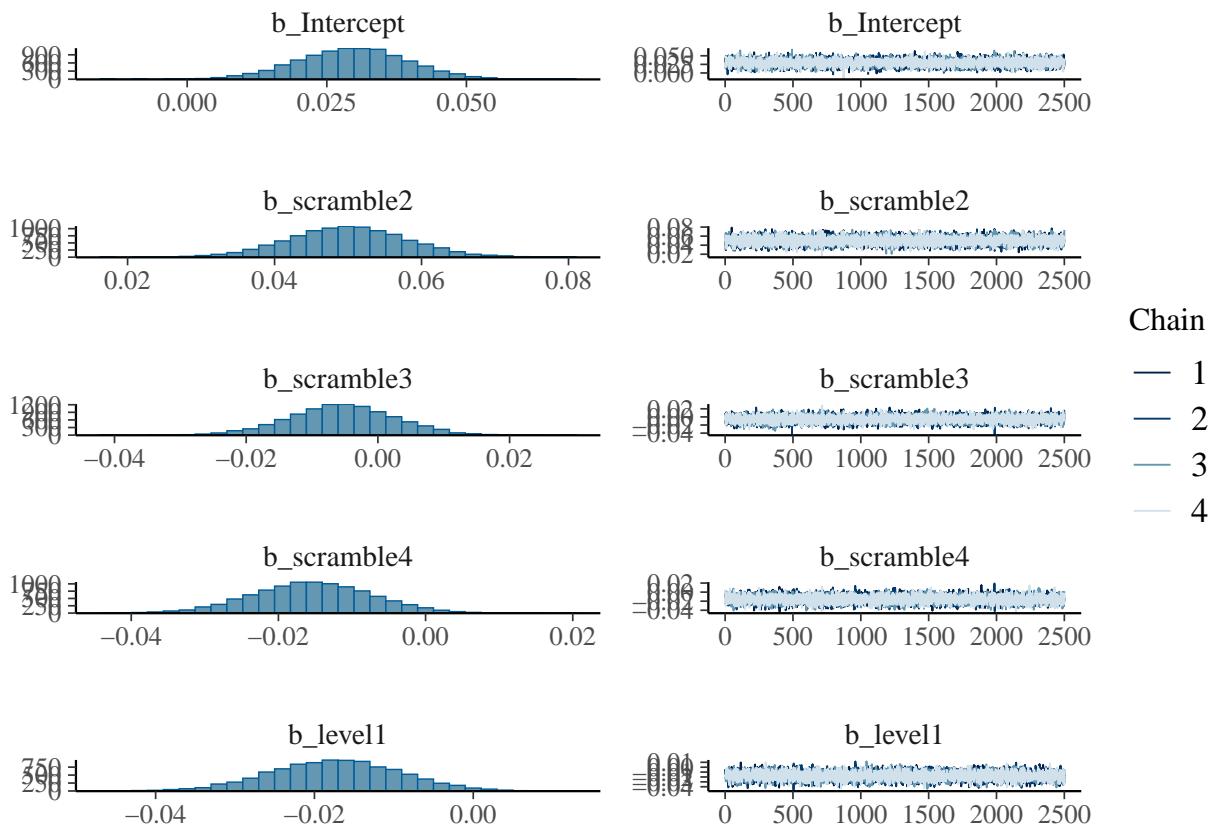
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 3.76 seconds (Warm-up)
## Chain 2:           1.585 seconds (Sampling)
## Chain 2:           5.345 seconds (Total)
## Chain 2:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 4e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.4 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 3.414 seconds (Warm-up)
## Chain 3:           1.589 seconds (Sampling)
## Chain 3:           5.003 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 4e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.4 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)

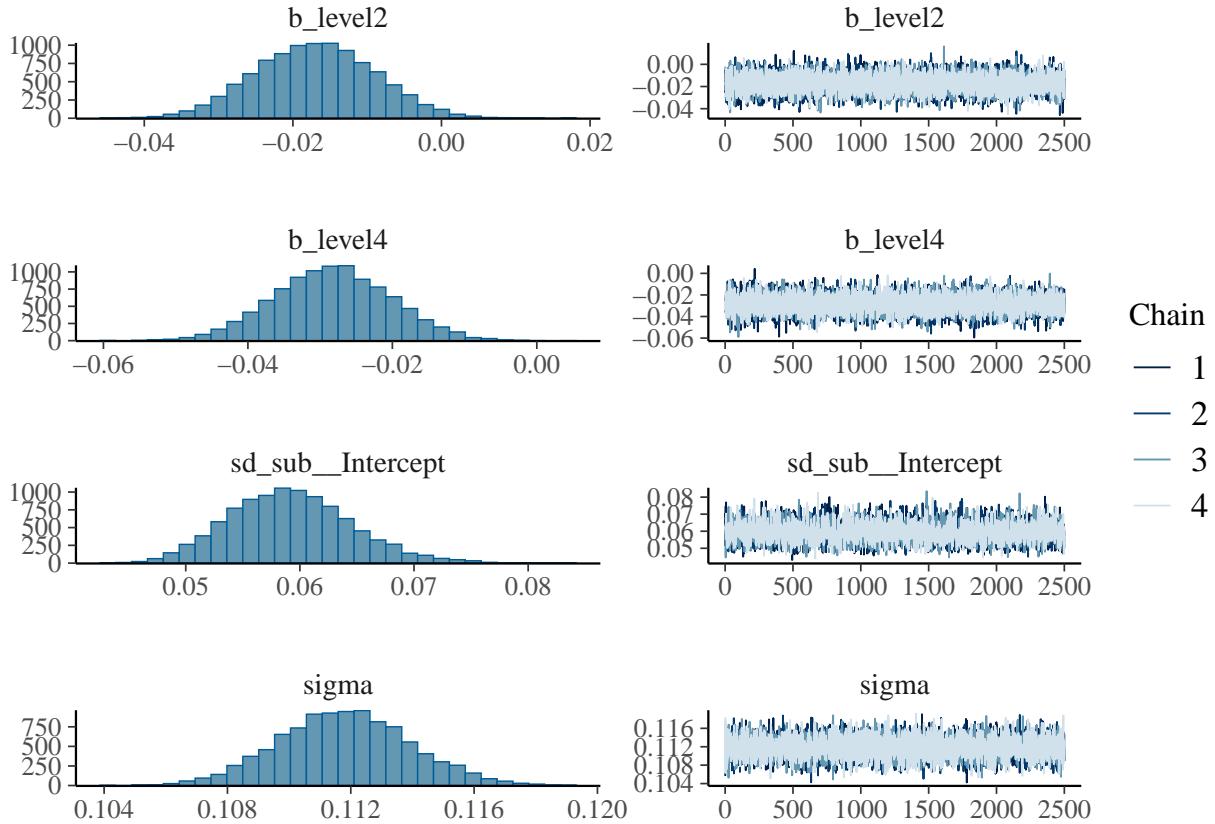
```

```
## Chain 4: Iteration: 5000 / 5000 [100%]  (Sampling)
## Chain 4:
## Chain 4:   Elapsed Time: 3.553 seconds (Warm-up)
## Chain 4:           1.575 seconds (Sampling)
## Chain 4:           5.128 seconds (Total)
## Chain 4:
```

Model without group:

```
plot(nested_noMus)
```





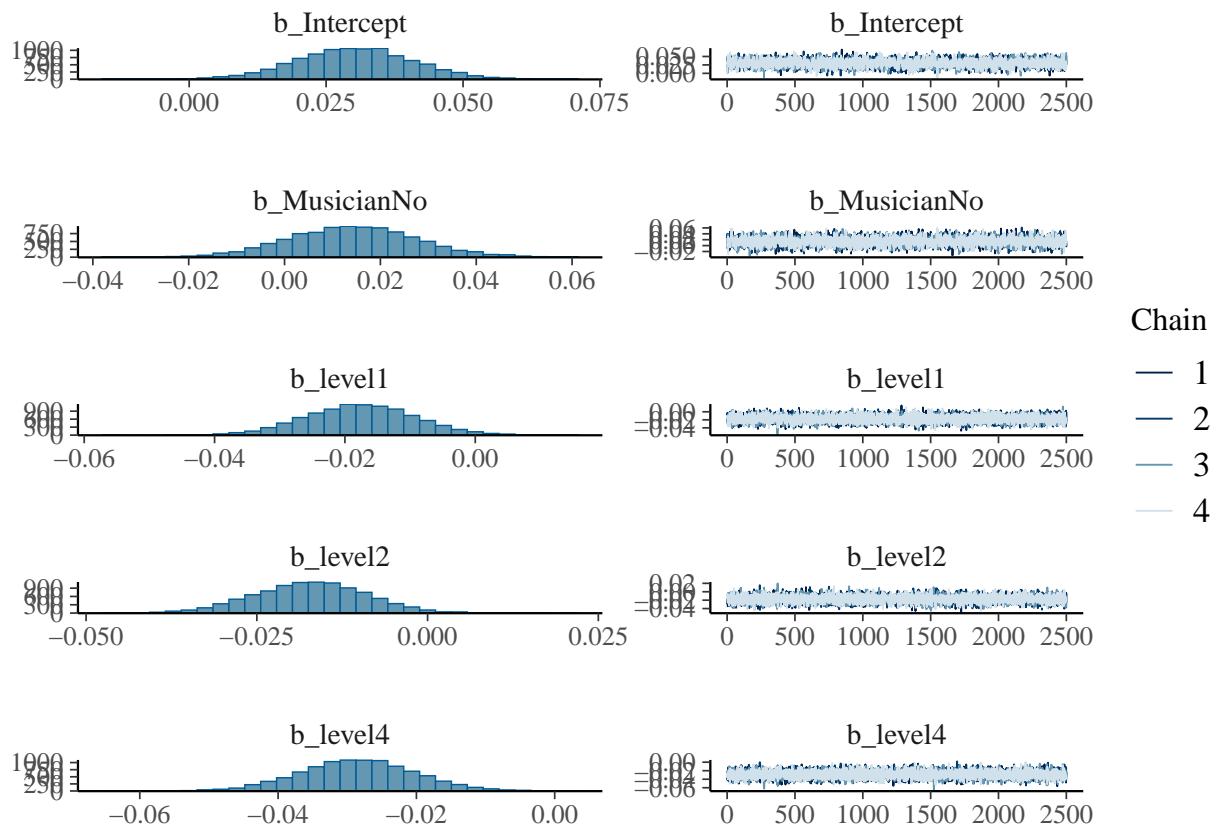
```
print(summary(nested_noMus), digits = 4)
```

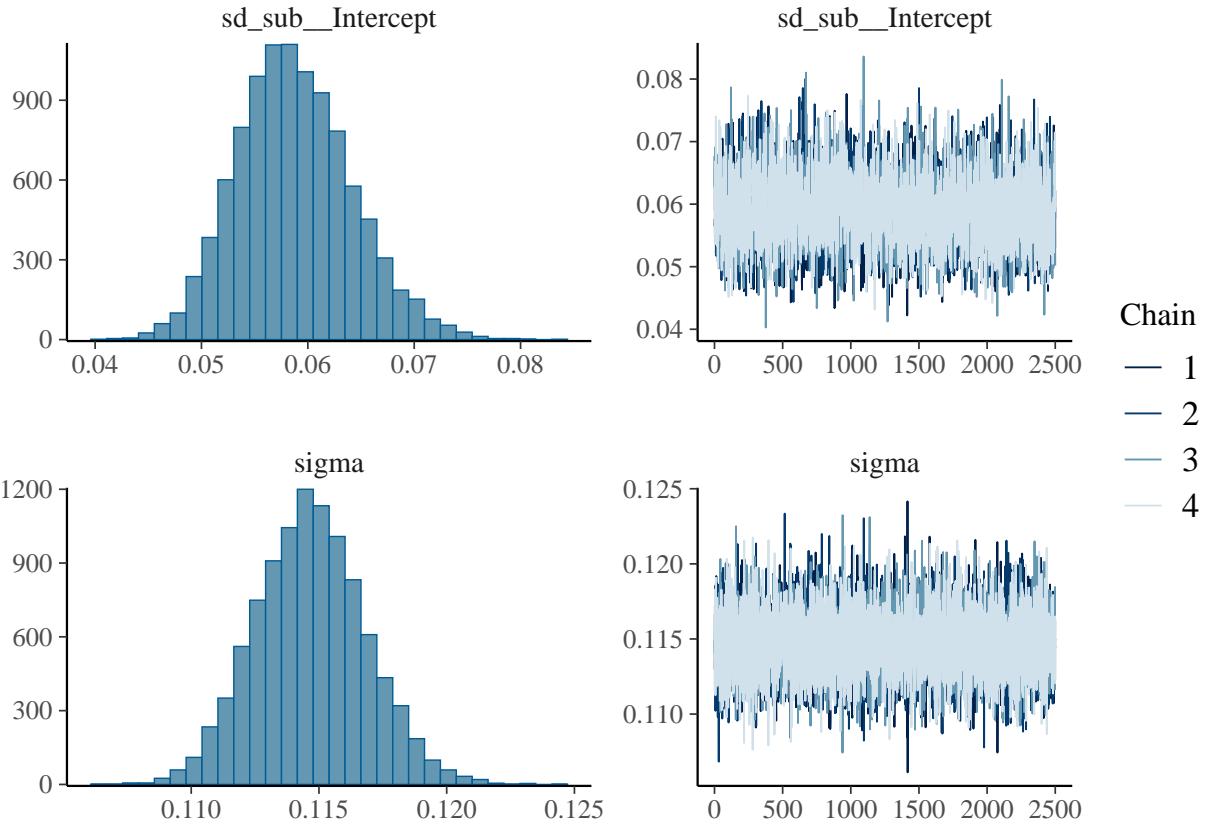
```
## Family: gaussian
##   Links: mu = identity; sigma = identity
## Formula: value ~ scramble + level + (1 | sub)
##   Data: data_nested (Number of observations: 1520)
##   Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0592    0.0054   0.0495   0.0706 1.0012     3832    6704
## 
## Regression Coefficients:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept    0.0297    0.0098   0.0104   0.0488 1.0009     6789    6824
## scramble2    0.0501    0.0080   0.0344   0.0659 0.9998    13688    7552
## scramble3   -0.0054    0.0080  -0.0213   0.0100 1.0001    14001    8961
## scramble4   -0.0154    0.0081  -0.0313   0.0002 1.0002    14051    8822
## level1     -0.0174    0.0081  -0.0331  -0.0017 1.0006    13739    8383
## level2     -0.0170    0.0080  -0.0324  -0.0014 0.9999    13115    8333
## level4     -0.0283    0.0081  -0.0442  -0.0125 1.0003    14329    7769
## 
## Further Distributional Parameters:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.1118    0.0021   0.1077   0.1161 1.0002    17671    6762
## 
```

```
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS  
## and Tail_ESS are effective sample size measures, and Rhat is the potential  
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

Model without condition:

```
plot(nested_noScram)
```





```

print(summary(nested_noScram), digits = 4)

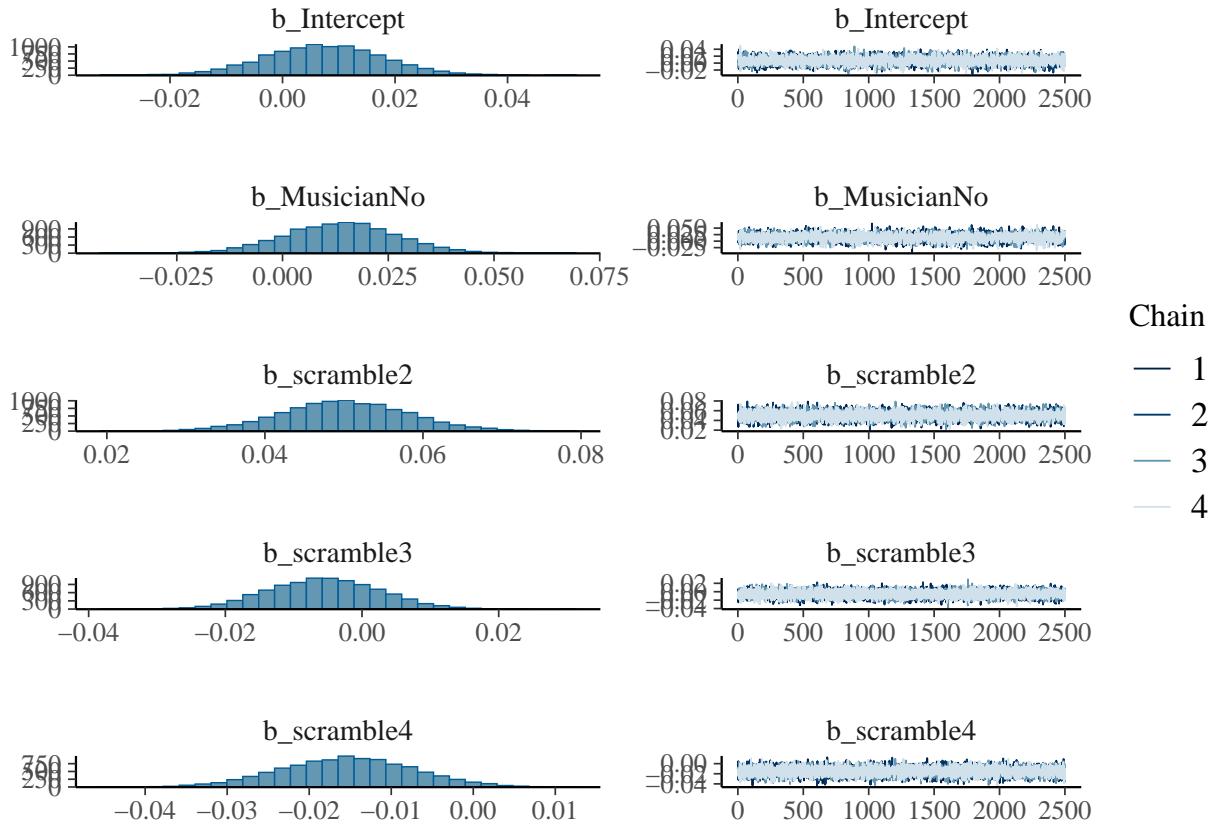
##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ Musician + level + (1 | sub)
##  Data: data_nested (Number of observations: 1520)
##  Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0588   0.0054   0.0491   0.0701 1.0023     3618    6154
## 
## Regression Coefficients:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept    0.0302   0.0106   0.0094   0.0509 1.0009     4241    6313
## MusicianNo   0.0143   0.0134  -0.0120   0.0410 1.0001     3736    5547
## level1      -0.0176   0.0083  -0.0337  -0.0013 0.9998    13487    8252
## level2      -0.0172   0.0082  -0.0334  -0.0015 0.9999    14208    8485
## level4      -0.0285   0.0083  -0.0446  -0.0123 0.9999    14547    8307
## 
## Further Distributional Parameters:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.1147   0.0022   0.1106   0.1190 1.0000    20090    7240
## 
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential

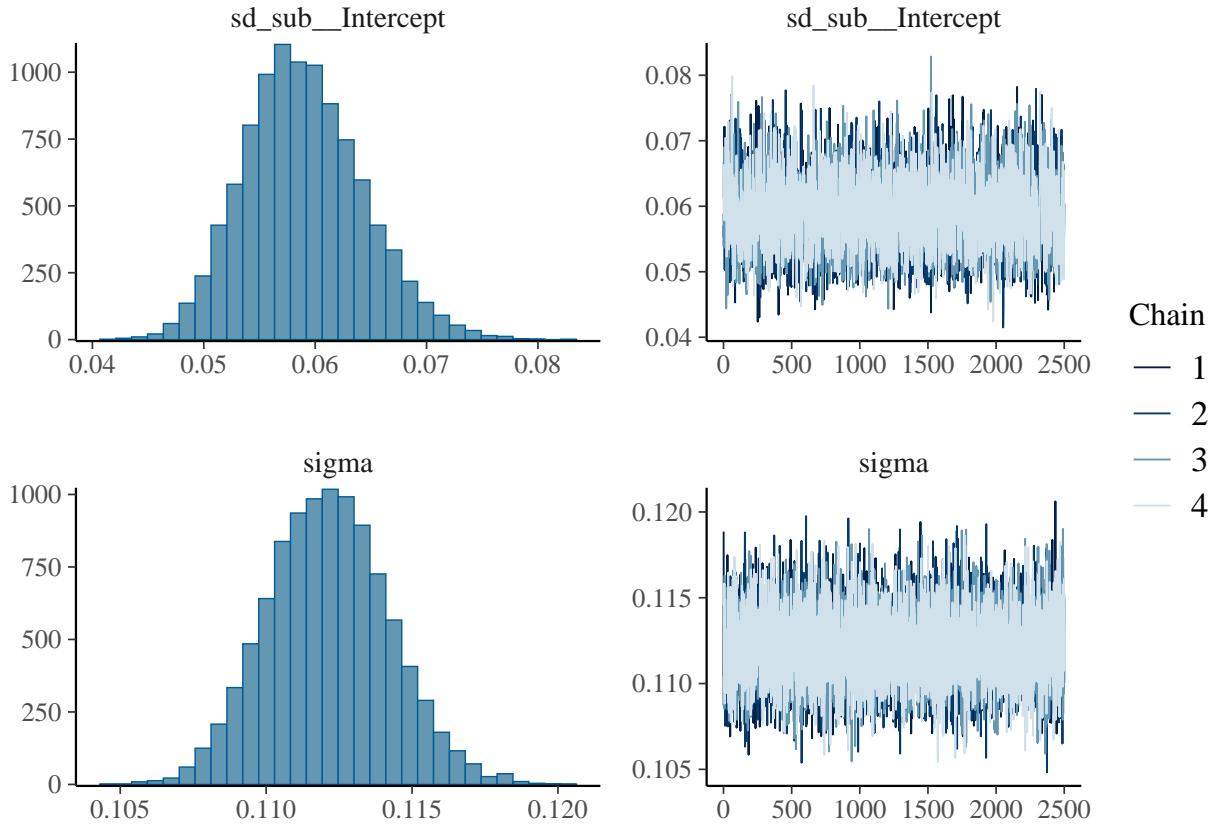
```

```
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

Model without level:

```
plot(nested_noLevel)
```





```

print(summary(nested_noLevel), digits = 4)

##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ Musician + scramble + (1 | sub)
##  Data: data_nested (Number of observations: 1520)
##  Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept) 0.0590   0.0053   0.0494   0.0701 1.0009     3532     5709
## 
## Regression Coefficients:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept    0.0073   0.0105  -0.0134   0.0278 1.0008     4931     7104
## MusicianNo   0.0137   0.0133  -0.0126   0.0397 1.0007     4464     6072
## scramble2    0.0501   0.0081   0.0341   0.0663 1.0008    14753     8969
## scramble3   -0.0055   0.0080  -0.0210   0.0102 1.0002    13825     8584
## scramble4   -0.0153   0.0080  -0.0312   0.0003 1.0002    15473     8664
## 
## Further Distributional Parameters:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma      0.1121   0.0021   0.1082   0.1163 0.9998    18378     7513
## 
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor for the estimate.
```

```
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

## Main effect of group

```
BF_nested_mus <- bayes_factor(nested_3way, nested_noMus)

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 7

print(BF_nested_mus)

## Estimated Bayes factor in favor of nested_3way over nested_noMus: 0.14202
```

Strong evidence against a main effect of group.

## Main effect of condition

```
BF_nested_scram <- bayes_factor(nested_3way, nested_noScram)

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 7

print(BF_nested_scram)

## Estimated Bayes factor in favor of nested_3way over nested_noScram: 3228206111358.53076
```

Very strong evidence for a main effect of condition.

## Main effect of level

```
BF_nested_level <- bayes_factor(nested_3way, nested_noLevel)

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
```

```
## Iteration: 5
## Iteration: 6
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
print(BF_nested_level)

## Estimated Bayes factor in favor of nested_3way over nested_noLevel: 0.01062
Moderate evidence against a main effect of level.
```

## Interactions

Does adding an interaction between condition and level improve the model? (Without group)

```
nested_justScram <- brm(value ~ scramble + (1|sub), data = data_nested,
  prior = c(
    set_prior('normal(0.1, 0.1)', coef = 'scramble2'),
    set_prior('normal(-0.1, 0.1)', coef = 'scramble3'),
    set_prior('normal(-0.1, 0.1)', coef = 'scramble4')
  ),
  save_pars = save_pars(all = TRUE), iter = 5000,
  file = 'models/E3_alignment_justScram')
```

```
## Compiling Stan program...
## Trying to compile a simple C file
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include/c++/v1"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:10
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:1
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/Block.h:42
##   679 | #include <cmath>
##       |         ^~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000111 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.11 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 3.418 seconds (Warm-up)
## Chain 1:                 1.578 seconds (Sampling)
## Chain 1:                 4.996 seconds (Total)
```

```

## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 3.9e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.39 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 4.211 seconds (Warm-up)
## Chain 2:           1.618 seconds (Sampling)
## Chain 2:           5.829 seconds (Total)
## Chain 2:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 4.1e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.41 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 3.527 seconds (Warm-up)
## Chain 3:           1.63 seconds (Sampling)
## Chain 3:           5.157 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:

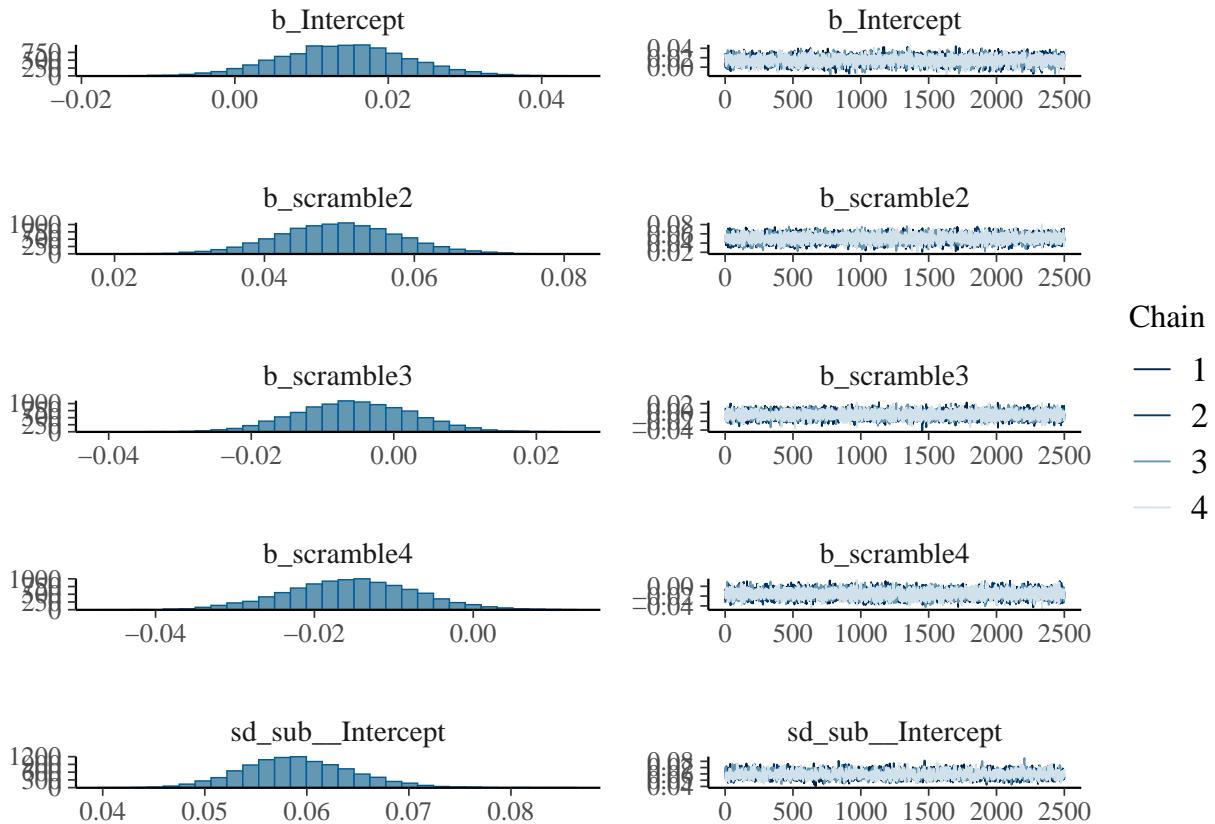
```

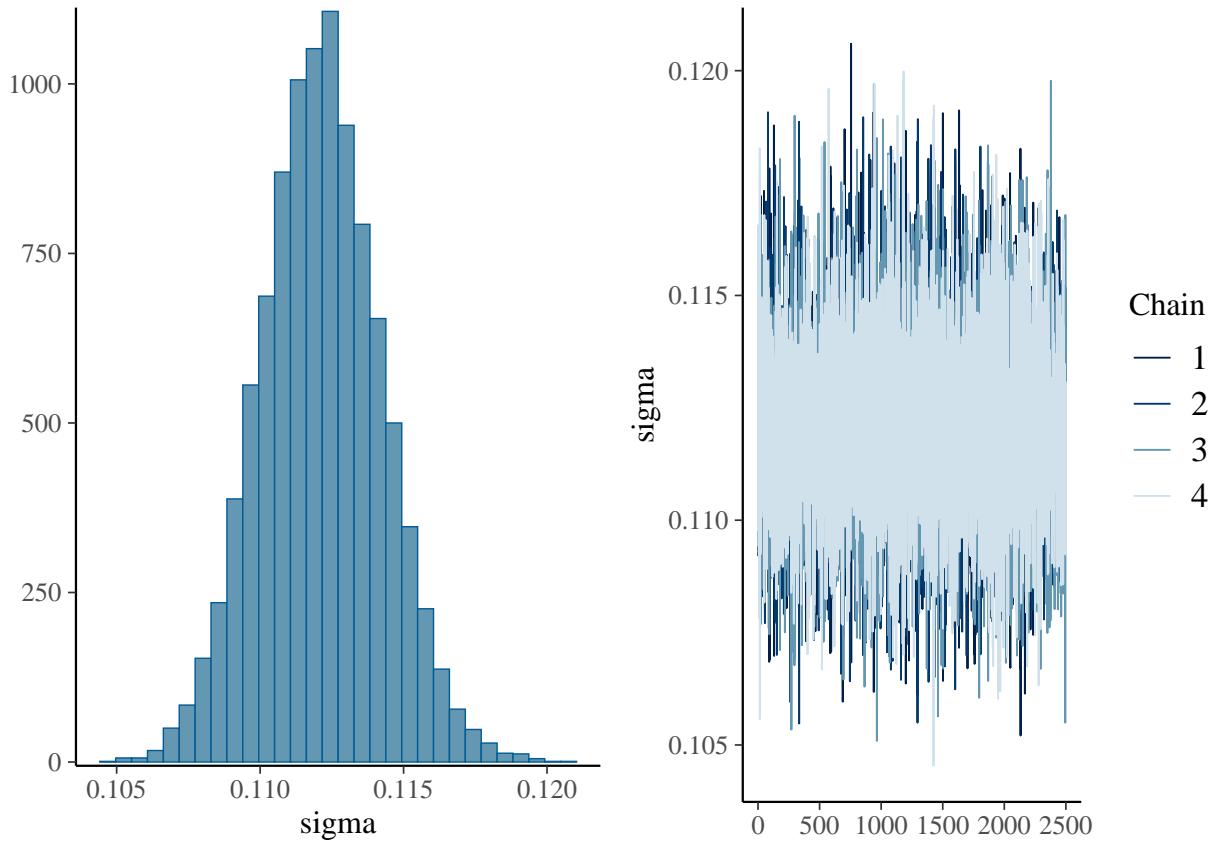
```

## Chain 4: Gradient evaluation took 4.4e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.44 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 3.513 seconds (Warm-up)
## Chain 4:           1.597 seconds (Sampling)
## Chain 4:           5.11 seconds (Total)
## Chain 4:

plot(nested_justScram)

```





```

print(summary(nested_justScram), digits = 4)

##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ scramble + (1 | sub)
##  Data: data_nested (Number of observations: 1520)
##  Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0591    0.0054   0.0492   0.0702 1.0006     3569     5515
## 
## Regression Coefficients:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept    0.0142    0.0083  -0.0022   0.0306 1.0004     5498     6411
## scramble2    0.0499    0.0081   0.0341   0.0660 1.0004    13766     8812
## scramble3   -0.0055    0.0081  -0.0211   0.0103 1.0002    13934     8513
## scramble4   -0.0154    0.0081  -0.0314   0.0005 1.0001    13906     8622
## 
## Further Distributional Parameters:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.1121    0.0021   0.1080   0.1163 1.0005    20746     6734
## 
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential

```

```
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

```

nested_2way_levelScram <- brm(value ~ scramble + scramble:level + (1|sub), data = data_nested,
                                prior = c(
                                    set_prior('normal(0, 0.1)', class = 'b'), # all interactions
                                    set_prior('normal(0.1, 0.1)', coef = 'scramble2'),
                                    set_prior('normal(-0.1, 0.1)', coef = 'scramble3'),
                                    set_prior('normal(-0.1, 0.1)', coef = 'scramble4')
                                ),
                                save_pars = save_pars(all = TRUE), iter = 5000,
                                file = 'models/E3_alignment_2way_levelScramInt')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       |           ^
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000132 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.32 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 4.242 seconds (Warm-up)
## Chain 1:                 1.78 seconds (Sampling)
## Chain 1:                 6.022 seconds (Total)
## Chain 1:
## 
```

```

## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 4.5e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.45 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 4.131 seconds (Warm-up)
## Chain 2:           1.774 seconds (Sampling)
## Chain 2:           5.905 seconds (Total)
## Chain 2:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 4.4e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.44 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 4.086 seconds (Warm-up)
## Chain 3:           1.791 seconds (Sampling)
## Chain 3:           5.877 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 4.9e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.49 seconds.

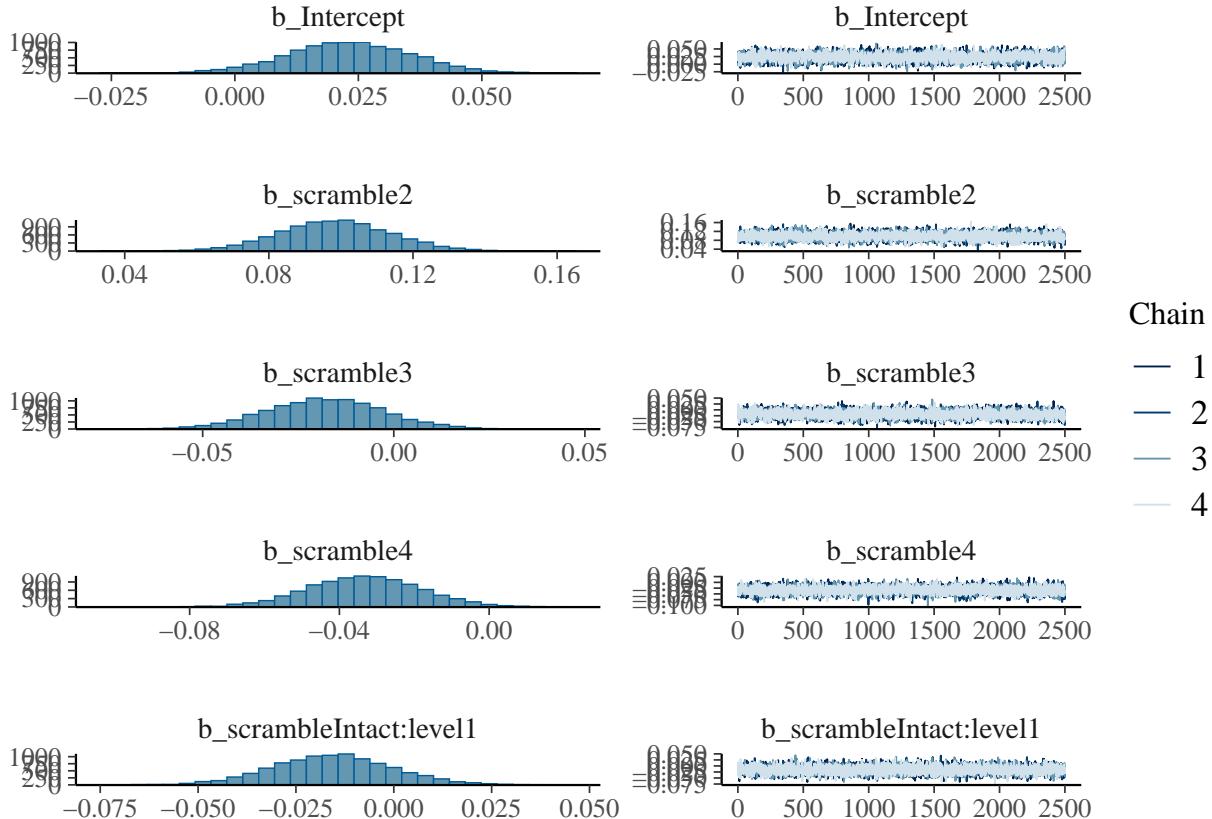
```

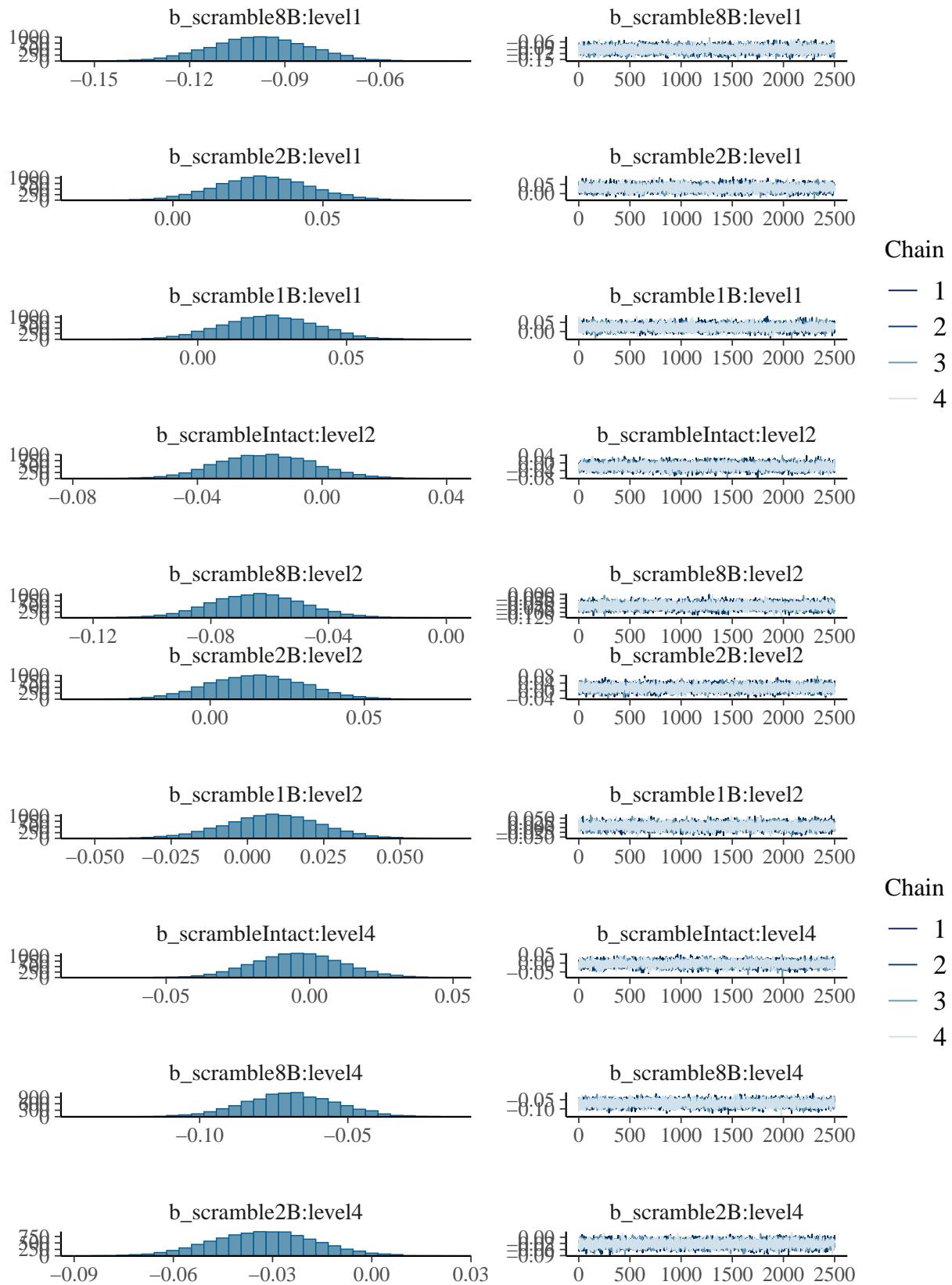
```

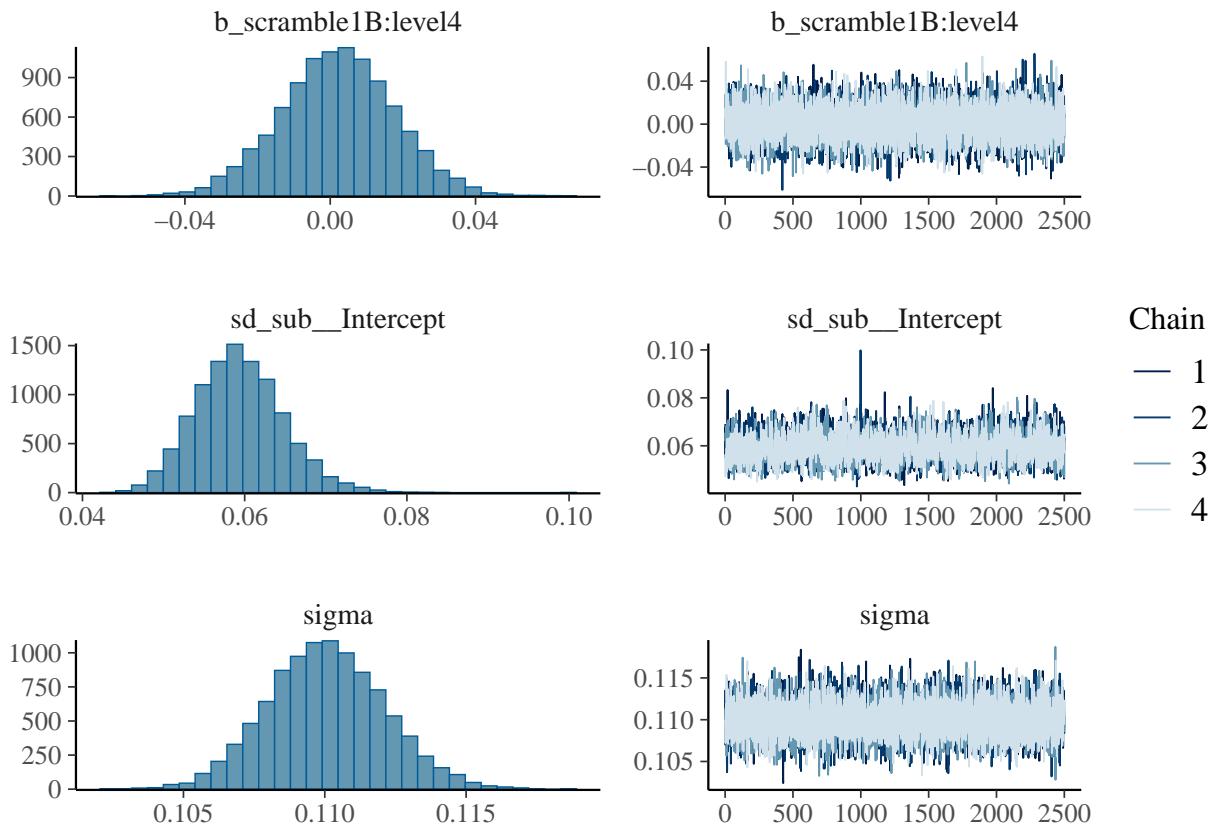
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 4.375 seconds (Warm-up)
## Chain 4:           1.778 seconds (Sampling)
## Chain 4:           6.153 seconds (Total)
## Chain 4:

```

```
plot(nested_2way_levelScram)
```







```
print(summary(nested_2way_levelScram), digits = 4)
```

```
##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ scramble + scramble:level + (1 | sub)
##  Data: data_nested (Number of observations: 1520)
##  Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept) 0.0594   0.0054   0.0495   0.0707 1.0019     3245     5555
## 
## Regression Coefficients:
##                               Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS
## Intercept                  0.0231   0.0126  -0.0018   0.0475 1.0006     4596
## scramble2                   0.0984   0.0155   0.0681   0.1287 1.0001     5735
## scramble3                  -0.0180   0.0152  -0.0478   0.0119 1.0001     6183
## scramble4                  -0.0333   0.0152  -0.0634  -0.0039 1.0002     6646
## scrambleIntact:level1     -0.0156   0.0152  -0.0452   0.0148 1.0002     8198
## scramble8B:level1        -0.0978   0.0154  -0.1280  -0.0680 1.0003    11265
## scramble2B:level1         0.0303   0.0157   0.0001   0.0613 1.0002    10608
## scramble1B:level1         0.0240   0.0157  -0.0066   0.0540 1.0002    12004
## scrambleIntact:level2     -0.0179   0.0154  -0.0472   0.0127 1.0005     8853
## scramble8B:level2        -0.0642   0.0156  -0.0943  -0.0336 1.0004    11750
## scramble2B:level2         0.0151   0.0156  -0.0153   0.0456 1.0002    11044
## scramble1B:level2         0.0083   0.0157  -0.0235   0.0385 1.0002    12280
```

```

## scrambleIntact:level4 -0.0040  0.0153 -0.0334  0.0261 1.0003   8037
## scramble8B:level4    -0.0694  0.0155 -0.1000 -0.0395 1.0009   11521
## scramble2B:level4    -0.0325  0.0156 -0.0628 -0.0021 1.0003   10172
## scramble1B:level4     0.0021  0.0157 -0.0292  0.0330 1.0004   11168
##
##                                     Tail_ESS
## Intercept                         6318
## scramble2                          6724
## scramble3                          7148
## scramble4                          7400
## scrambleIntact:level1             8131
## scramble8B:level1                8710
## scramble2B:level1                8169
## scramble1B:level1                8415
## scrambleIntact:level2             7546
## scramble8B:level2                8676
## scramble2B:level2                8404
## scramble1B:level2                8632
## scrambleIntact:level4             7428
## scramble8B:level4                7680
## scramble2B:level4                8215
## scramble1B:level4                8317
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS Tail_ESS
## sigma      0.1100    0.0021   0.1061   0.1142 1.0000    18325    7933
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
BF_nested_2way_levelScram <- bayes_factor(nested_2way_levelScram, nested_justScram)

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 7

print(BF_nested_2way_levelScram)

## Estimated Bayes factor in favor of nested_2way_levelScram over nested_justScram: 3311.32564
Strong evidence for an interaction between condition and level.

```

Check the other interactions.

```
nested_justLevel <- brm(value ~ level + (1|sub), data = data_nested,
                         prior = c(
                           set_prior('normal(-0.2, 0.1)', coef = 'level1'),
                           set_prior('normal(-0.1, 0.1)', coef = c('level2', 'level4'))
                         ),
                         save_pars = save_pars(all = TRUE), iter = 5000,
                         file = 'models/E3_alignment_justLevel')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include/c++/v1"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:10
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:1
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/SolverBase:1
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/Matrix.h:679 | #include <cmath>
##           |          ^~~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.00011 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.1 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 3.398 seconds (Warm-up)
## Chain 1:                 1.588 seconds (Sampling)
## Chain 1:                 4.986 seconds (Total)
## Chain 1:
## 

## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
```

```

## Chain 2:
## Chain 2: Gradient evaluation took 4e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.4 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 3.436 seconds (Warm-up)
## Chain 2:           1.576 seconds (Sampling)
## Chain 2:           5.012 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 4.4e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.44 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 3.518 seconds (Warm-up)
## Chain 3:           1.596 seconds (Sampling)
## Chain 3:           5.114 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 4.3e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.43 seconds.
## Chain 4: Adjust your expectations accordingly!

```

```

## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 3.516 seconds (Warm-up)
## Chain 4:           1.584 seconds (Sampling)
## Chain 4:           5.1 seconds (Total)
## Chain 4:

nested_2way_musScram <- brm(value ~ scramble + scramble:Musician + (1|sub), data = data_nested,
                           prior = c(
                             set_prior('normal(0, 0.1)', class = 'b'), # all interactions
                             set_prior('normal(0.1, 0.1)', coef = 'scramble2'),
                             set_prior('normal(-0.1, 0.1)', coef = 'scramble3'),
                             set_prior('normal(-0.1, 0.1)', coef = 'scramble4')
                           ),
                           save_pars = save_pars(all = TRUE), iter = 5000,
                           file = 'models/E3_alignment_2way_musScramInt')

## Compiling Stan program...
## Trying to compile a simple C file
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:10,
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/RcppEigen.hpp:10,
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:10,
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/DenseBase.h:10,
##   679 | #include <cmath>
##       | ^~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000112 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.12 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:

```

```

## Chain 1:
## Chain 1: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 3.659 seconds (Warm-up)
## Chain 1: 1.651 seconds (Sampling)
## Chain 1: 5.31 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 4.1e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.41 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 3.962 seconds (Warm-up)
## Chain 2: 1.65 seconds (Sampling)
## Chain 2: 5.612 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 5.4e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.54 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)

```

```

## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 3.891 seconds (Warm-up)
## Chain 3:           1.653 seconds (Sampling)
## Chain 3:           5.544 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 4.2e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.42 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 3.721 seconds (Warm-up)
## Chain 4:           1.658 seconds (Sampling)
## Chain 4:           5.379 seconds (Total)
## Chain 4:
nested_2way_musLevel <- brm(value ~ level + level:Musician + (1|sub), data = data_nested,
                               prior = c(
                                 set_prior('normal(0, 0.1)', class = 'b'), # all interactions
                                 set_prior('normal(-0.2, 0.1)', coef = 'level1'),
                                 set_prior('normal(-0.1, 0.1)', coef = c('level2', 'level4'))
                               ),
                               save_pars = save_pars(all = TRUE), iter = 5000,
                               file = 'models/E3_alignment_2way_musLevelInt')

## Compiling Stan program...
## Trying to compile a simple C file
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'

```

```

## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       | ^~~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000116 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.16 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 3.896 seconds (Warm-up)
## Chain 1:           1.678 seconds (Sampling)
## Chain 1:           5.574 seconds (Total)
## Chain 1:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 4.2e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.42 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)

```

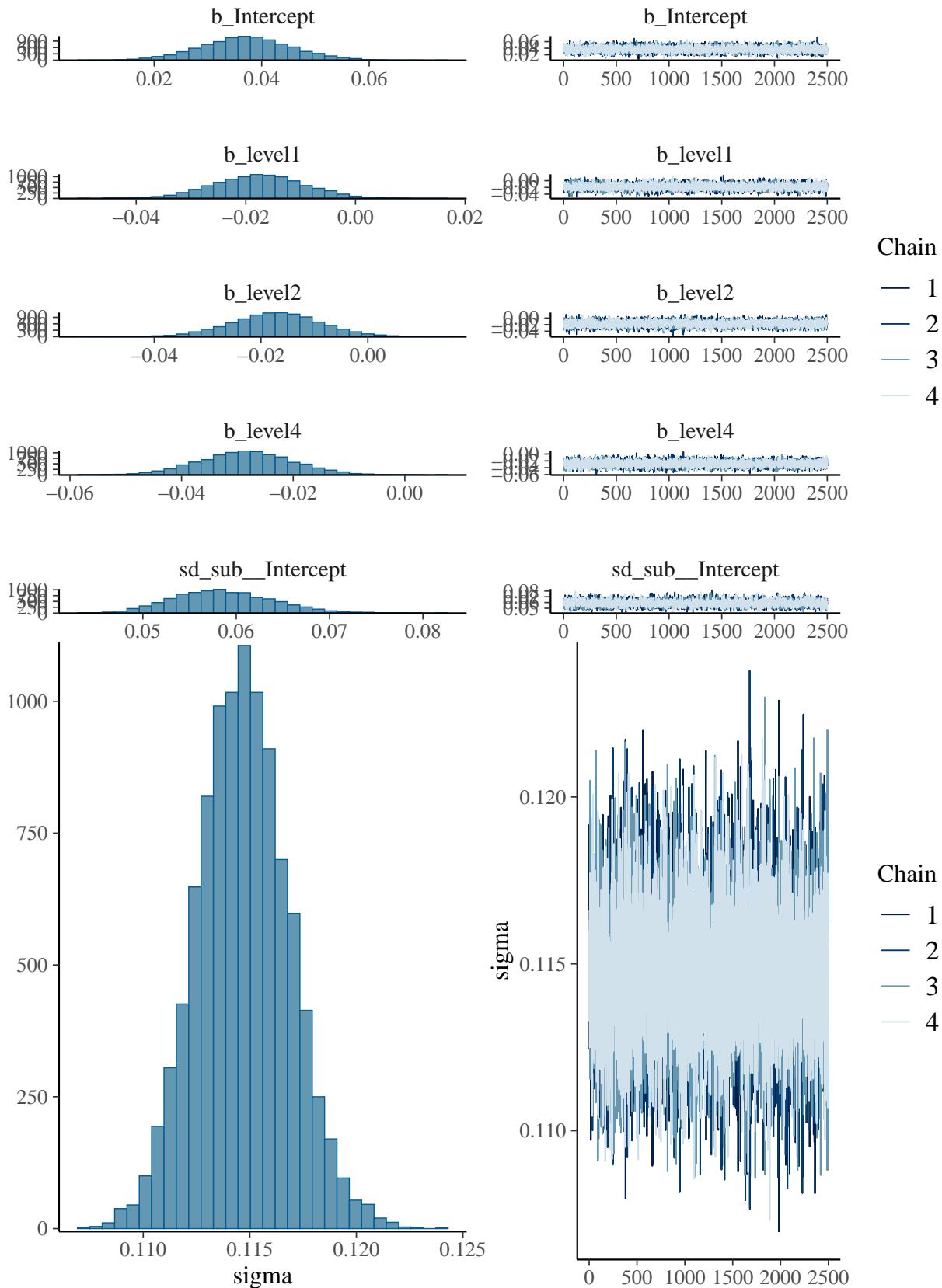
```

## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 3.941 seconds (Warm-up)
## Chain 2:           1.686 seconds (Sampling)
## Chain 2:           5.627 seconds (Total)
## Chain 2:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 4.2e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.42 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 3.872 seconds (Warm-up)
## Chain 3:           1.668 seconds (Sampling)
## Chain 3:           5.54 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 5.5e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.55 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:

```

```
## Chain 4: Elapsed Time: 3.816 seconds (Warm-up)
## Chain 4:          1.72 seconds (Sampling)
## Chain 4:          5.536 seconds (Total)
## Chain 4:
```

```
plot(nested_justLevel)
```



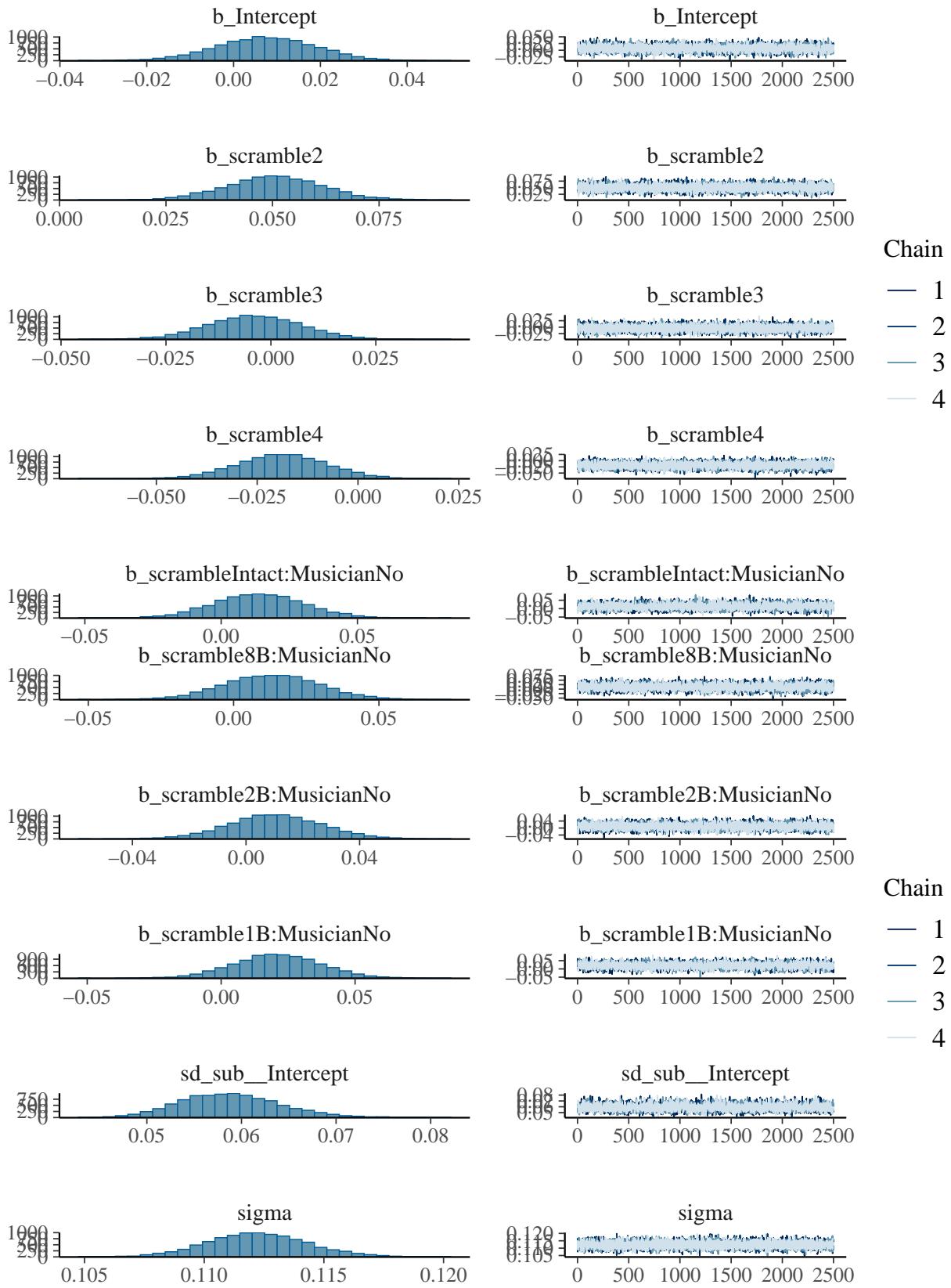
```

print(summary(nested_justLevel), digits = 4)

##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ level + (1 | sub)
##  Data: data_nested (Number of observations: 1520)
##  Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0586   0.0053   0.0491   0.0697 1.0005     3936    5076
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept   0.0372   0.0084   0.0208   0.0539 1.0002     6321    7519
## level1     -0.0176   0.0083  -0.0337  -0.0016 1.0003    13277    8288
## level2     -0.0171   0.0083  -0.0334  -0.0010 1.0001    14789    8487
## level4     -0.0284   0.0083  -0.0447  -0.0119 1.0001    14597    8684
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma      0.1147   0.0022   0.1106   0.1190 1.0009    20047    7130
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).

```

```
plot(nested_2way_musScram)
```



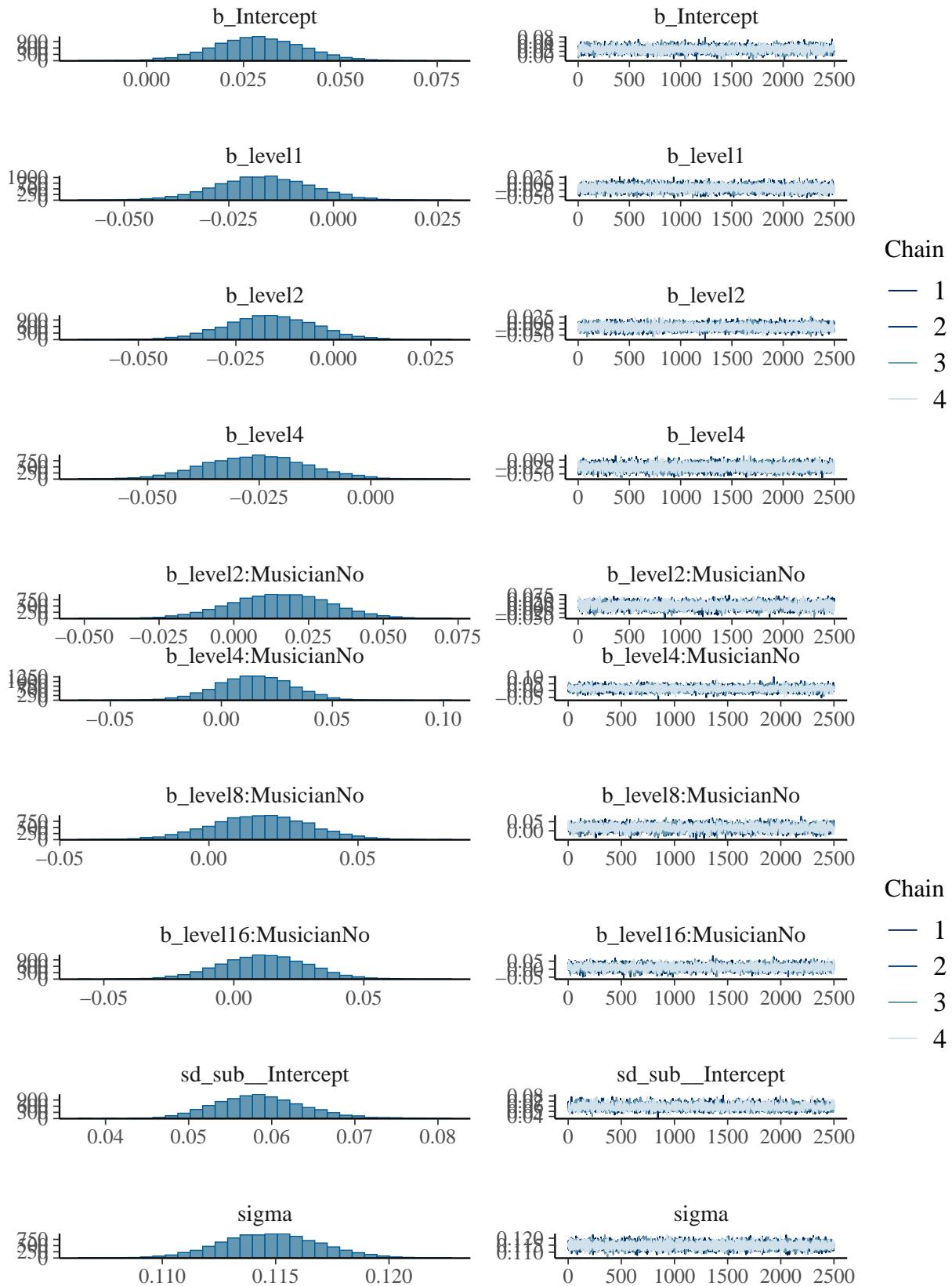
```

print(summary(nested_2way_musScram), digits = 4)

##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ scramble + scramble:Musician + (1 | sub)
##  Data: data_nested (Number of observations: 1520)
##  Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0589    0.0053   0.0492   0.0700 1.0006     4014    6205
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS
## Intercept      0.0075    0.0115  -0.0153   0.0296 1.0004     4618
## scramble2       0.0505    0.0113   0.0286   0.0729 1.0004    13301
## scramble3      -0.0038    0.0111  -0.0252   0.0181 1.0003    12721
## scramble4      -0.0187    0.0111  -0.0406   0.0029 1.0004    12668
## scrambleIntact:MusicianNo  0.0139    0.0165  -0.0178   0.0467 1.0018    3725
## scramble8B:MusicianNo     0.0131    0.0163  -0.0191   0.0452 1.0012    4081
## scramble2B:MusicianNo    0.0104    0.0163  -0.0218   0.0427 1.0015    3993
## scramble1B:MusicianNo    0.0209    0.0164  -0.0113   0.0530 1.0023    3959
##
##           Tail_ESS
## Intercept        6124
## scramble2        8059
## scramble3        8653
## scramble4        7947
## scrambleIntact:MusicianNo  6108
## scramble8B:MusicianNo     6216
## scramble2B:MusicianNo     5364
## scramble1B:MusicianNo     6525
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS Tail_ESS
## sigma     0.1122    0.0021   0.1081   0.1165 1.0002     19113    6752
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).

```

```
plot(nested_2way_musLevel)
```



```

print(summary(nested_2way_musLevel), digits = 4)

##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ level + level:Musician + (1 | sub)
##  Data: data_nested (Number of observations: 1520)
##  Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0586   0.0054   0.0489   0.0701 1.0007     3711     6269
##
## Regression Coefficients:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS
## Intercept      0.0288   0.0116   0.0063   0.0517 1.0006     4902
## level1        -0.0168   0.0114  -0.0396   0.0050 1.0000    13570
## level2        -0.0162   0.0115  -0.0388   0.0067 1.0001    13403
## level4        -0.0257   0.0116  -0.0479  -0.0029 1.0001    13612
## level2:MusicianNo 0.0154   0.0166  -0.0175   0.0476 1.0000    4609
## level4:MusicianNo  0.0150   0.0168  -0.0185   0.0472 1.0002    4635
## level8:MusicianNo  0.0172   0.0165  -0.0156   0.0493 1.0005    4330
## level16:MusicianNo 0.0115   0.0169  -0.0221   0.0444 1.0001    4702
##             Tail_ESS
## Intercept      6550
## level1        8534
## level2        8201
## level4        8304
## level2:MusicianNo 6887
## level4:MusicianNo 6281
## level8:MusicianNo 6112
## level16:MusicianNo 6842
##
## Further Distributional Parameters:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma     0.1148   0.0022   0.1106   0.1192 1.0001     19019     7249
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).

```

```

BF_nested_2way_musScram <- bayes_factor(nested_2way_musScram, nested_justScram)

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 7
print(BF_nested_2way_musScram)

## Estimated Bayes factor in favor of nested_2way_musScram over nested_justScram: 0.00096

BF_nested_2way_musLevel <- bayes_factor(nested_2way_musLevel, nested_justLevel)

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
print(BF_nested_2way_musLevel)

## Estimated Bayes factor in favor of nested_2way_musLevel over nested_justLevel: 0.00091

```

Very strong evidence against interactions between group and condition and group and level.

## 1B

```
data1B <- filter(data, scramble == '1B')

levels1B_null <- brm(value ~ 1 + (1|sub), data = data1B,
                      save_pars = save_pars(all = TRUE), iter = 5000,
                      file = 'models/E3_alignment_1B_null')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       |           ^
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 6.5e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.65 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 1.722 seconds (Warm-up)
## Chain 1:                 0.741 seconds (Sampling)
## Chain 1:                 2.463 seconds (Total)
## Chain 1:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
```

```

## Chain 2: Gradient evaluation took 1.9e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.19 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 1.942 seconds (Warm-up)
## Chain 2: 0.743 seconds (Sampling)
## Chain 2: 2.685 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 1.8e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.18 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 1.6 seconds (Warm-up)
## Chain 3: 0.737 seconds (Sampling)
## Chain 3: 2.337 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 1.9e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.19 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:

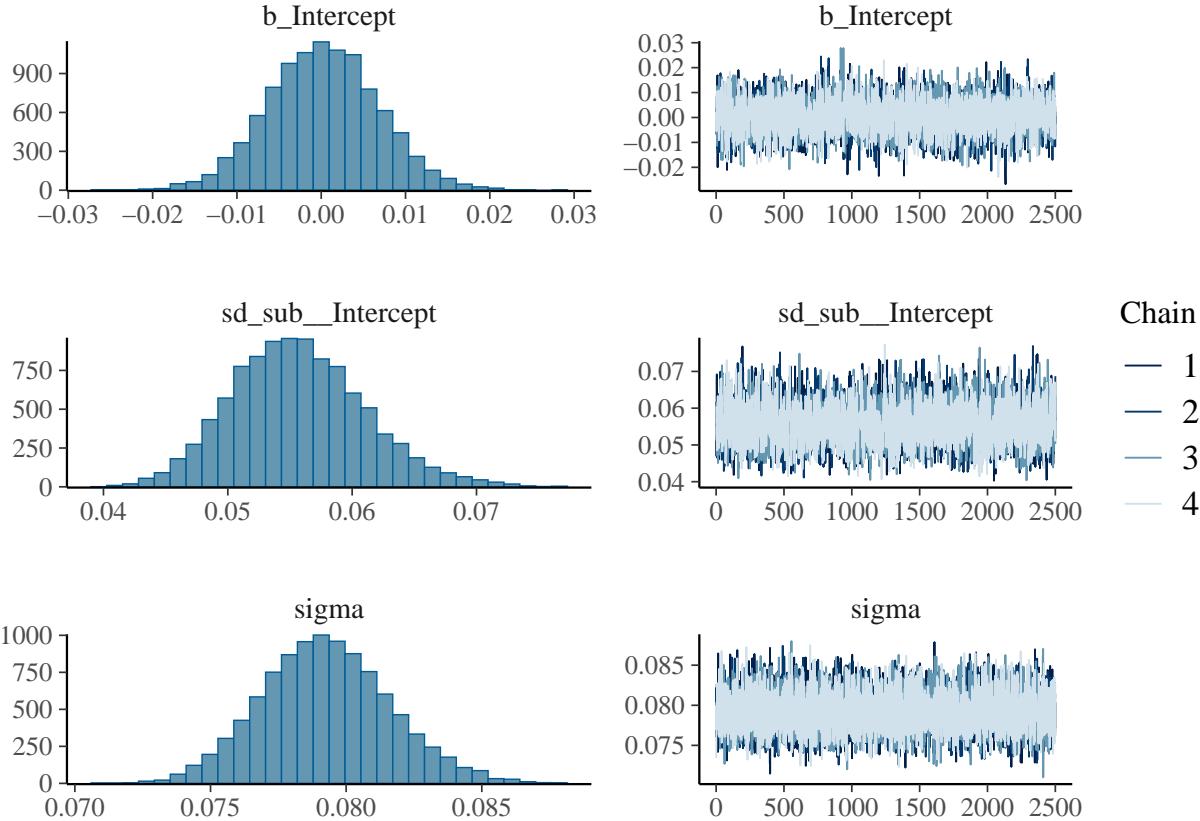
```

```

## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 1.727 seconds (Warm-up)
## Chain 4: 0.742 seconds (Sampling)
## Chain 4: 2.469 seconds (Total)
## Chain 4:

```

```
plot(levels1B_null)
```



```
print(summary(levels1B_null), digits = 4)
```

```

## Family: gaussian
## Links: mu = identity; sigma = identity
## Formula: value ~ 1 + (1 | sub)
## Data: data1B (Number of observations: 665)
## Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##         total post-warmup draws = 10000

```

```

## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)   0.0557     0.0054    0.0460    0.0672 1.0007      3563     5357
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept     0.0003     0.0066   -0.0125    0.0132 1.0002      5639     6858
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.0793     0.0024    0.0748    0.0842 0.9998     13037     7959
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
levels1B <- brm(value ~ level + (1|sub), data = data1B,
                  prior = c(
                    set_prior('normal(-0.2, 0.1)', coef = c('level1', 'level2', 'level3', 'level5')),
                    set_prior('normal(-0.1, 0.1)', coef = c('level4', 'level7')))
                  ),
                  save_pars = save_pars(all = TRUE), iter = 5000,
                  file = 'models/E3_alignment_1B')

## Compiling Stan program...
## Trying to compile a simple C file
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:10:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/Block.h:1:
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/DenseBase.h:679:1: #include <cmath>
## |           ^~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000102 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.02 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)

```

```

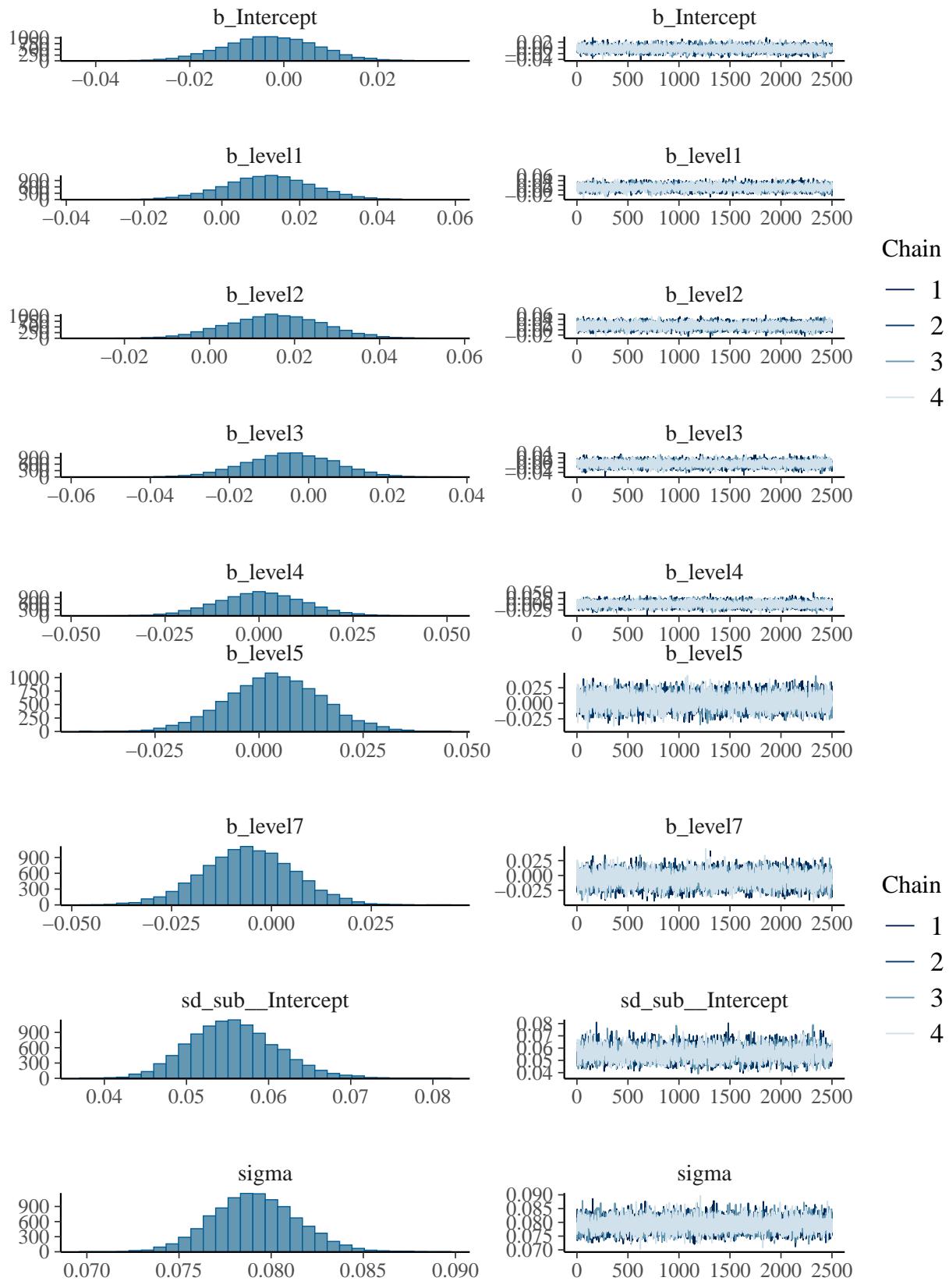
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 1.82 seconds (Warm-up)
## Chain 1:           0.792 seconds (Sampling)
## Chain 1:           2.612 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 2e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.2 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 1.838 seconds (Warm-up)
## Chain 2:           0.797 seconds (Sampling)
## Chain 2:           2.635 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 2e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.2 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)

```

```

## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 1.762 seconds (Warm-up)
## Chain 3:           0.797 seconds (Sampling)
## Chain 3:           2.559 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 2e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.2 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 1.733 seconds (Warm-up)
## Chain 4:           0.797 seconds (Sampling)
## Chain 4:           2.53 seconds (Total)
## Chain 4:
plot(levels1B)

```



```

## Family: gaussian
## Links: mu = identity; sigma = identity
## Formula: value ~ level + (1 | sub)
## Data: data1B (Number of observations: 665)
## Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0557    0.0054   0.0459   0.0671 1.0004     3647    4770
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS Tail_ESS
## Intercept -0.0028    0.0098  -0.0220   0.0166 1.0003     5518    6077
## level1    0.0120    0.0113  -0.0103   0.0340 1.0000     9200    8554
## level2    0.0155    0.0112  -0.0061   0.0372 1.0002     8504    7953
## level3   -0.0046    0.0113  -0.0267   0.0171 1.0001     9231    9016
## level4    0.0005    0.0113  -0.0214   0.0229 1.0004     8322    7997
## level5    0.0038    0.0114  -0.0186   0.0264 1.0011     8642    8167
## level7   -0.0057    0.0114  -0.0283   0.0165 1.0001     8558    8421
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS Tail_ESS
## sigma     0.0791    0.0023   0.0747   0.0838 0.9998    12557    7368
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
BF_1B_level <- bayes_factor(levels1B, levels1B_null)

```

```

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 7
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6

```

```
print(BF_1B_level)
```

```
## Estimated Bayes factor in favor of levels1B over levels1B_null: 0.00000
```

There is very strong evidence against a main effect of level.

```
emm_1B <- emmeans(levels1B, specs = "level")
summary(emm_1B)
```

```
##  level    emmean lower.HPD upper.HPD
##  1      0.009124 -0.01075   0.0281
```

```

## 2      0.012676 -0.00612   0.0321
## 3     -0.007242 -0.02722   0.0123
## 4     -0.002363 -0.02171   0.0174
## 5      0.000914 -0.01833   0.0204
## 8     -0.002725 -0.02265   0.0156
## 16    -0.008569 -0.02861   0.0104
##
## Point estimate displayed: median
## HPD interval probability: 0.95

All levels at chance.

contrast(emm_1B, method = "pairwise")

## contrast      estimate lower.HPD upper.HPD
## level1 - level2 -0.003557 -0.02693   0.0183
## level1 - level3  0.016563 -0.00618   0.0382
## level1 - level4  0.011566 -0.01120   0.0335
## level1 - level5  0.008167 -0.01474   0.0310
## level1 - level8  0.011962 -0.01038   0.0339
## level1 - level16 0.017500 -0.00400   0.0411
## level2 - level3  0.020095 -0.00243   0.0424
## level2 - level4  0.015013 -0.00539   0.0383
## level2 - level5  0.011810 -0.00982   0.0338
## level2 - level8  0.015594 -0.00535   0.0378
## level2 - level16 0.021304 -0.00126   0.0433
## level3 - level4 -0.004998 -0.02797   0.0165
## level3 - level5 -0.008397 -0.03052   0.0134
## level3 - level8 -0.004509 -0.02661   0.0171
## level3 - level16 0.001031 -0.02105   0.0238
## level4 - level5 -0.003382 -0.02610   0.0187
## level4 - level8  0.000517 -0.02106   0.0232
## level4 - level16 0.006141 -0.01619   0.0284
## level5 - level8  0.003728 -0.01856   0.0265
## level5 - level16 0.009451 -0.01351   0.0323
## level8 - level16 0.005761 -0.01648   0.0282
##
## Point estimate displayed: median
## HPD interval probability: 0.95

```

No differences between any levels.

## 2B

```
data2B <- filter(data, scramble == '2B')

levels2B_null <- brm(value ~ 1 + (1|sub), data = data2B,
                      save_pars = save_pars(all = TRUE), iter = 5000,
                      file = 'models/E3_alignment_2B_null')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       |           ^
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 5.5e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.55 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 1.587 seconds (Warm-up)
## Chain 1:                 0.736 seconds (Sampling)
## Chain 1:                 2.323 seconds (Total)
## Chain 1:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
```

```

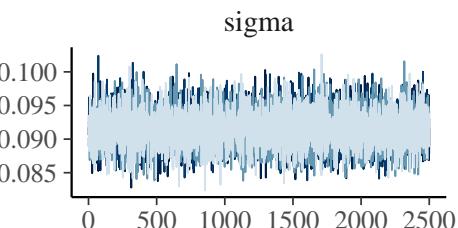
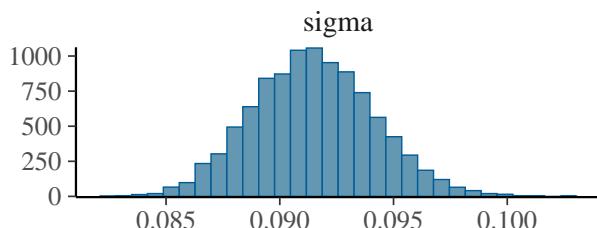
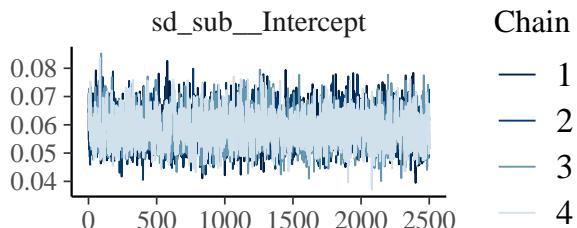
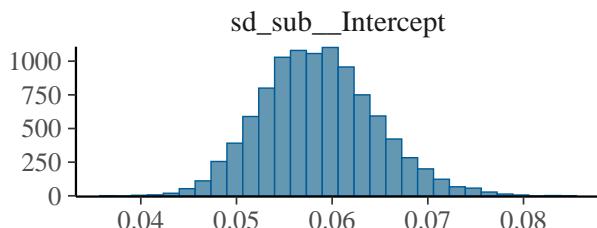
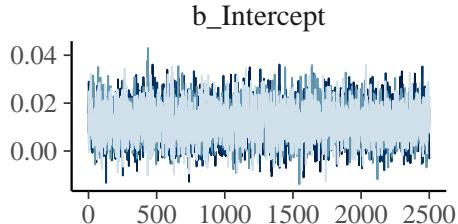
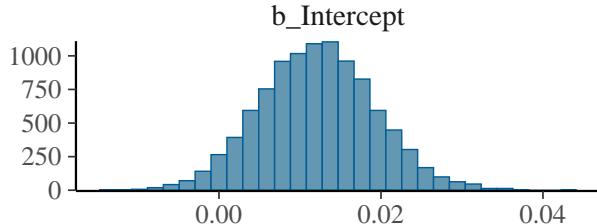
## Chain 2: Gradient evaluation took 1.9e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.19 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 1.651 seconds (Warm-up)
## Chain 2: 0.737 seconds (Sampling)
## Chain 2: 2.388 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 1.9e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.19 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 1.628 seconds (Warm-up)
## Chain 3: 0.613 seconds (Sampling)
## Chain 3: 2.241 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 2.3e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.23 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:

```

```

## Chain 4:
## Chain 4: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 1.646 seconds (Warm-up)
## Chain 4: 0.713 seconds (Sampling)
## Chain 4: 2.359 seconds (Total)
## Chain 4:
plot(levels2B_null)

```



```
print(summary(levels2B_null), digits = 4)
```

```

## Family: gaussian
##   Links: mu = identity; sigma = identity
## Formula: value ~ 1 + (1 | sub)
##   Data: data2B (Number of observations: 665)
##   Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000

```

```

## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)   0.0586     0.0059    0.0479    0.0711 1.0008      3149     4979
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept     0.0121     0.0071   -0.0014    0.0263 1.0005      5212     6230
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.0915     0.0027    0.0864    0.0968 1.0005     10224     7066
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).

levels2B <- brm(value ~ level + (1|sub), data = data2B,
                  prior = c(
                    set_prior('normal(-0.2, 0.1)', coef = c('level1', 'level2', 'level3', 'level5')),
                    set_prior('normal(-0.1, 0.1)', coef = c('level4', 'level7')))
                  ),
                  save_pars = save_pars(all = TRUE), iter = 5000,
                  file = 'models/E3_alignment_2B')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:10:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/Block.h:1:
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/DenseBase.h:679 | #include <cmath>
## |          ^~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 9e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.9 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)

```

```

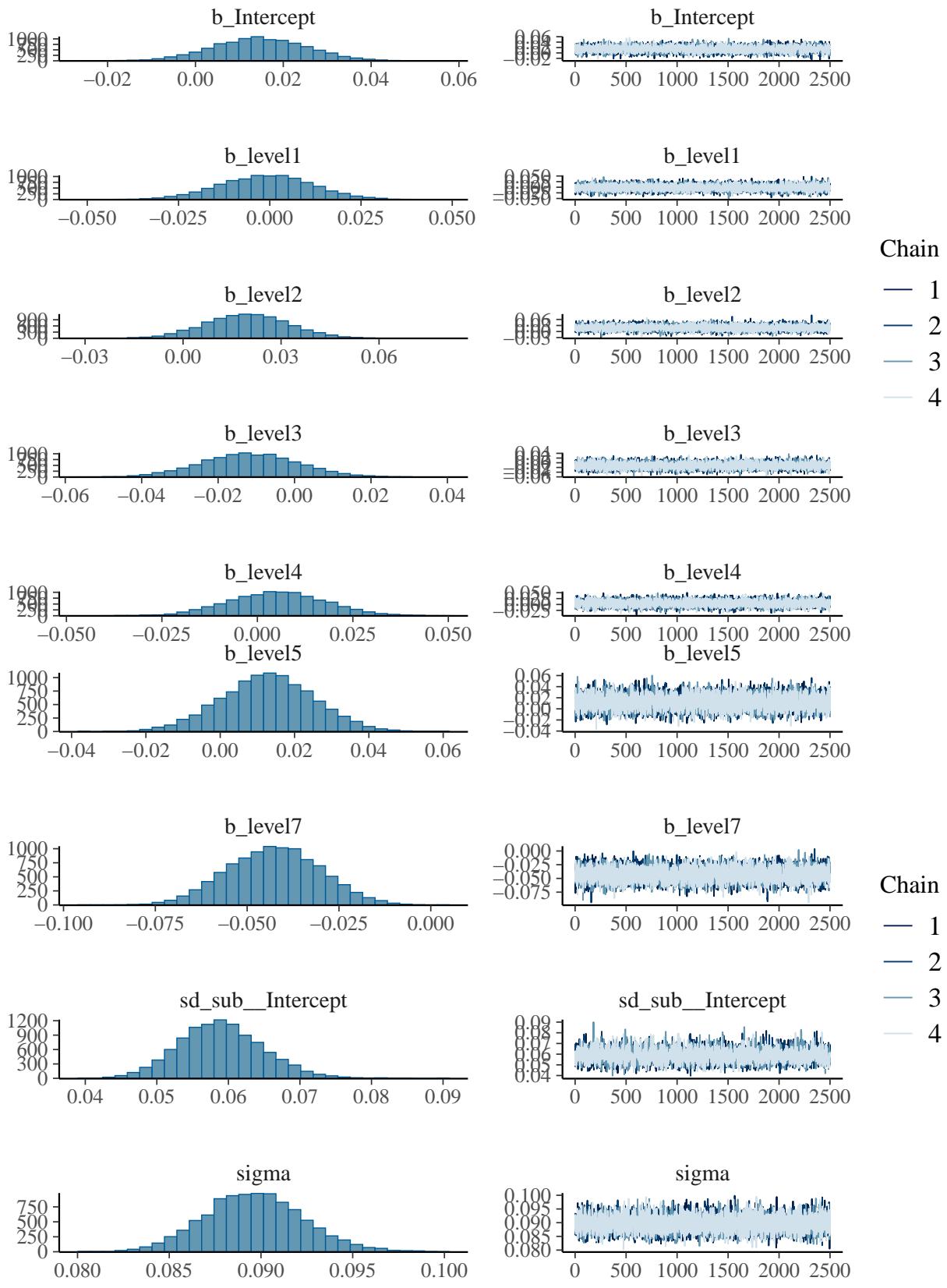
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 1.754 seconds (Warm-up)
## Chain 1:           0.8 seconds (Sampling)
## Chain 1:           2.554 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 2.1e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.21 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 1.643 seconds (Warm-up)
## Chain 2:           0.797 seconds (Sampling)
## Chain 2:           2.44 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 2.1e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.21 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)

```

```

## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 1.737 seconds (Warm-up)
## Chain 3:           0.8 seconds (Sampling)
## Chain 3:           2.537 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 2.1e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.21 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 1.719 seconds (Warm-up)
## Chain 4:           0.803 seconds (Sampling)
## Chain 4:           2.522 seconds (Total)
## Chain 4:
plot(levels2B)

```



```
print(summary(levels2B), digits = 4)
```

```

## Family: gaussian
## Links: mu = identity; sigma = identity
## Formula: value ~ level + (1 | sub)
## Data: data2B (Number of observations: 665)
## Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0590    0.0059   0.0481   0.0710 1.0008     3303    4903
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS Tail_ESS
## Intercept    0.0147    0.0106  -0.0060   0.0355 1.0003     6173    7185
## level1      -0.0009    0.0126  -0.0258   0.0236 1.0002     9137    7844
## level2       0.0196    0.0126  -0.0046   0.0445 1.0005     9625    8061
## level3      -0.0117    0.0127  -0.0363   0.0131 1.0000    10400    8681
## level4       0.0052    0.0127  -0.0190   0.0300 1.0000     9792    8751
## level5       0.0128    0.0125  -0.0120   0.0372 1.0003    10267    9047
## level7      -0.0427    0.0126  -0.0668  -0.0184 1.0000     9543    8008
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI   Rhat Bulk_ESS Tail_ESS
## sigma       0.0896    0.0027   0.0845   0.0952 1.0010    13365    7579
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
BF_2B_level <- bayes_factor(levels2B, levels2B_null)

```

```

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6

```

```
print(BF_2B_level)
```

```
## Estimated Bayes factor in favor of levels2B over levels2B_null: 0.00041
```

There is strong evidence against an effect of level.

```
emm_2B <- emmeans(levels2B, specs = "level")
summary(emm_2B)
```

```

## level    emmean lower.HPD upper.HPD
## 1        0.01380 -0.00753   0.03546
## 2        0.03437  0.01262   0.05552
## 3        0.00306 -0.01772   0.02469
## 4        0.01988 -0.00169   0.04094

```

```

##   5      0.02761  0.00584  0.04854
##   8      0.01458 -0.00529  0.03613
##  16     -0.02783 -0.04974 -0.00638
##
## Point estimate displayed: median
## HPD interval probability: 0.95

Above chance: 2, 5 Below chance: 16 All others at chance

contrast(emm_2B, method = "pairwise")

## contrast      estimate lower.HPD upper.HPD
## level1 - level2 -0.020642 -0.04665  0.003954
## level1 - level3  0.010672 -0.01536  0.035818
## level1 - level4 -0.006004 -0.03221  0.018567
## level1 - level5 -0.013689 -0.03782  0.012445
## level1 - level8 -0.000765 -0.02578  0.023587
## level1 - level16 0.041758  0.01691  0.067509
## level2 - level3  0.031328  0.00508  0.054821
## level2 - level4  0.014509 -0.01032  0.039923
## level2 - level5  0.006727 -0.01763  0.033347
## level2 - level8  0.019606 -0.00497  0.044021
## level2 - level16 0.062324  0.03670  0.087874
## level3 - level4 -0.016934 -0.04234  0.009008
## level3 - level5 -0.024382 -0.04970  0.000353
## level3 - level8 -0.011803 -0.03650  0.012732
## level3 - level16 0.031053  0.00503  0.056079
## level4 - level5 -0.007460 -0.03292  0.017671
## level4 - level8  0.005190 -0.01956  0.029213
## level4 - level16 0.048038  0.02223  0.072954
## level5 - level8  0.012852 -0.01099  0.037861
## level5 - level16 0.055419  0.02859  0.080045
## level8 - level16 0.042534  0.01827  0.066570
##
## Point estimate displayed: median
## HPD interval probability: 0.95

```

1 > 16, 2 > 16, 3 > 16, 4 > 16, 5 > 16, 8 > 16

2 > 3

## 8B

```
data8B <- filter(data, scramble == '8B')

levels8B_null <- brm(value ~ 1 + (1|sub), data = data8B,
                      save_pars = save_pars(all = TRUE), iter = 5000,
                      file = 'models/E3_alignment_8B_null')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       |           ^
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 8.6e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.86 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 1.423 seconds (Warm-up)
## Chain 1:                 0.708 seconds (Sampling)
## Chain 1:                 2.131 seconds (Total)
## Chain 1:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
```

```

## Chain 2: Gradient evaluation took 2.7e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.27 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 1.301 seconds (Warm-up)
## Chain 2:           0.675 seconds (Sampling)
## Chain 2:           1.976 seconds (Total)
## Chain 2:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 1.9e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.19 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 1.38 seconds (Warm-up)
## Chain 3:           0.737 seconds (Sampling)
## Chain 3:           2.117 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 2.6e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.26 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:

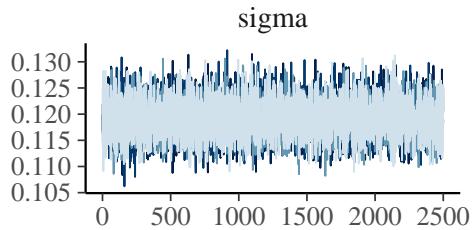
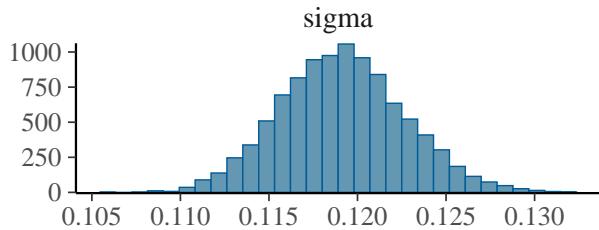
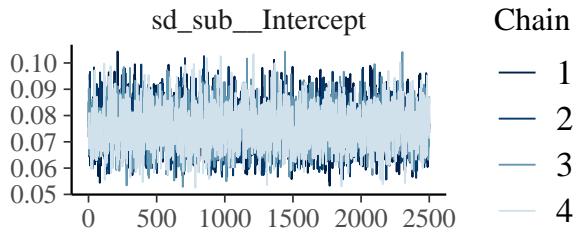
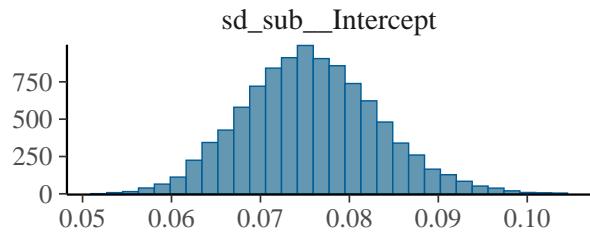
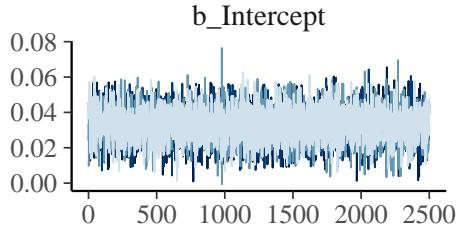
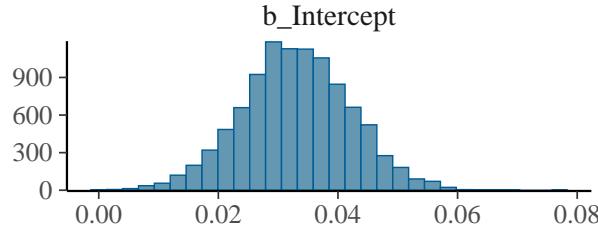
```

```

## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 1.463 seconds (Warm-up)
## Chain 4:                      0.74 seconds (Sampling)
## Chain 4:                      2.203 seconds (Total)
## Chain 4:

plot(levels8B_null)

```



```
print(summary(levels8B_null), digits = 4)
```

```

##   Family: gaussian
##   Links: mu = identity; sigma = identity
## Formula: value ~ 1 + (1 | sub)
##   Data: data8B (Number of observations: 665)
##   Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000

```

```

## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)   0.0757     0.0075   0.0618   0.0915 1.0002      3923     5623
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept     0.0330     0.0091   0.0148   0.0508 1.0003      6150     6831
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.1191     0.0035   0.1125   0.1263 1.0010     12384     7474
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
levels8B <- brm(value ~ level + (1|sub), data = data8B,
                  prior = c(
                    set_prior('normal(-0.2, 0.1)', coef = c('level1', 'level2', 'level3', 'level5')),
                    set_prior('normal(-0.1, 0.1)', coef = c('level4', 'level7')))
                  ),
                  save_pars = save_pars(all = TRUE), iter = 5000,
                  file = 'models/E3_alignment_8B')

## Compiling Stan program...
## Trying to compile a simple C file
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:32:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:18:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/SpecialFunctions:18:
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/Block.h:679 | #include <cmath>
##               |          ^~~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000111 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.11 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)

```

```

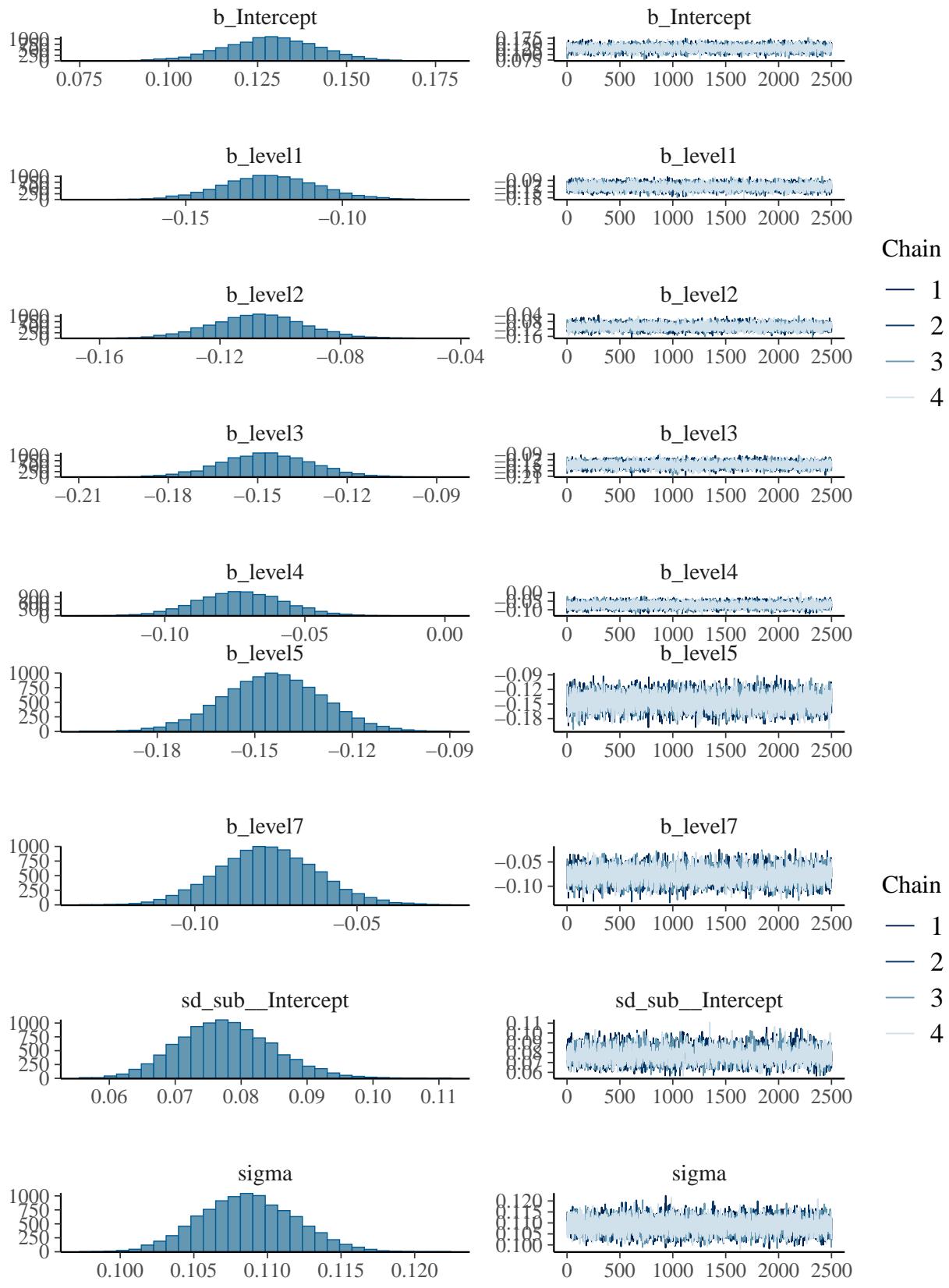
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 1.583 seconds (Warm-up)
## Chain 1:           0.802 seconds (Sampling)
## Chain 1:           2.385 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 2.2e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.22 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 1.644 seconds (Warm-up)
## Chain 2:           0.803 seconds (Sampling)
## Chain 2:           2.447 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 2e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.2 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)

```

```

## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 1.542 seconds (Warm-up)
## Chain 3:           0.801 seconds (Sampling)
## Chain 3:           2.343 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 2e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.2 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration:    1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration:   500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration:  1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration:  1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration:  2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration:  2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 1.478 seconds (Warm-up)
## Chain 4:           0.801 seconds (Sampling)
## Chain 4:           2.279 seconds (Total)
## Chain 4:
plot(levels8B)

```



```

## Family: gaussian
## Links: mu = identity; sigma = identity
## Formula: value ~ level + (1 | sub)
## Data: data8B (Number of observations: 665)
## Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##         total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0777    0.0073   0.0644   0.0929 1.0005      3769     5685
##
## Regression Coefficients:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept    0.1289    0.0132   0.1025   0.1541 0.9999      5326     7067
## level1      -0.1230    0.0153  -0.1529  -0.0918 1.0002      8543     7748
## level2      -0.1073    0.0154  -0.1377  -0.0774 1.0003      8613     8298
## level3      -0.1471    0.0153  -0.1772  -0.1168 1.0001      8495     8201
## level4      -0.0728    0.0154  -0.1028  -0.0424 1.0004      8456     7926
## level5      -0.1445    0.0154  -0.1753  -0.1145 0.9998      8627     8496
## level7      -0.0774    0.0154  -0.1075  -0.0464 0.9999      8922     8453
##
## Further Distributional Parameters:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.1087    0.0032   0.1025   0.1152 1.0003     14431     8183
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
BF_8B_level <- bayes_factor(levels8B, levels8B_null)

```

```

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 7

```

```
print(BF_8B_level)
```

```
## Estimated Bayes factor in favor of levels8B over levels8B_null: 1420501433223188480.00000
```

There is very strong evidence for an effect of level.

```
emm_8B <- emmeans(levels8B, specs = "level")
summary(emm_8B)
```

```
##  level    emmean lower.HPD upper.HPD
##  1        0.00593 -0.02053   0.03281
```

```

## 2      0.02161 -0.00551  0.04796
## 3     -0.01809 -0.04523  0.00852
## 4      0.05602  0.02925  0.08196
## 5     -0.01556 -0.04254  0.01154
## 8      0.12897  0.10336  0.15488
## 16     0.05137  0.02478  0.07864
##
## Point estimate displayed: median
## HPD interval probability: 0.95

Above chance: 4, 8, 16 At chance: 1, 2, 3, 5

contrast(emm_8B, method = "pairwise")

```

	contrast	estimate	lower.HPD	upper.HPD
##	level1 - level2	-0.01556	-0.04497	0.01498
##	level1 - level3	0.02437	-0.00665	0.05416
##	level1 - level4	-0.05037	-0.08122	-0.01912
##	level1 - level5	0.02142	-0.00843	0.05352
##	level1 - level8	-0.12314	-0.15476	-0.09417
##	level1 - level16	-0.04557	-0.07389	-0.01374
##	level2 - level3	0.03985	0.00972	0.07075
##	level2 - level4	-0.03471	-0.06501	-0.00298
##	level2 - level5	0.03714	0.00544	0.06847
##	level2 - level8	-0.10728	-0.13870	-0.07862
##	level2 - level16	-0.03005	-0.06210	0.00013
##	level3 - level4	-0.07417	-0.10380	-0.04331
##	level3 - level5	-0.00252	-0.03340	0.02816
##	level3 - level8	-0.14716	-0.17757	-0.11727
##	level3 - level16	-0.06959	-0.10134	-0.03852
##	level4 - level5	0.07172	0.04088	0.10375
##	level4 - level8	-0.07298	-0.10370	-0.04343
##	level4 - level16	0.00448	-0.02545	0.03643
##	level5 - level8	-0.14432	-0.17600	-0.11523
##	level5 - level16	-0.06722	-0.09695	-0.03496
##	level8 - level16	0.07769	0.04710	0.10794

2 > 3, 2 > 5

4 > 1, 4 > 2, 4 > 3, 4 > 5

8 > 1, 8 > 2, 8 > 3, 8 > 4, 8 > 5, 8 > 16

16 > 1, 16 > 3, 16 > 5

Phrase level greater than all others. Structurally relevant levels (2,4,8,16) are consistently greater than structurally irrelevant levels (3,5), BUT participants align to longer SRL (4,8) more than 2 - consistent with lower rate of response

## Intact

```
dataI <- filter(data, scramble == 'Intact')

levelsI_null <- brm(value ~ 1 + (1|sub), data = dataI,
                     save_pars = save_pars(all = TRUE), iter = 5000,
                     file = 'models/E3_alignment_Intact_null')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core
##   679 | #include <cmath>
##       |           ^
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 7.6e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.76 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 1.564 seconds (Warm-up)
## Chain 1:                 0.669 seconds (Sampling)
## Chain 1:                 2.233 seconds (Total)
## Chain 1:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
```

```

## Chain 2: Gradient evaluation took 2.6e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.26 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 1.504 seconds (Warm-up)
## Chain 2: 0.737 seconds (Sampling)
## Chain 2: 2.241 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 1.9e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.19 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 1.628 seconds (Warm-up)
## Chain 3: 0.739 seconds (Sampling)
## Chain 3: 2.367 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 1.9e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.19 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:

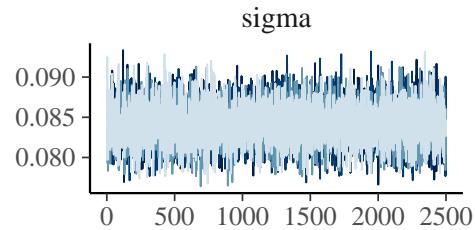
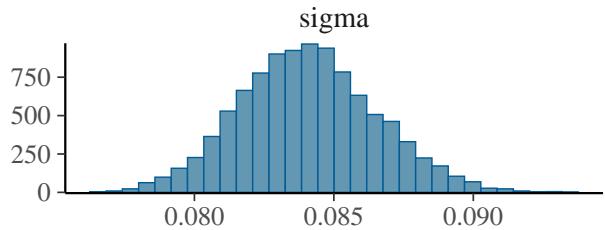
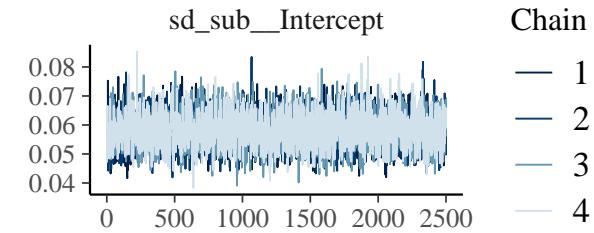
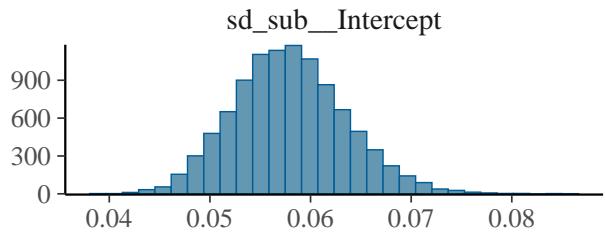
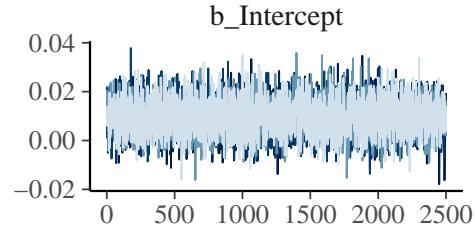
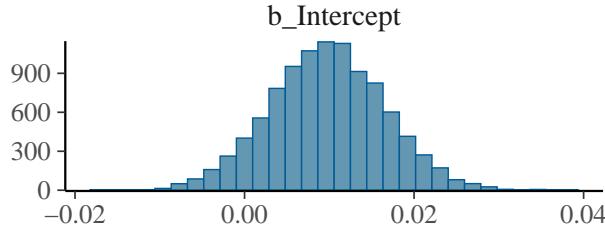
```

```

## Chain 4:
## Chain 4: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 1.541 seconds (Warm-up)
## Chain 4: 0.726 seconds (Sampling)
## Chain 4: 2.267 seconds (Total)
## Chain 4:

plot(levelsI_null)

```



```
print(summary(levelsI_null), digits = 4)
```

```

## Family: gaussian
##   Links: mu = identity; sigma = identity
## Formula: value ~ 1 + (1 | sub)
##   Data: dataI (Number of observations: 665)
##   Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000

```

```

## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)   0.0579     0.0056   0.0477   0.0695 1.0005      3528     6119
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept     0.0097     0.0068  -0.0036   0.0231 1.0004      5283     6814
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.0841     0.0025   0.0794   0.0891 0.9999      12792    7527
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
levelsI <- brm(value ~ level + (1|sub), data = dataI,
                 prior = c(
                   set_prior('normal(-0.2, 0.1)', coef = c('level1', 'level2', 'level3', 'level5')),
                   set_prior('normal(-0.1, 0.1)', coef = c('level4', 'level7')))
                 ),
                 save_pars = save_pars(all = TRUE), iter = 5000,
                 file = 'models/E3_alignment_Intact')

## Compiling Stan program...
## Trying to compile a simple C file
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:32:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:18:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/SpecialFunctions:18:
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/Block.h:679 | #include <cmath>
##               |          ^~~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.000105 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 1.05 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)

```

```

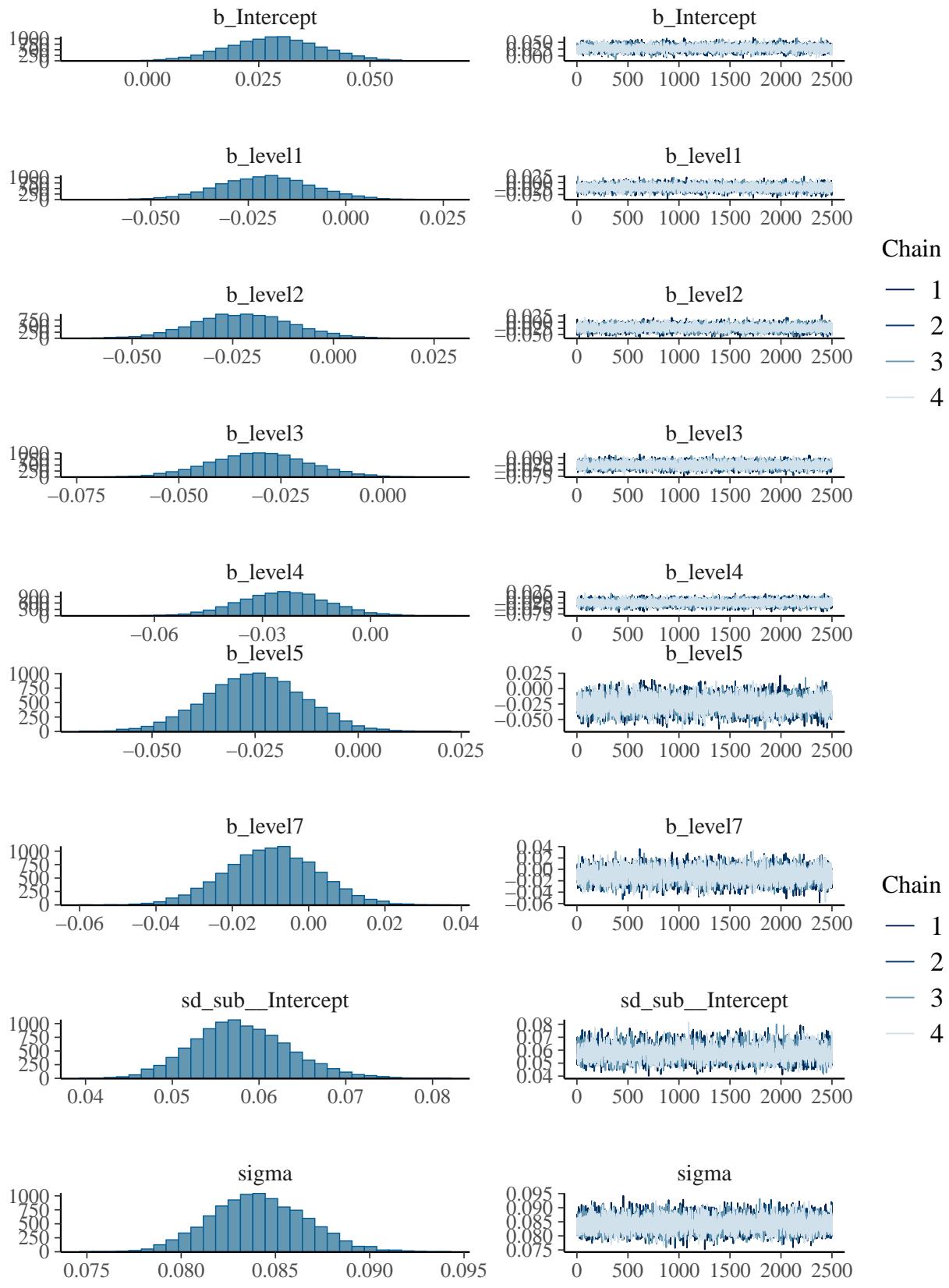
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 1.835 seconds (Warm-up)
## Chain 1:           0.799 seconds (Sampling)
## Chain 1:           2.634 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 2e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.2 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 1.756 seconds (Warm-up)
## Chain 2:           0.799 seconds (Sampling)
## Chain 2:           2.555 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 2e-05 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.2 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)

```

```

## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 1.728 seconds (Warm-up)
## Chain 3:           0.832 seconds (Sampling)
## Chain 3:           2.56 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 2e-05 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.2 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration:    1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration:   500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration:  1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration:  1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration:  2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration:  2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 1.657 seconds (Warm-up)
## Chain 4:           0.797 seconds (Sampling)
## Chain 4:           2.454 seconds (Total)
## Chain 4:
plot(levelsI)

```



```
print(summary(levelsI), digits = 4)
```

```

## Family: gaussian
## Links: mu = identity; sigma = identity
## Formula: value ~ level + (1 | sub)
## Data: dataI (Number of observations: 665)
## Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 95)
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0580     0.0056   0.0476   0.0697 1.0001      3730     5517
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept    0.0286     0.0105   0.0080   0.0491 1.0002      6815     7292
## level1     -0.0205     0.0121  -0.0442   0.0035 1.0005      9241     7820
## level2     -0.0224     0.0120  -0.0457   0.0013 1.0004     9903     8125
## level3     -0.0303     0.0120  -0.0537  -0.0068 1.0002     9810     8234
## level4     -0.0241     0.0121  -0.0478  -0.0003 1.0007    10217     8719
## level5     -0.0250     0.0119  -0.0485  -0.0020 1.0004     9410     7785
## level7     -0.0098     0.0121  -0.0339   0.0138 1.0008     9647     8493
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.0841     0.0025   0.0793   0.0892 1.0009    14079     8068
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).

BF_I_level <- bayes_factor(levelsI, levelsI_null)

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6
## Iteration: 7
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 6

print(BF_I_level)

## Estimated Bayes factor in favor of levelsI over levelsI_null: 0.00000
There is strong evidence against an effect of level.

emm_I <- emmeans(levelsI, specs = "level")
summary(emm_I)

##   level   emmean lower.HPD upper.HPD
##   1       0.00815 -0.01378   0.0278

```

```

## 2      0.00613 -0.01480  0.0261
## 3     -0.00152 -0.02244  0.0185
## 4      0.00443 -0.01644  0.0247
## 5      0.00368 -0.01579  0.0246
## 8      0.02867  0.00788  0.0490
## 16     0.01872 -0.00177  0.0388
##
## Point estimate displayed: median
## HPD interval probability: 0.95

Only level above chance is 8-bar level.

contrast(emm_I, method = "pairwise")

## contrast      estimate lower.HPD upper.HPD
## level1 - level2  0.001867 -0.0214  0.026729
## level1 - level3  0.009732 -0.0134  0.033907
## level1 - level4  0.003645 -0.0195  0.028731
## level1 - level5  0.004449 -0.0178  0.028706
## level1 - level8 -0.020424 -0.0434  0.004071
## level1 - level16 -0.010720 -0.0352  0.011452
## level2 - level3  0.007886 -0.0161  0.030725
## level2 - level4  0.001676 -0.0219  0.025681
## level2 - level5  0.002549 -0.0208  0.026173
## level2 - level8 -0.022470 -0.0463  0.000628
## level2 - level16 -0.012600 -0.0344  0.012824
## level3 - level4 -0.006145 -0.0306  0.017140
## level3 - level5 -0.005372 -0.0274  0.018783
## level3 - level8 -0.030249 -0.0534 -0.006572
## level3 - level16 -0.020534 -0.0431  0.003845
## level4 - level5  0.000827 -0.0221  0.025682
## level4 - level8 -0.024026 -0.0489 -0.001499
## level4 - level16 -0.014266 -0.0388  0.010125
## level5 - level8 -0.024999 -0.0486 -0.002119
## level5 - level16 -0.015325 -0.0404  0.007220
## level8 - level16  0.009720 -0.0125  0.034909
##
## Point estimate displayed: median
## HPD interval probability: 0.95

```

8 > 3, 8 > 4, 8 > 5

## 8B vs Intact, 8 vs 16

```
data_longTS <- data %>%
  filter(scramble %in% c('Intact', '8B')) %>%
  filter(level %in% c('8', '16')) %>%
  mutate(scramble = factor(scramble, levels = c('Intact', '8B')),
         level = factor(level, levels = c('8', '16')))

contrasts(data_longTS$level) <- contr.treatment(2)

data_longTS_M <- filter(data_longTS, Musician == 'Yes')
data_longTS_NM <- filter(data_longTS, Musician == 'No')

longTS_M <- brm(value ~ scramble + level + (1|sub), data = data_longTS_M,
                  prior = set_prior('normal(0, 0.1)', class = 'b'),
                  save_pars = save_pars(all = TRUE), iter = 5000,
                  file = 'models/E3_alignment_longTimescales_mus')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:10:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:1:
##   679 | #include <cmath>
##       |           ^~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

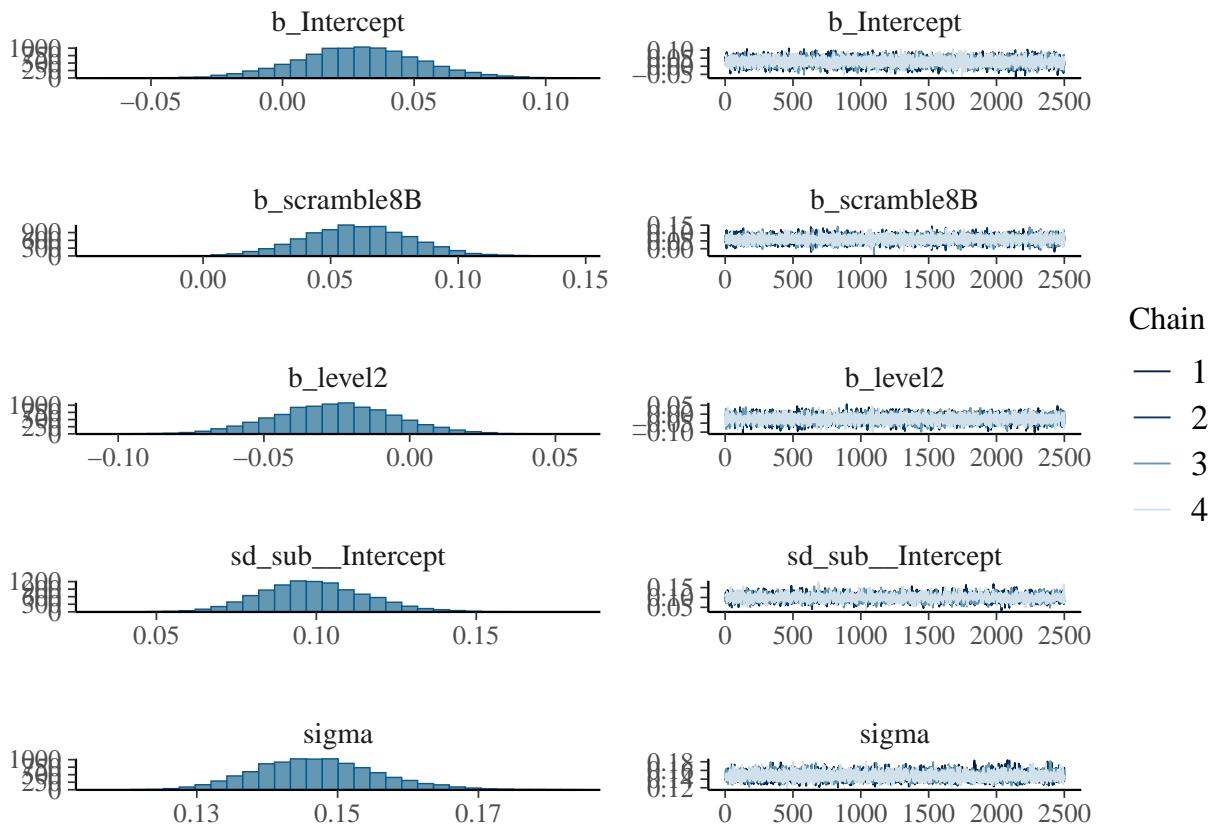
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 5.1e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.51 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
```

```

## Chain 1: Iteration: 5000 / 5000 [100%]  (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 0.371 seconds (Warm-up)
## Chain 1:           0.181 seconds (Sampling)
## Chain 1:           0.552 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 7e-06 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.07 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration:    1 / 5000 [  0%] (Warmup)
## Chain 2: Iteration:  500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 0.386 seconds (Warm-up)
## Chain 2:           0.195 seconds (Sampling)
## Chain 2:           0.581 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 7e-06 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.07 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration:    1 / 5000 [  0%] (Warmup)
## Chain 3: Iteration:  500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 0.398 seconds (Warm-up)
## Chain 3:           0.239 seconds (Sampling)

```

```
## Chain 3:          0.637 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 8e-06 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.08 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration:    1 / 5000 [  0%] (Warmup)
## Chain 4: Iteration:  500 / 5000 [ 10%] (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 0.388 seconds (Warm-up)
## Chain 4:           0.281 seconds (Sampling)
## Chain 4:           0.669 seconds (Total)
## Chain 4:
plot(longTS_M)
```



```
print(summary(longTS_M), digits = 4)
```

```
##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ scramble + level + (1 | sub)
##  Data: data_longTS_M (Number of observations: 196)
##  Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 49)
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0993   0.0165   0.0689   0.1336 1.0001     3182     5290
## 
## Regression Coefficients:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept     0.0288   0.0233  -0.0175   0.0752 1.0004     6064     6732
## scramble8B    0.0604   0.0210   0.0192   0.1011 1.0006    13269     7520
## level2       -0.0257   0.0206  -0.0663   0.0143 1.0003    12774     7464
## 
## Further Distributional Parameters:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma        0.1471   0.0087   0.1312   0.1655 1.0007     7205     7057
## 
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

```

longTS_M_int <- brm(value ~ scramble*level + (1|sub), data = data_longTS_M,
                     prior = set_prior('normal(0, 0.1)', class = 'b'),
                     save_pars = save_pars(all = TRUE), iter = 5000,
                     file = 'models/E3_alignment_longTimescales_musInt')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include/c++/v1"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:10
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/RcppEigen.hpp:10
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:10
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/Block.h:679 | #include <cmath>
##           |          ~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 6.2e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.62 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 0.414 seconds (Warm-up)
## Chain 1:          0.265 seconds (Sampling)
## Chain 1:          0.679 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 8e-06 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.08 seconds.
## Chain 2: Adjust your expectations accordingly!

```

```

## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 0.41 seconds (Warm-up)
## Chain 2: 0.265 seconds (Sampling)
## Chain 2: 0.675 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 8e-06 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.08 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 0.394 seconds (Warm-up)
## Chain 3: 0.295 seconds (Sampling)
## Chain 3: 0.689 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 8e-06 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.08 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)

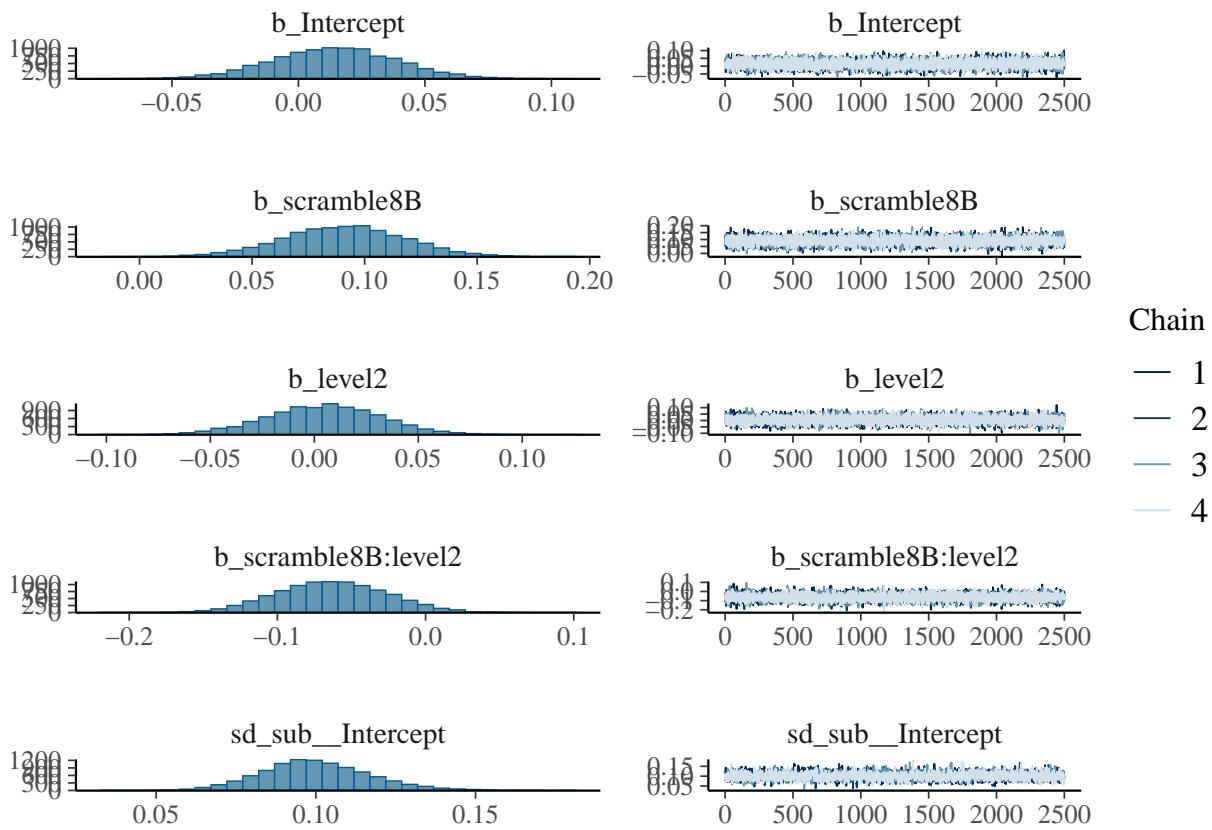
```

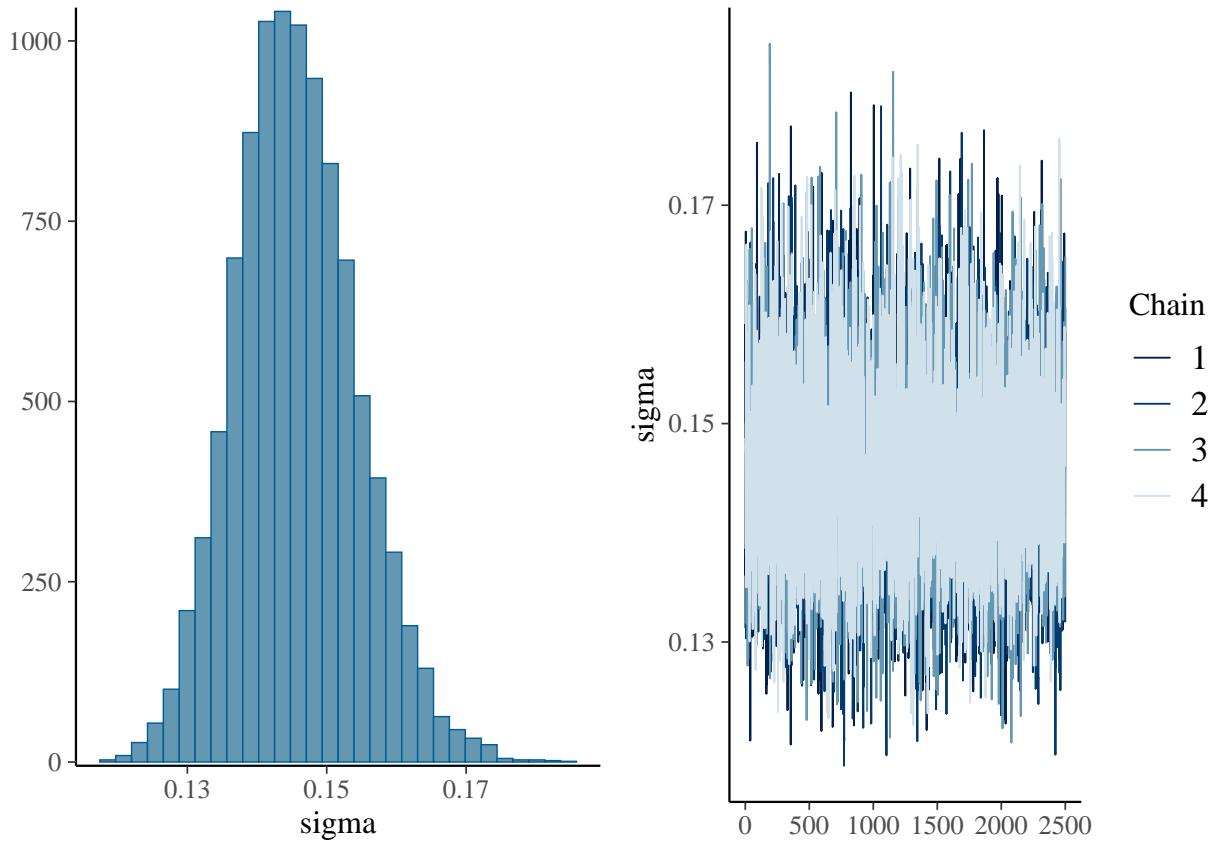
```

## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 0.414 seconds (Warm-up)
## Chain 4:                      0.293 seconds (Sampling)
## Chain 4:                      0.707 seconds (Total)
## Chain 4:

plot(longTS_M_int)

```





```

print(summary(longTS_M_int), digits = 4)

##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ scramble * level + (1 | sub)
##  Data: data_longTS_M (Number of observations: 196)
##  Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 49)
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.1001    0.0170   0.0686   0.1360 1.0008     2886     4748
## 
## Regression Coefficients:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept      0.0141    0.0244  -0.0343   0.0620 1.0000     8386    7769
## scramble8B     0.0908    0.0270   0.0374   0.1435 1.0007    11288    8419
## level2        0.0046    0.0272  -0.0495   0.0579 1.0002    12226    7812
## scramble8B:level2 -0.0633    0.0372 -0.1343   0.0092 1.0003    10723    7653
## 
## Further Distributional Parameters:
##             Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma       0.1457    0.0088   0.1295   0.1641 1.0002     7243     6935
## 
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential

```

```
## scale reduction factor on split chains (at convergence, Rhat = 1).  
BF_longM <- bayes_factor(longTS_M_int, longTS_M)  
  
## Iteration: 1  
## Iteration: 2  
## Iteration: 3  
## Iteration: 4  
## Iteration: 5  
## Iteration: 1  
## Iteration: 2  
## Iteration: 3  
## Iteration: 4  
## Iteration: 5  
## Iteration: 6  
  
print(BF_longM)  
  
## Estimated Bayes factor in favor of longTS_M_int over longTS_M: 1.62797
```

There is weak evidence for an interaction for musicians.

```

longTS_NM <- brm(value ~ scramble + level + (1|sub), data = data_longTS_NM,
                  prior = set_prior('normal(0, 0.1)', class = 'b'),
                  save_pars = save_pars(all = TRUE), iter = 5000,
                  file = 'models/E3_alignment_longTimescales_nonmus')

## Compiling Stan program...

## Trying to compile a simple C file

## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include/c++/v1"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:10
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/RcppEigen.hpp:10
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/Dense:10
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/Block.h:679 | #include <cmath>
##           |          ~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling

##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 7e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.7 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 0.384 seconds (Warm-up)
## Chain 1:          0.249 seconds (Sampling)
## Chain 1:          0.633 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 8e-06 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.08 seconds.
## Chain 2: Adjust your expectations accordingly!

```

```

## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 0.407 seconds (Warm-up)
## Chain 2: 0.23 seconds (Sampling)
## Chain 2: 0.637 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 8e-06 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.08 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 3: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 3:
## Chain 3: Elapsed Time: 0.386 seconds (Warm-up)
## Chain 3: 0.182 seconds (Sampling)
## Chain 3: 0.568 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 7e-06 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.07 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 4: Iteration: 500 / 5000 [ 10%] (Warmup)

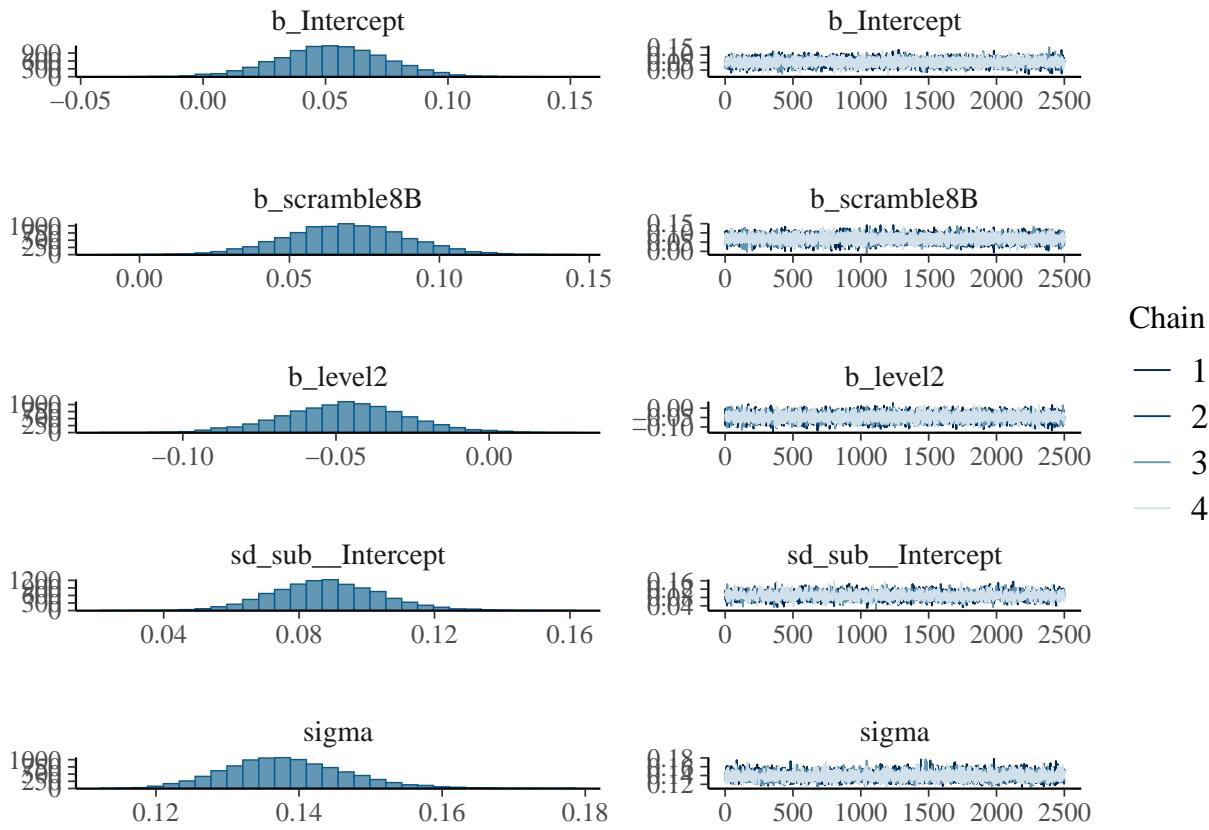
```

```

## Chain 4: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 4:
## Chain 4: Elapsed Time: 0.379 seconds (Warm-up)
## Chain 4:           0.256 seconds (Sampling)
## Chain 4:           0.635 seconds (Total)
## Chain 4:

plot(longTS_NM)

```



```
print(summary(longTS_NM), digits = 4)
```

```

## Family: gaussian
## Links: mu = identity; sigma = identity
## Formula: value ~ scramble + level + (1 | sub)
## Data: data_longTS_NM (Number of observations: 184)
## Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##         total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 46)

```

```

##          Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0882     0.0161   0.0576   0.1216 1.0008      3427     5742
##
## Regression Coefficients:
##          Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept    0.0526     0.0220   0.0089   0.0953 1.0006      7737     7439
## scramble8B   0.0690     0.0200   0.0298   0.1082 1.0002      13521     7525
## level2      -0.0472    0.0200  -0.0873  -0.0075 1.0008      15058     7356
##
## Further Distributional Parameters:
##          Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma     0.1383     0.0085   0.1229   0.1567 1.0001      6507     6635
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
longTS_NM_int <- brm(value ~ scramble*level + (1|sub), data = data_longTS_NM,
                      prior = set_prior('normal(0, 0.1)', class = 'b'),
                      save_pars = save_pars(all = TRUE), iter = 5000,
                      file = 'models/E3_alignment_longTimescales_nonmusInt')

## Compiling Stan program...
## Trying to compile a simple C file
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## using C compiler: 'Apple clang version 16.0.0 (clang-1600.0.26.6)'
## using SDK: 'MacOSX15.2.sdk'
## clang -arch arm64 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG -I"/Library/Frameworks/R.framework/Resources/include"
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/StanHeaders/include.hpp:32
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/RcppEigen.hpp:42
## In file included from /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/Block.h:42
## /Library/Frameworks/R.framework/Versions/4.3-arm64/Resources/library/RcppEigen/include/Eigen/src/Core/DenseMatrix.h:679 | #include <cmath>
##           |           ^~~~~~~
## 1 error generated.
## make: *** [foo.o] Error 1

## Start sampling
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 5.9e-05 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 0.59 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration: 1 / 5000 [  0%] (Warmup)
## Chain 1: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 1: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 1: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 1: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 1: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 1: Iteration: 2501 / 5000 [ 50%] (Sampling)

```

```

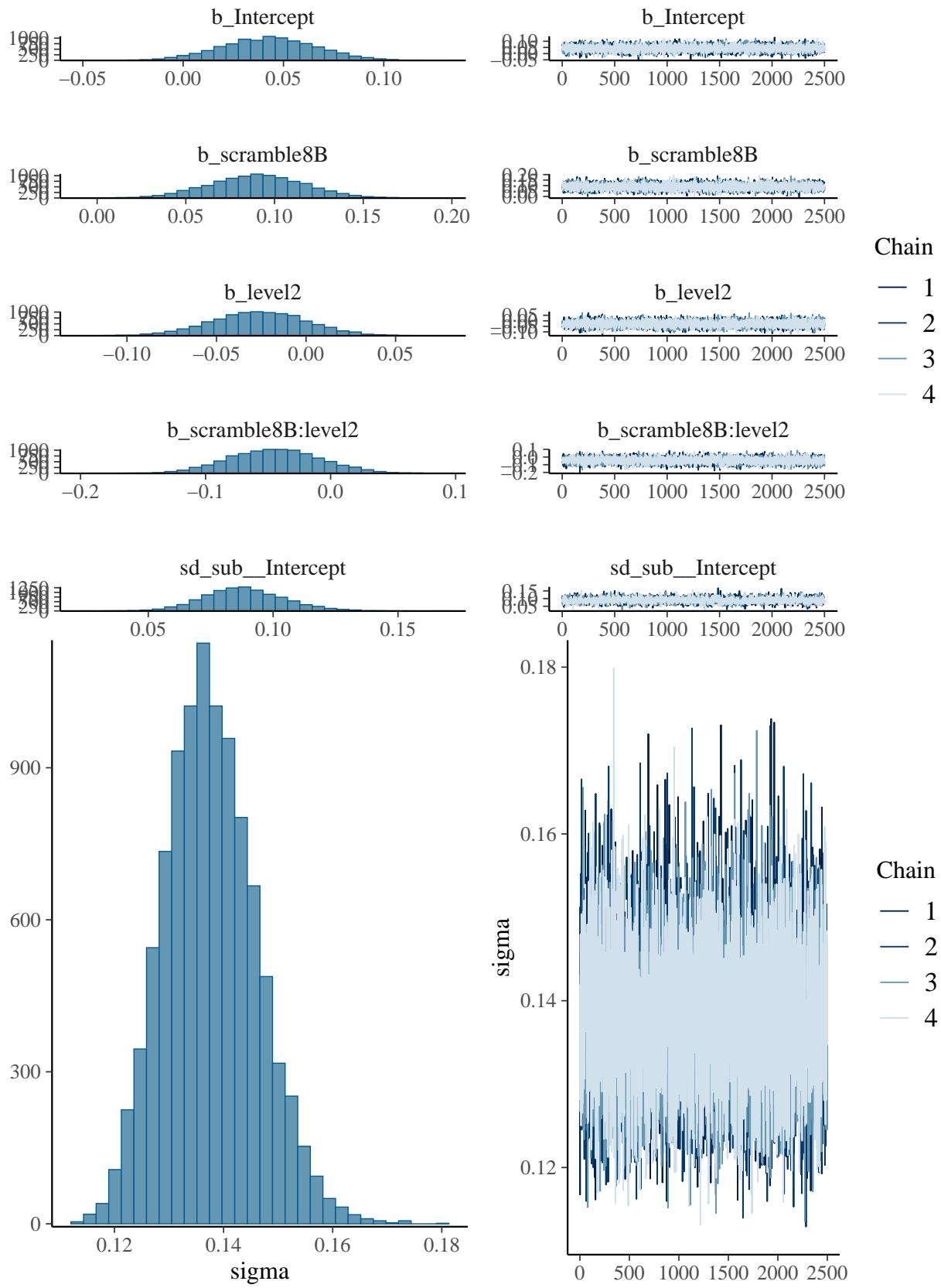
## Chain 1: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 1: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 1: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 1: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 1: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 1:
## Chain 1: Elapsed Time: 0.403 seconds (Warm-up)
## Chain 1:           0.283 seconds (Sampling)
## Chain 1:           0.686 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 1e-05 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 0.1 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 2: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 2: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 2: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 2: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 2: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 2: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 2: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 2: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 2: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 2: Iteration: 4500 / 5000 [ 90%] (Sampling)
## Chain 2: Iteration: 5000 / 5000 [100%] (Sampling)
## Chain 2:
## Chain 2: Elapsed Time: 0.419 seconds (Warm-up)
## Chain 2:           0.25 seconds (Sampling)
## Chain 2:           0.669 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 8e-06 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 0.08 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration: 1 / 5000 [ 0%] (Warmup)
## Chain 3: Iteration: 500 / 5000 [ 10%] (Warmup)
## Chain 3: Iteration: 1000 / 5000 [ 20%] (Warmup)
## Chain 3: Iteration: 1500 / 5000 [ 30%] (Warmup)
## Chain 3: Iteration: 2000 / 5000 [ 40%] (Warmup)
## Chain 3: Iteration: 2500 / 5000 [ 50%] (Warmup)
## Chain 3: Iteration: 2501 / 5000 [ 50%] (Sampling)
## Chain 3: Iteration: 3000 / 5000 [ 60%] (Sampling)
## Chain 3: Iteration: 3500 / 5000 [ 70%] (Sampling)
## Chain 3: Iteration: 4000 / 5000 [ 80%] (Sampling)
## Chain 3: Iteration: 4500 / 5000 [ 90%] (Sampling)

```

```

## Chain 3: Iteration: 5000 / 5000 [100%]  (Sampling)
## Chain 3:
## Chain 3:   Elapsed Time: 0.39 seconds (Warm-up)
## Chain 3:           0.244 seconds (Sampling)
## Chain 3:           0.634 seconds (Total)
## Chain 3:
## 
## SAMPLING FOR MODEL 'anon_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 7e-06 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 0.07 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration:    1 / 5000 [  0%]  (Warmup)
## Chain 4: Iteration:  500 / 5000 [ 10%]  (Warmup)
## Chain 4: Iteration: 1000 / 5000 [ 20%]  (Warmup)
## Chain 4: Iteration: 1500 / 5000 [ 30%]  (Warmup)
## Chain 4: Iteration: 2000 / 5000 [ 40%]  (Warmup)
## Chain 4: Iteration: 2500 / 5000 [ 50%]  (Warmup)
## Chain 4: Iteration: 2501 / 5000 [ 50%]  (Sampling)
## Chain 4: Iteration: 3000 / 5000 [ 60%]  (Sampling)
## Chain 4: Iteration: 3500 / 5000 [ 70%]  (Sampling)
## Chain 4: Iteration: 4000 / 5000 [ 80%]  (Sampling)
## Chain 4: Iteration: 4500 / 5000 [ 90%]  (Sampling)
## Chain 4: Iteration: 5000 / 5000 [100%]  (Sampling)
## Chain 4:
## Chain 4:   Elapsed Time: 0.392 seconds (Warm-up)
## Chain 4:           0.257 seconds (Sampling)
## Chain 4:           0.649 seconds (Total)
## Chain 4:
plot(longTS_NM_int)

```



```

print(summary(longTS_NM_int), digits = 4)

##  Family: gaussian
##  Links: mu = identity; sigma = identity
## Formula: value ~ scramble * level + (1 | sub)
##   Data: data_longTS_NM (Number of observations: 184)
##   Draws: 4 chains, each with iter = 5000; warmup = 2500; thin = 1;
##          total post-warmup draws = 10000
##
## Multilevel Hyperparameters:
## ~sub (Number of levels: 46)
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sd(Intercept)  0.0886    0.0162   0.0583   0.1223 1.0008      3621     5727
##
## Regression Coefficients:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## Intercept       0.0428    0.0237  -0.0035   0.0890 1.0011      8081     7657
## scramble8B      0.0903    0.0265   0.0389   0.1418 1.0006      10359    8288
## level2        -0.0260    0.0266  -0.0784   0.0255 0.9999      10415    8440
## scramble8B:level2 -0.0444    0.0366  -0.1144   0.0273 1.0000      9132     7235
##
## Further Distributional Parameters:
##           Estimate Est.Error l-95% CI u-95% CI    Rhat Bulk_ESS Tail_ESS
## sigma     0.1377    0.0085   0.1222   0.1552 1.0008      7347     7615
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
BF_longNM <- bayes_factor(longTS_NM_int, longTS_NM)

## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5

print(BF_longNM)

## Estimated Bayes factor in favor of longTS_NM_int over longTS_NM: 0.78534

```

There is weak evidence against an interaction for musicians.