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1 Reanalysis of the vowel parsing results. Exp 02.

The results of three experiments assessing the parsing of vowels are reanalyzed here using the brms package. In all three experiments, listeners were presented with short-to-long diphthong-duration continuum in a /C-ai-t/ string in the context of a sentence that had been manipulated to sound as though it were spoken at fast, moderate, or slow rate. In Experiment 1, the initial consonant was a /b/, and listeners were asked to respond that the target consisted of just one syllable, i.e., "Bight," or two, i.e., "Byatt." (Upper case is used here because the sentence conveyed that the responses were surnames.) In Experiment 2, transition durations were manipulated at the beginning of the target stimulus to produce a stop-glide /b-w/ continuum, while in Experiment 3, voice onset times were manipulated instead to produce voiced-voiceless /b-p/ continuum. In both of these latter experiments, listeners chose one from four possible responses on each trial; in Experiment 2, "Bight," "Byatt," "Wight," or "Wyatt," in Experiment 3, "Bight," "Byatt," "Pight," or "Pyatt."

1.1 Packages, etc.

Load packages.

```
#library(Hmisc)
#library(foreign)
library(rstan)
```

```
## Loading required package: StanHeaders

## Loading required package: ggplot2

## rstan (Version 2.21.2, GitRev: 2e1f913d3ca3)

## For execution on a local, multicore CPU with excess RAM we recommend calling
## options(mc.cores = parallel::detectCores()).
## To avoid recompilation of unchanged Stan programs, we recommend calling
## rstan_options(auto_write = TRUE)
```

```
library(rstanarm)
```

```
## Loading required package: Rcpp

## This is rstanarm version 2.21.1

## - See https://mc-stan.org/rstanarm/articles/priors for changes to default priors!

## - Default priors may change, so it's safest to specify priors, even if equivalent to the defaults.

## - For execution on a local, multicore CPU with excess RAM we recommend calling

##   options(mc.cores = parallel::detectCores())

##
## Attaching package: 'rstanarm'

## The following object is masked from 'package:rstan':
##
```

```
##     loo
```

```r
library(brms)
```

```
## Loading 'brms' package (version 2.14.4). Useful instructions
## can be found by typing help('brms'). A more detailed introduction
## to the package is available through vignette('brms_overview').

##
## Attaching package: 'brms'

## The following objects are masked from 'package:rstanarm':
##
##     dirichlet, exponential, get_y, lasso, ngrps

## The following object is masked from 'package:rstan':
##
##     loo

## The following object is masked from 'package:stats':
##
##     ar
```

```r
library(bayesplot)
```

```
## This is bayesplot version 1.8.0

## - Online documentation and vignettes at mc-stan.org/bayesplot

## - bayesplot theme set to bayesplot::theme_default()

##    * Does _not_ affect other ggplot2 plots

##    * See ?bayesplot_theme_set for details on theme setting
```

```r
library(loo)
```

```
## This is loo version 2.4.1

## - Online documentation and vignettes at mc-stan.org/loo

## - As of v2.0.0 loo defaults to 1 core but we recommend using as many as possible. Use the 'cores' arg

##
## Attaching package: 'loo'

## The following object is masked from 'package:rstan':
##
##     loo
```

```r
library(tidyr)
```

```
##
## Attaching package: 'tidyr'

## The following object is masked from 'package:rstan':
##
##     extract
```

```r
#library(dplyr)
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --
```

```
## v tibble  3.0.6     v dplyr   1.0.4
## v readr   1.4.0     v stringr 1.4.0
## v purrr   0.3.4     v forcats 0.5.1
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x tidyr::extract() masks rstan::extract()
## x dplyr::filter()  masks stats::filter()
## x dplyr::lag()     masks stats::lag()
```

```
library(tidybayes)
```

```
##
## Attaching package: 'tidybayes'
```

```
## The following objects are masked from 'package:brms':
##
##     dstudent_t, pstudent_t, qstudent_t, rstudent_t
```

```
library(knitr)
library(scales)
```

```
##
## Attaching package: 'scales'
```

```
## The following object is masked from 'package:purrr':
##
##     discard
```

```
## The following object is masked from 'package:readr':
##
##     col_factor
```

```
require(grid)
```

```
## Loading required package: grid
```

```
require(ggpubr)
```

```
## Loading required package: ggpubr
```

```
## Registered S3 methods overwritten by 'car':
##   method                          from
##   influence.merMod                lme4
##   cooks.distance.influence.merMod lme4
##   dfbeta.influence.merMod         lme4
##   dfbetas.influence.merMod        lme4
```

```
require(gsubfn)
```

```
## Loading required package: gsubfn
```

```
## Loading required package: proto
```

```
library(purrr)
#library(corrplot)
#library(broom.mixed)
#library(dotwhisker)
library(ggplot2)
```

Set up to save figures, and set options, theme, palette.

Working directory:

```
## [1] "/Users/jkingstn/Dropbox/current projects/vowel parsing/reanalysis_30jul20"
```

1.1.1 Prepare the data

Read in the data file and reformat it.

```
exp2 <- read.csv(file = "/Users/jkingstn/Dropbox/current projects/vowel parsing/reanalysis_30jul20/bw_3
         header = TRUE,
         as.is = TRUE)

head(exp2)
```

```
##   subject f_b1_v01_td_01 f_b1_v01_td_02 f_b1_v01_td_03 f_b1_v01_td_04
## 1 bah bw1              2              2              7              9
## 2 iad bw1              3              3             11             12
## 3 sts bw1              4              4             11             12
## 4 iki bw2              3              2              7              8
## 5 tne bw2              1              3             11              9
## 6 daw bw2              0              4              9             10
##   f_b1_v01_td_05 f_b1_v01_td_06 f_b1_v01_td_07 f_b1_v01_td_08 f_b1_v01_td_09
## 1              4              1              0              2              0
## 2              2              0              0              0              0
## 3             11              0              0              0              0
## 4              6              0              0              0              0
## 5              0              0              1              0              0
## 6              8              2              0              0              0
##   f_b1_v01_td_10 f_b1_v05_td_01 f_b1_v05_td_02 f_b1_v05_td_03 f_b1_v05_td_04
## 1              2              0              1              0              1
## 2              0              0              0              2              6
## 3              0              1              0              8              8
## 4              1              1              0              6              6
## 5              0              1              1              2              1
## 6              0              1              0              2              4
##   f_b1_v05_td_05 f_b1_v05_td_06 f_b1_v05_td_07 f_b1_v05_td_08 f_b1_v05_td_09
## 1              2              1              0              1              0
## 2              1              0              0              0              0
## 3             11              0              0              0              0
## 4              4              1              1              0              0
## 5              0              0              0              0              0
## 6              2              0              0              0              0
##   f_b1_v05_td_10 f_b1_v06_td_01 f_b1_v06_td_02 f_b1_v06_td_03 f_b1_v06_td_04
## 1              1              1              0              0              1
## 2              0              0              0              0              2
## 3              0              0              0              0              3
## 4              1              0              1              1              4
## 5              0              0              0              3              2
## 6              1              0              0              0              0
##   f_b1_v06_td_05 f_b1_v06_td_06 f_b1_v06_td_07 f_b1_v06_td_08 f_b1_v06_td_09
## 1              0              0              0              1              0
## 2              0              0              0              0              0
## 3              3              0              0              0              0
## 4              2              1              0              0              0
## 5              0              0              0              0              0
## 6              0              0              1              0              0
##   f_b1_v06_td_10 f_b1_v10_td_01 f_b1_v10_td_02 f_b1_v10_td_03 f_b1_v10_td_04
```

```
## 1              0              0              1              1              0
## 2              0              0              0              0              0
## 3              0              0              0              0              1
## 4              0              1              1              1              3
## 5              0              0              1              1              0
## 6              0              0              0              0              0
##   f_b1_v10_td_05 f_b1_v10_td_06 f_b1_v10_td_07 f_b1_v10_td_08 f_b1_v10_td_09
## 1              0              0              0              1              0
## 2              0              0              0              0              0
## 3              1              0              0              0              0
## 4              4              0              0              2              0
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   f_b1_v10_td_10 f_b2_v01_td_01 f_b2_v01_td_02 f_b2_v01_td_03 f_b2_v01_td_04
## 1              0              0              1              1              1
## 2              0              1              1              0              0
## 3              0              0              0              0              0
## 4              0              1              0              4              2
## 5              0              3              1              1              2
## 6              0              4              0              3              1
##   f_b2_v01_td_05 f_b2_v01_td_06 f_b2_v01_td_07 f_b2_v01_td_08 f_b2_v01_td_09
## 1              0              0              0              0              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              2              3              0              0              0
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   f_b2_v01_td_10 f_b2_v05_td_01 f_b2_v05_td_02 f_b2_v05_td_03 f_b2_v05_td_04
## 1              0              3              3              6              7
## 2              0              4              4              8              5
## 3              0              3              4              4              4
## 4              0              2              3              3              4
## 5              0              3              3              9             10
## 6              0              3              4             10              8
##   f_b2_v05_td_05 f_b2_v05_td_06 f_b2_v05_td_07 f_b2_v05_td_08 f_b2_v05_td_09
## 1              0              1              0              0              0
## 2              2              0              0              0              0
## 3              1              0              0              0              0
## 4              2              2              2              0              0
## 5              0              0              0              0              0
## 6              3              0              0              0              0
##   f_b2_v05_td_10 f_b2_v06_td_01 f_b2_v06_td_02 f_b2_v06_td_03 f_b2_v06_td_04
## 1              0              3              4             11              9
## 2              0              4              4             11              9
## 3              0              4              4             12              9
## 4              0              3              1              6              7
## 5              0              4              4              9             10
## 6              0              4              4             12             12
##   f_b2_v06_td_05 f_b2_v06_td_06 f_b2_v06_td_07 f_b2_v06_td_08 f_b2_v06_td_09
## 1              2              0              0              1              1
## 2              3              0              0              0              0
## 3              7              0              0              0              0
## 4              6              0              0              0              1
## 5              0              0              0              0              0
```

```
## 6              9              1              0              0              0
##   f_b2_v06_td_10 f_b2_v10_td_01 f_b2_v10_td_02 f_b2_v10_td_03 f_b2_v10_td_04
## 1              0              4              3              9             10
## 2              0              4              4              9             12
## 3              1              4              4             12             11
## 4              0              3              3              8              8
## 5              0              4              3             11             11
## 6              0              4              4             12             12
##   f_b2_v10_td_05 f_b2_v10_td_06 f_b2_v10_td_07 f_b2_v10_td_08 f_b2_v10_td_09
## 1              0              1              0              1              1
## 2              7              0              0              0              0
## 3              9              0              0              0              0
## 4              6              0              1              0              0
## 5              0              0              0              0              0
## 6             11              6              1              0              0
##   f_b2_v10_td_10 f_w1_v01_td_01 f_w1_v01_td_02 f_w1_v01_td_03 f_w1_v01_td_04
## 1              0              1              0              3              2
## 2              0              0              0              1              0
## 3              0              0              0              1              0
## 4              0              0              0              0              1
## 5              0              0              0              0              1
## 6              0              0              0              0              1
##   f_w1_v01_td_05 f_w1_v01_td_06 f_w1_v01_td_07 f_w1_v01_td_08 f_w1_v01_td_09
## 1              7             10             11             10              3
## 2             10             12             12             12              4
## 3              1             12             12             12              4
## 4              0              7              9             10              3
## 5              9             11             11             12              4
## 6              4             10             12             12              4
##   f_w1_v01_td_10 f_w1_v05_td_01 f_w1_v05_td_02 f_w1_v05_td_03 f_w1_v05_td_04
## 1              2              0              0              1              1
## 2              4              0              0              0              0
## 3              4              0              0              0              0
## 4              1              0              0              0              1
## 5              4              0              0              1              1
## 6              4              0              0              0              0
##   f_w1_v05_td_05 f_w1_v05_td_06 f_w1_v05_td_07 f_w1_v05_td_08 f_w1_v05_td_09
## 1              4              7              8              7              2
## 2              1              6              6              7              3
## 3              0              4              8              7              2
## 4              1              1              5              8              1
## 5              8              7             12             12              3
## 6              6              8             11              6              3
##   f_w1_v05_td_10 f_w1_v06_td_01 f_w1_v06_td_02 f_w1_v06_td_03 f_w1_v06_td_04
## 1              3              0              0              0              0
## 2              4              0              0              0              0
## 3              3              0              0              0              0
## 4              3              0              0              0              1
## 5              4              0              0              0              0
## 6              2              0              0              0              0
##   f_w1_v06_td_05 f_w1_v06_td_06 f_w1_v06_td_07 f_w1_v06_td_08 f_w1_v06_td_09
## 1              1              2              1              2              0
## 2              0              1              1              0              0
## 3              0              0              2              0              0
```

```
## 4              0              1              2              3              0
## 5              4              4              3              7              2
## 6              1              1              2              1              0
##   f_w1_v06_td_10 f_w1_v10_td_01 f_w1_v10_td_02 f_w1_v10_td_03 f_w1_v10_td_04
## 1              0              0              0              0              0
## 2              1              0              0              0              0
## 3              0              0              0              0              0
## 4              2              0              0              0              1
## 5              2              0              0              0              0
## 6              0              0              0              0              0
##   f_w1_v10_td_05 f_w1_v10_td_06 f_w1_v10_td_07 f_w1_v10_td_08 f_w1_v10_td_09
## 1              2              0              1              0              1
## 2              0              0              1              0              0
## 3              0              0              0              0              0
## 4              1              2              1              2              1
## 5              2              1              1              1              1
## 6              0              0              2              2              0
##   f_w1_v10_td_10 f_w2_v01_td_01 f_w2_v01_td_02 f_w2_v01_td_03 f_w2_v01_td_04
## 1              0              1              1              1              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              1              0              1              0              1
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   f_w2_v01_td_05 f_w2_v01_td_06 f_w2_v01_td_07 f_w2_v01_td_08 f_w2_v01_td_09
## 1              1              1              1              0              1
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              2              2              1              2              1
## 5              3              1              0              0              0
## 6              0              0              0              0              0
##   f_w2_v01_td_10 f_w2_v05_td_01 f_w2_v05_td_02 f_w2_v05_td_03 f_w2_v05_td_04
## 1              0              0              0              5              3
## 2              0              0              0              2              1
## 3              0              0              0              0              0
## 4              2              0              1              2              1
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   f_w2_v05_td_05 f_w2_v05_td_06 f_w2_v05_td_07 f_w2_v05_td_08 f_w2_v05_td_09
## 1              6              3              4              4              2
## 2              7              6              6              5              1
## 3              0              8              4              5              2
## 4              2              8              4              4              3
## 5              4              5              0              0              1
## 6              1              4              1              5              1
##   f_w2_v05_td_10 f_w2_v06_td_01 f_w2_v06_td_02 f_w2_v06_td_03 f_w2_v06_td_04
## 1              0              0              0              0              2
## 2              0              0              0              1              1
## 3              1              0              0              0              0
## 4              0              1              1              2              0
## 5              0              0              0              0              0
## 6              1              0              0              0              0
##   f_w2_v06_td_05 f_w2_v06_td_06 f_w2_v06_td_07 f_w2_v06_td_08 f_w2_v06_td_09
## 1              8             10             11              8              3
```

```
## 2              9             11             11             12              4
## 3              2             12              9             12              4
## 4              3              8             10              9              3
## 5              8              8              9              5              2
## 6              2             10              9             11              4
##   f_w2_v06_td_10 f_w2_v10_td_01 f_w2_v10_td_02 f_w2_v10_td_03 f_w2_v10_td_04
## 1              4              0              0              2              1
## 2              3              0              0              3              0
## 3              3              0              0              0              0
## 4              2              0              0              0              0
## 5              2              0              0              0              1
## 6              4              0              0              0              0
##   f_w2_v10_td_05 f_w2_v10_td_06 f_w2_v10_td_07 f_w2_v10_td_08 f_w2_v10_td_09
## 1             10             11             11             10              2
## 2              5             12             11             12              4
## 3              2             12             12             12              4
## 4              0              9              9              7              3
## 5             10             11             11             11              3
## 6              1              6              9             10              4
##   f_w2_v10_td_10 s_b1_v01_td_01 s_b1_v01_td_02 s_b1_v01_td_03 s_b1_v01_td_04
## 1              4              4              2             10             11
## 2              4              4              4              9             10
## 3              4              4              4             12             12
## 4              3              2              4             11              8
## 5              4              4              3             11             10
## 6              4              4              3             12             11
##   s_b1_v01_td_05 s_b1_v01_td_06 s_b1_v01_td_07 s_b1_v01_td_08 s_b1_v01_td_09
## 1              2              0              0              0              0
## 2              1              0              0              0              0
## 3             11              0              0              0              0
## 4              5              0              0              1              0
## 5              0              0              0              0              0
## 6              5              0              0              0              1
##   s_b1_v01_td_10 s_b1_v05_td_01 s_b1_v05_td_02 s_b1_v05_td_03 s_b1_v05_td_04
## 1              0              1              3              6              9
## 2              0              3              2              9              5
## 3              0              3              3             12             12
## 4              0              2              2              7              8
## 5              0              4              3             10              7
## 6              0              2              2              9             10
##   s_b1_v05_td_05 s_b1_v05_td_06 s_b1_v05_td_07 s_b1_v05_td_08 s_b1_v05_td_09
## 1              3              1              0              1              0
## 2              0              0              0              0              0
## 3             12              0              0              0              0
## 4              4              0              2              0              0
## 5              0              0              0              0              0
## 6              4              0              0              0              0
##   s_b1_v05_td_10 s_b1_v06_td_01 s_b1_v06_td_02 s_b1_v06_td_03 s_b1_v06_td_04
## 1              0              0              0              4              6
## 2              0              0              0              2              7
## 3              0              0              1              7              7
## 4              0              1              3              4              7
## 5              0              2              3              5              7
## 6              0              0              0              3              3
```

```
##   s_b1_v06_td_05 s_b1_v06_td_06 s_b1_v06_td_07 s_b1_v06_td_08 s_b1_v06_td_09
## 1              2              1              0              0              0
## 2              0              0              0              0              0
## 3             11              2              0              0              0
## 4              4              0              0              1              0
## 5              0              0              0              0              0
## 6              2              0              0              0              0
##   s_b1_v06_td_10 s_b1_v10_td_01 s_b1_v10_td_02 s_b1_v10_td_03 s_b1_v10_td_04
## 1              0              0              0              1              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              1              0              0              2              3
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   s_b1_v10_td_05 s_b1_v10_td_06 s_b1_v10_td_07 s_b1_v10_td_08 s_b1_v10_td_09
## 1              0              0              0              0              0
## 2              0              0              0              0              0
## 3              1              0              0              0              0
## 4              3              0              0              0              0
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   s_b1_v10_td_10 s_b2_v01_td_01 s_b2_v01_td_02 s_b2_v01_td_03 s_b2_v01_td_04
## 1              0              0              1              0              1
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              0              2              0              0              2
## 5              0              0              1              1              1
## 6              0              0              1              0              0
##   s_b2_v01_td_05 s_b2_v01_td_06 s_b2_v01_td_07 s_b2_v01_td_08 s_b2_v01_td_09
## 1              0              0              0              0              0
## 2              0              1              0              0              0
## 3              0              0              0              0              0
## 4              0              0              0              0              0
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   s_b2_v01_td_10 s_b2_v05_td_01 s_b2_v05_td_02 s_b2_v05_td_03 s_b2_v05_td_04
## 1              0              3              1              4              1
## 2              0              0              2              0              0
## 3              0              1              1              0              0
## 4              0              2              0              3              2
## 5              0              0              1              2              2
## 6              0              2              2              3              2
##   s_b2_v05_td_05 s_b2_v05_td_06 s_b2_v05_td_07 s_b2_v05_td_08 s_b2_v05_td_09
## 1              0              1              1              0              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              3              1              0              1              0
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   s_b2_v05_td_10 s_b2_v06_td_01 s_b2_v06_td_02 s_b2_v06_td_03 s_b2_v06_td_04
## 1              0              4              4              8              5
## 2              0              4              4              7              3
## 3              0              4              3              5              5
## 4              0              1              1              5              5
```

```
## 5              0              2              1              7              2
## 6              0              4              4              7              8
##   s_b2_v06_td_05 s_b2_v06_td_06 s_b2_v06_td_07 s_b2_v06_td_08 s_b2_v06_td_09
## 1              1              0              0              0              0
## 2              0              0              0              0              0
## 3              1              0              0              0              0
## 4              1              1              0              2              1
## 5              0              0              0              0              0
## 6              3              0              1              0              0
##   s_b2_v06_td_10 s_b2_v10_td_01 s_b2_v10_td_02 s_b2_v10_td_03 s_b2_v10_td_04
## 1              0              3              4             11             12
## 2              0              4              4              9              9
## 3              0              4              4             12             12
## 4              0              2              4              5              9
## 5              0              4              4             12             10
## 6              0              4              4             12             12
##   s_b2_v10_td_05 s_b2_v10_td_06 s_b2_v10_td_07 s_b2_v10_td_08 s_b2_v10_td_09
## 1              3              0              0              0              0
## 2              1              1              0              0              0
## 3             11              5              0              0              0
## 4              5              2              1              0              0
## 5              1              0              0              0              0
## 6              7              2              0              0              0
##   s_b2_v10_td_10 s_w1_v01_td_01 s_w1_v01_td_02 s_w1_v01_td_03 s_w1_v01_td_04
## 1              0              0              1              1              0
## 2              0              0              0              3              2
## 3              0              0              0              0              0
## 4              1              0              0              0              0
## 5              0              0              0              0              1
## 6              0              0              0              0              1
##   s_w1_v01_td_05 s_w1_v01_td_06 s_w1_v01_td_07 s_w1_v01_td_08 s_w1_v01_td_09
## 1              9             11             11             10              3
## 2             11             11             12             12              4
## 3              1             12             12             12              4
## 4              3             10              8             11              3
## 5             12             12             12             12              4
## 6              7             12             12             12              3
##   s_w1_v01_td_10 s_w1_v05_td_01 s_w1_v05_td_02 s_w1_v05_td_03 s_w1_v05_td_04
## 1              4              0              0              1              2
## 2              4              0              0              3              7
## 3              4              0              0              0              0
## 4              3              0              1              0              0
## 5              4              0              0              0              3
## 6              4              0              0              0              0
##   s_w1_v05_td_05 s_w1_v05_td_06 s_w1_v05_td_07 s_w1_v05_td_08 s_w1_v05_td_09
## 1              9             10             10             10              3
## 2             11             12             12             12              4
## 3              0             12             12             11              4
## 4              3              8              6              7              1
## 5             12             12             12             12              4
## 6              8             11             11             12              4
##   s_w1_v05_td_10 s_w1_v06_td_01 s_w1_v06_td_02 s_w1_v06_td_03 s_w1_v06_td_04
## 1              4              0              0              0              1
## 2              4              0              0              3              0
```

```
## 3              4              0              0              0              0
## 4              3              2              0              0              0
## 5              4              0              0              0              3
## 6              4              0              0              0              0
##   s_w1_v06_td_05 s_w1_v06_td_06 s_w1_v06_td_07 s_w1_v06_td_08 s_w1_v06_td_09
## 1              6              7              9              8              2
## 2             11              9             12              9              4
## 3              0              6              8              7              4
## 4              6              6              6              9              2
## 5             12             11             12             11              4
## 6              5             10             10             10              4
##   s_w1_v06_td_10 s_w1_v10_td_01 s_w1_v10_td_02 s_w1_v10_td_03 s_w1_v10_td_04
## 1              3              1              0              0              0
## 2              3              0              0              1              0
## 3              3              0              0              0              0
## 4              3              0              0              0              0
## 5              4              0              0              0              1
## 6              4              0              0              0              0
##   s_w1_v10_td_05 s_w1_v10_td_06 s_w1_v10_td_07 s_w1_v10_td_08 s_w1_v10_td_09
## 1              2              0              0              0              0
## 2              0              0              0              1              0
## 3              0              0              0              0              0
## 4              0              1              0              4              1
## 5              2              3              5              5              1
## 6              0              0              0              3              1
##   s_w1_v10_td_10 s_w2_v01_td_01 s_w2_v01_td_02 s_w2_v01_td_03 s_w2_v01_td_04
## 1              0              0              0              1              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              2              0              0              1              2
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   s_w2_v01_td_05 s_w2_v01_td_06 s_w2_v01_td_07 s_w2_v01_td_08 s_w2_v01_td_09
## 1              1              1              1              2              1
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              3              2              3              0              1
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   s_w2_v01_td_10 s_w2_v05_td_01 s_w2_v05_td_02 s_w2_v05_td_03 s_w2_v05_td_04
## 1              0              0              0              1              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              1              0              1              0              1
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   s_w2_v05_td_05 s_w2_v05_td_06 s_w2_v05_td_07 s_w2_v05_td_08 s_w2_v05_td_09
## 1              0              0              1              1              1
## 2              1              0              0              0              0
## 3              0              0              0              1              0
## 4              1              3              1              3              3
## 5              0              0              0              0              0
## 6              0              1              1              0              0
##   s_w2_v05_td_10 s_w2_v06_td_01 s_w2_v06_td_02 s_w2_v06_td_03 s_w2_v06_td_04
```

```
## 1              0              0              0              0              0
## 2              0              0              0              0              2
## 3              0              0              0              0              0
## 4              1              0              0              1              0
## 5              0              0              0              0              0
## 6              0              0              0              2              0
##   s_w2_v06_td_05 s_w2_v06_td_06 s_w2_v06_td_07 s_w2_v06_td_08 s_w2_v06_td_09
## 1              3              4              3              4              2
## 2              1              3              0              3              0
## 3              0              4              4              5              0
## 4              0              5              3              0              1
## 5              0              1              0              1              0
## 6              2              2              1              2              0
##   s_w2_v06_td_10 s_w2_v10_td_01 s_w2_v10_td_02 s_w2_v10_td_03 s_w2_v10_td_04
## 1              1              0              0              0              0
## 2              1              0              0              2              3
## 3              1              0              0              0              0
## 4              0              0              0              3              0
## 5              0              0              0              0              1
## 6              0              0              0              0              0
##   s_w2_v10_td_05 s_w2_v10_td_06 s_w2_v10_td_07 s_w2_v10_td_08 s_w2_v10_td_09
## 1              7             12             12             12              4
## 2             11             11             12             11              4
## 3              0              7             12             12              4
## 4              3              9             10              8              3
## 5              9              9              7              7              3
## 6              5             10             12              9              3
##   s_w2_v10_td_10 m_b1_v01_td_01 m_b1_v01_td_02 m_b1_v01_td_03 m_b1_v01_td_04
## 1              4              4              2              7              9
## 2              4              2              2             10              8
## 3              4              4              4             12             11
## 4              1              2              1              6              9
## 5              4              4              4             10              9
## 6              4              4              4             10             12
##   m_b1_v01_td_05 m_b1_v01_td_06 m_b1_v01_td_07 m_b1_v01_td_08 m_b1_v01_td_09
## 1              5              1              0              1              0
## 2              0              0              0              0              0
## 3             11              0              0              0              0
## 4              4              1              1              1              1
## 5              0              0              0              0              0
## 6              3              0              0              0              0
##   m_b1_v01_td_10 m_b1_v05_td_01 m_b1_v05_td_02 m_b1_v05_td_03 m_b1_v05_td_04
## 1              0              1              0              2              9
## 2              0              1              3              3              6
## 3              0              1              1             10             12
## 4              0              2              2              6              9
## 5              0              2              2              8             10
## 6              0              3              1              7              7
##   m_b1_v05_td_05 m_b1_v05_td_06 m_b1_v05_td_07 m_b1_v05_td_08 m_b1_v05_td_09
## 1              4              1              0              1              0
## 2              0              0              0              0              0
## 3             11              0              0              0              0
## 4              3              1              0              0              0
## 5              0              0              0              0              0
```

```
## 6              3              0              0              0              0
##   m_b1_v05_td_10 m_b1_v06_td_01 m_b1_v06_td_02 m_b1_v06_td_03 m_b1_v06_td_04
## 1              1              0              0              0              2
## 2              0              0              0              2              1
## 3              0              1              0              6              3
## 4              1              0              1              4              5
## 5              0              0              0              1              2
## 6              0              0              0              1              2
##   m_b1_v06_td_05 m_b1_v06_td_06 m_b1_v06_td_07 m_b1_v06_td_08 m_b1_v06_td_09
## 1              2              0              0              0              0
## 2              0              0              0              0              0
## 3              8              0              0              0              0
## 4              5              0              0              1              0
## 5              0              0              0              0              0
## 6              2              0              0              0              0
##   m_b1_v06_td_10 m_b1_v10_td_01 m_b1_v10_td_02 m_b1_v10_td_03 m_b1_v10_td_04
## 1              1              1              0              0              0
## 2              0              0              0              0              1
## 3              0              0              0              1              0
## 4              0              0              0              2              4
## 5              0              0              0              1              0
## 6              0              0              0              0              0
##   m_b1_v10_td_05 m_b1_v10_td_06 m_b1_v10_td_07 m_b1_v10_td_08 m_b1_v10_td_09
## 1              0              0              0              0              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              3              1              0              1              0
## 5              0              0              0              0              0
## 6              0              0              0              0              0
##   m_b1_v10_td_10 m_b2_v01_td_01 m_b2_v01_td_02 m_b2_v01_td_03 m_b2_v01_td_04
## 1              0              0              2              2              1
## 2              0              1              0              0              0
## 3              0              0              0              0              1
## 4              1              0              3              2              2
## 5              0              0              0              2              1
## 6              0              0              0              1              0
##   m_b2_v01_td_05 m_b2_v01_td_06 m_b2_v01_td_07 m_b2_v01_td_08 m_b2_v01_td_09
## 1              0              0              0              0              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              2              0              0              1              0
## 5              1              0              0              0              0
## 6              0              0              0              0              0
##   m_b2_v01_td_10 m_b2_v05_td_01 m_b2_v05_td_02 m_b2_v05_td_03 m_b2_v05_td_04
## 1              0              3              4              5              2
## 2              0              3              0              8              3
## 3              0              3              3              2              0
## 4              0              1              1              5              3
## 5              0              2              2              4              2
## 6              0              1              3              3              5
##   m_b2_v05_td_05 m_b2_v05_td_06 m_b2_v05_td_07 m_b2_v05_td_08 m_b2_v05_td_09
## 1              1              0              0              2              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
```

```
## 4              2              0              0              0              0
## 5              0              0              0              0              0
## 6              1              0              0              0              0
##   m_b2_v05_td_10 m_b2_v06_td_01 m_b2_v06_td_02 m_b2_v06_td_03 m_b2_v06_td_04
## 1              0              4              4              9             10
## 2              0              4              4              7              8
## 3              0              3              4              6              9
## 4              1              4              3              4              4
## 5              0              3              4             11              9
## 6              0              4              4             10             10
##   m_b2_v06_td_05 m_b2_v06_td_06 m_b2_v06_td_07 m_b2_v06_td_08 m_b2_v06_td_09
## 1              0              0              0              0              0
## 2              1              0              0              0              0
## 3              4              1              0              0              0
## 4              0              0              1              0              0
## 5              0              0              0              0              0
## 6              6              0              0              0              0
##   m_b2_v06_td_10 m_b2_v10_td_01 m_b2_v10_td_02 m_b2_v10_td_03 m_b2_v10_td_04
## 1              1              3              4              9             11
## 2              0              2              4             12              7
## 3              0              4              4             11             12
## 4              0              4              2              9              7
## 5              0              4              4             11             12
## 6              0              4              4             12             12
##   m_b2_v10_td_05 m_b2_v10_td_06 m_b2_v10_td_07 m_b2_v10_td_08 m_b2_v10_td_09
## 1              4              0              0              4              0
## 2              1              0              0              0              0
## 3             12              4              0              0              0
## 4              3              4              0              2              0
## 5              0              0              0              1              0
## 6              8              0              0              0              0
##   m_b2_v10_td_10 m_w1_v01_td_01 m_w1_v01_td_02 m_w1_v01_td_03 m_w1_v01_td_04
## 1              0              0              0              2              1
## 2              0              1              2              2              4
## 3              0              0              0              0              0
## 4              0              0              0              0              0
## 5              0              0              0              0              2
## 6              0              0              0              1              0
##   m_w1_v01_td_05 m_w1_v01_td_06 m_w1_v01_td_07 m_w1_v01_td_08 m_w1_v01_td_09
## 1              5              9             12              9              4
## 2             12             12             12             12              4
## 3              1             12             12             12              4
## 4              4              8              9              7              3
## 5             10             12             12             12              4
## 6              9             12             12             12              2
##   m_w1_v01_td_10 m_w1_v05_td_01 m_w1_v05_td_02 m_w1_v05_td_03 m_w1_v05_td_04
## 1              4              0              0              2              0
## 2              4              0              0              0              1
## 3              4              0              0              0              0
## 4              4              0              0              0              0
## 5              4              0              0              0              0
## 6              4              0              0              1              0
##   m_w1_v05_td_05 m_w1_v05_td_06 m_w1_v05_td_07 m_w1_v05_td_08 m_w1_v05_td_09
## 1              4             10             12              7              4
```

```
## 2              9             11             12             12              4
## 3              1             11             12             10              4
## 4              2              9             11             10              3
## 5             10             11             11             10              4
## 6              7             11             12             11              4
##   m_w1_v05_td_10 m_w1_v06_td_01 m_w1_v06_td_02 m_w1_v06_td_03 m_w1_v06_td_04
## 1              3              0              0              0              0
## 2              4              0              0              1              0
## 3              4              0              0              0              0
## 4              1              0              0              1              1
## 5              3              0              0              0              0
## 6              4              0              0              0              0
##   m_w1_v06_td_05 m_w1_v06_td_06 m_w1_v06_td_07 m_w1_v06_td_08 m_w1_v06_td_09
## 1              3              4              6              8              3
## 2              2              7              7              8              3
## 3              0              3              5              2              1
## 4              1              2              3              3              1
## 5             10             10              9              9              4
## 6              1              3              7              3              3
##   m_w1_v06_td_10 m_w1_v10_td_01 m_w1_v10_td_02 m_w1_v10_td_03 m_w1_v10_td_04
## 1              2              0              0              0              0
## 2              2              0              0              0              0
## 3              1              0              0              0              0
## 4              1              0              1              0              0
## 5              4              0              0              0              0
## 6              2              0              0              0              0
##   m_w1_v10_td_05 m_w1_v10_td_06 m_w1_v10_td_07 m_w1_v10_td_08 m_w1_v10_td_09
## 1              1              1              0              1              0
## 2              0              0              0              0              1
## 3              0              0              0              1              0
## 4              1              1              4              2              1
## 5              2              1              3              1              2
## 6              0              0              3              0              0
##   m_w1_v10_td_10 m_w2_v01_td_01 m_w2_v01_td_02 m_w2_v01_td_03 m_w2_v01_td_04
## 1              1              0              0              1              1
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              0              1              0              2              1
## 5              1              0              0              0              0
## 6              0              0              0              0              0
##   m_w2_v01_td_05 m_w2_v01_td_06 m_w2_v01_td_07 m_w2_v01_td_08 m_w2_v01_td_09
## 1              2              2              0              2              0
## 2              0              0              0              0              0
## 3              0              0              0              0              0
## 4              2              2              2              3              0
## 5              1              0              0              0              0
## 6              0              0              0              0              1
##   m_w2_v01_td_10 m_w2_v05_td_01 m_w2_v05_td_02 m_w2_v05_td_03 m_w2_v05_td_04
## 1              0              0              0              3              1
## 2              0              0              1              1              2
## 3              0              0              0              0              0
## 4              0              1              1              0              0
## 5              0              0              0              0              0
## 6              0              0              0              1              0
```

```
##   m_w2_v05_td_05 m_w2_v05_td_06 m_w2_v05_td_07 m_w2_v05_td_08 m_w2_v05_td_09
## 1              3              1              0              1              0
## 2              3              1              0              0              0
## 3              0              1              0              2              0
## 4              4              2              1              1              1
## 5              2              1              1              2              0
## 6              1              1              0              1              0
##   m_w2_v05_td_10 m_w2_v06_td_01 m_w2_v06_td_02 m_w2_v06_td_03 m_w2_v06_td_04
## 1              0              0              0              2              0
## 2              0              0              0              2              3
## 3              0              0              0              0              0
## 4              1              0              0              1              0
## 5              1              1              0              0              1
## 6              0              0              0              1              0
##   m_w2_v06_td_05 m_w2_v06_td_06 m_w2_v06_td_07 m_w2_v06_td_08 m_w2_v06_td_09
## 1              6              8              5              4              1
## 2              9              5              5              4              1
## 3              0              8              7             10              3
## 4              6             10              8              8              2
## 5              2              2              3              3              0
## 6              3              9              5              9              1
##   m_w2_v06_td_10 m_w2_v10_td_01 m_w2_v10_td_02 m_w2_v10_td_03 m_w2_v10_td_04
## 1              0              0              0              3              1
## 2              2              2              0              0              4
## 3              3              0              0              0              0
## 4              3              0              1              0              0
## 5              0              0              0              0              0
## 6              2              0              0              0              0
##   m_w2_v10_td_05 m_w2_v10_td_06 m_w2_v10_td_07 m_w2_v10_td_08 m_w2_v10_td_09
## 1              7             11             12              7              4
## 2             11             12             12             12              3
## 3              0              8             12             11              4
## 4              5              6              8              6              3
## 5             10             11              9             10              2
## 6              4             12              9             12              4
##   m_w2_v10_td_10
## 1              3
## 2              4
## 3              4
## 4              3
## 5              3
## 6              4
```

```
exp2 <- exp2 %>% gather("f_b1_v01_td_01":"m_w2_v10_td_10", key = "spdRspVwlTd", value = "responses")

head(exp2)
```

```
##   subject    spdRspVwlTd responses
## 1 bah bw1 f_b1_v01_td_01         2
## 2 iad bw1 f_b1_v01_td_01         3
## 3 sts bw1 f_b1_v01_td_01         4
## 4 iki bw2 f_b1_v01_td_01         3
## 5 tne bw2 f_b1_v01_td_01         1
## 6 daw bw2 f_b1_v01_td_01         0
```

Code the cases.

```
exp2$speed <- substr(exp2$spdRspVwlTd, 1, 1)

exp2$speed <- ifelse(exp2$speed == "f", "fas",
                     ifelse(exp2$speed == "m", "med", "slo"))

exp2$speed <- factor(exp2$speed,
                     levels = c("fas", "med", "slo"))

exp2$nSpeed <- ifelse(exp2$speed == "fas", 1,
                      ifelse(exp2$speed == "med", 0, -1))

exp2$cRsp <- substr(exp2$spdRspVwlTd, 3, 3)

exp2$sRsp <- as.numeric(substr(exp2$spdRspVwlTd, 4, 4))

exp2$csRsp <- substr(exp2$spdRspVwlTd, 3, 4)

exp2$vDuration <- as.numeric(substr(exp2$spdRspVwlTd, 7, 8))

exp2$fVDuration <- factor(exp2$vDuration,
                          levels = c("1", "5", "6", "10"))

exp2$tDuration <- as.numeric(substr(exp2$spdRspVwlTd, 13, 14))

head(exp2)
```

```
##   subject    spdRspVwlTd responses speed nSpeed cRsp sRsp csRsp vDuration
## 1 bah bw1 f_b1_v01_td_01         2   fas      1    b    1    b1         1
## 2 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 3 sts bw1 f_b1_v01_td_01         4   fas      1    b    1    b1         1
## 4 iki bw2 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 5 tne bw2 f_b1_v01_td_01         1   fas      1    b    1    b1         1
## 6 daw bw2 f_b1_v01_td_01         0   fas      1    b    1    b1         1
##   fVDuration tDuration
## 1          1         1
## 2          1         1
## 3          1         1
## 4          1         1
## 5          1         1
## 6          1         1
```

Calculate proportions for each response.

```
exp2$maxRsps <- ifelse(exp2$tDuration <= 2 | exp2$tDuration >= 9, 4, 12)

exp2$rspProp <- exp2$responses / exp2$maxRsps
```

Rewrite each response to a separate row.

```
tmp <- {}

for (i in 1:length(exp2$responses)) {
  count <- exp2$responses[i]
  if (count > 0) {
```

```r
    for (j in 1:count) {
      tmp <- rbind(tmp, exp2[i,])
    }
  }
}

head(tmp)
```

```
##    subject    spdRspVwlTd responses speed nSpeed cRsp sRsp csRsp vDuration
## 1  bah bw1 f_b1_v01_td_01         2   fas      1    b    1    b1         1
## 2  bah bw1 f_b1_v01_td_01         2   fas      1    b    1    b1         1
## 21 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 22 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 23 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 3  sts bw1 f_b1_v01_td_01         4   fas      1    b    1    b1         1
##    fVDuration tDuration maxRsps rspProp
## 1           1         1       4    0.50
## 2           1         1       4    0.50
## 21          1         1       4    0.75
## 22          1         1       4    0.75
## 23          1         1       4    0.75
## 3           1         1       4    1.00
```

Confirm rewrite.

```r
sum(exp2$responses)
```

```
## [1] 12503
```

```r
length(tmp$responses)
```

```
## [1] 12503
```

```r
unique(tmp$cRsp); unique(tmp$sRsp)
```

```
## [1] "b" "w"
```

```
## [1] 1 2
```

```r
exp2l <- tmp

head(exp2l)
```

```
##    subject    spdRspVwlTd responses speed nSpeed cRsp sRsp csRsp vDuration
## 1  bah bw1 f_b1_v01_td_01         2   fas      1    b    1    b1         1
## 2  bah bw1 f_b1_v01_td_01         2   fas      1    b    1    b1         1
## 21 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 22 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 23 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 3  sts bw1 f_b1_v01_td_01         4   fas      1    b    1    b1         1
##    fVDuration tDuration maxRsps rspProp
## 1           1         1       4    0.50
## 2           1         1       4    0.50
## 21          1         1       4    0.75
## 22          1         1       4    0.75
## 23          1         1       4    0.75
## 3           1         1       4    1.00
```

```r
exp2l$ncRsp <- ifelse(exp2l$cRsp == "b", 0, 1)
exp2l$nsRsp <- ifelse(exp2l$sRsp == "1", 0, 1)

head(exp2l)
```

```
##    subject    spdRspVwlTd responses speed nSpeed cRsp sRsp csRsp vDuration
## 1  bah bw1 f_b1_v01_td_01         2   fas      1    b    1    b1         1
## 2  bah bw1 f_b1_v01_td_01         2   fas      1    b    1    b1         1
## 21 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 22 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 23 iad bw1 f_b1_v01_td_01         3   fas      1    b    1    b1         1
## 3  sts bw1 f_b1_v01_td_01         4   fas      1    b    1    b1         1
##    fVDuration tDuration maxRsps rspProp ncRsp nsRsp
## 1           1         1       4    0.50     0     0
## 2           1         1       4    0.50     0     0
## 21          1         1       4    0.75     0     0
## 22          1         1       4    0.75     0     0
## 23          1         1       4    0.75     0     0
## 3           1         1       4    1.00     0     0
```

```r
xtabs(~ ncRsp + nsRsp,
      data = exp2l)
```

```
##      nsRsp
## ncRsp    0    1
##     0 2406 2622
##     1 4217 3258
```

1.1.2 Condition

Code condition and estimate mean proportions of each response.

```r
exp2$condition <- substr(exp2$subject, nchar(exp2$subject), nchar(exp2$subject))

exp2$nCondition <- as.numeric(as.character(exp2$condition))

exp2l$condition <- substr(exp2l$subject, nchar(exp2l$subject), nchar(exp2l$subject))

exp2l$nCondition <- as.numeric(as.character(exp2l$condition))

tmp0 <- exp2 %>% group_by(condition,
                          csRsp) %>%
  summarise(mean(rspProp))
```

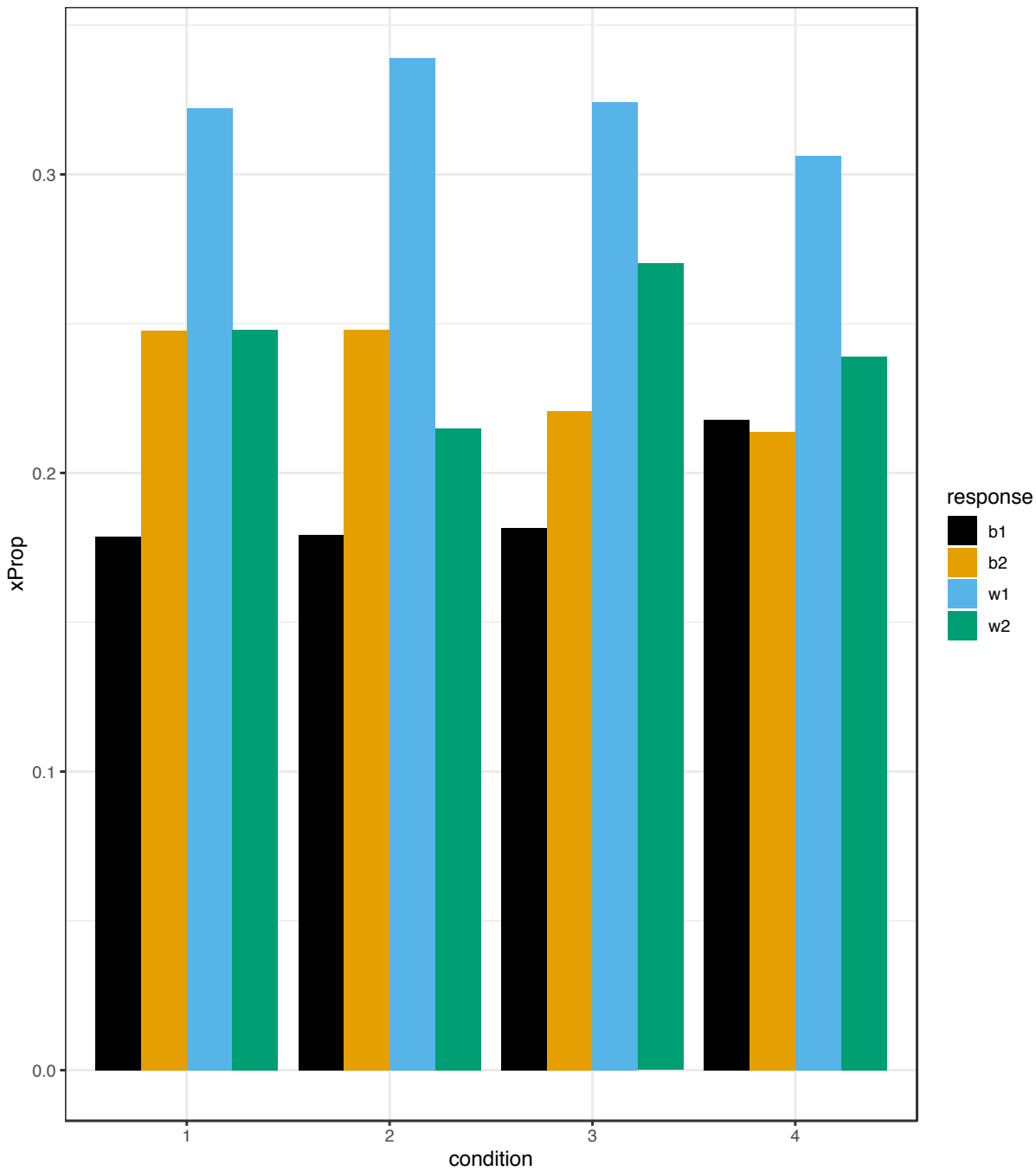
```
## `summarise()` has grouped output by 'condition'. You can override using the `.groups` argument.
```

```r
head(tmp0)
```

```
## # A tibble: 6 x 3
## # Groups:   condition [2]
##   condition csRsp `mean(rspProp)`
##   <chr>     <chr>           <dbl>
## 1 1         b1              0.179
## 2 1         b2              0.248
## 3 1         w1              0.322
## 4 1         w2              0.248
```

```
## 5 2         b1              0.179
## 6 2         b2              0.248
```

```r
colnames(tmp0) <- c("condition",
                    "response",
                    "xProp")

tmp1 <- ggplot(tmp0,
               aes(condition, xProp,
                   fill = response))

tmp2 <- tmp1 + geom_bar(stat = "identity",
                        position = "dodge") +
  scale_fill_manual(values = cbbPalette)

tmp2
```




```
ggsave(filename = "exp02RspsByCondition_13may21.pdf",
       device = "pdf")
```

```
## Saving 8 x 9 in image
```

1.1.3 Plot by response

Plot the mean proportions in a separate panel for each response.

Separate plots for vowel duration and speed.

```
# vowel duration
```

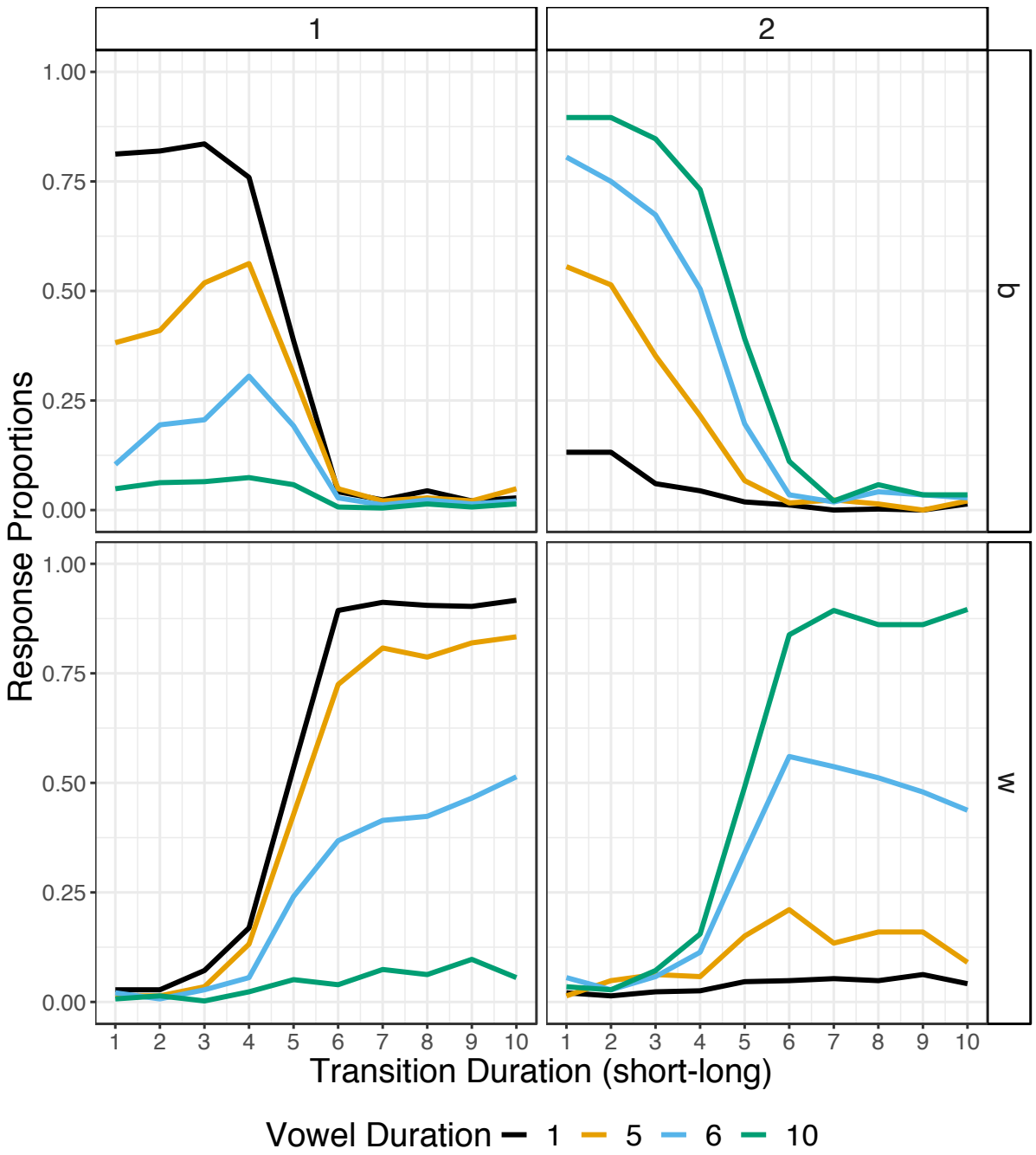
```r
tmp0 <- exp2 %>% group_by(fVDuration,
                          tDuration,
                          cRsp,
                          sRsp) %>%
  summarise(mean(rspProp))
```

```
## `summarise()` has grouped output by 'fVDuration', 'tDuration', 'cRsp'. You can override using the `.g
```

```r
head(tmp0)
```

```
## # A tibble: 6 x 5
## # Groups:   fVDuration, tDuration, cRsp [3]
##   fVDuration tDuration cRsp   sRsp `mean(rspProp)`
##   <fct>          <dbl> <chr> <dbl>           <dbl>
## 1 1                  1 b         1          0.812
## 2 1                  1 b         2          0.132
## 3 1                  1 w         1          0.0278
## 4 1                  1 w         2          0.0208
## 5 1                  2 b         1          0.819
## 6 1                  2 b         2          0.132
```

```r
colnames(tmp0) <- c("vowelDuration",
                    "transitionDuration",
                    "consonantRsp",
                    "syllableRsp",
                    "xProp")

tmp1 <- ggplot(tmp0,
               aes(transitionDuration, xProp,
                   colour = vowelDuration)) +
  geom_line(size = 1) +
  facet_grid(consonantRsp ~ syllableRsp) +
  scale_x_continuous(name = "Transition Duration (short-long)",
                     limits = c(1,10),
                     breaks = seq(1, 10, 1)) +
  scale_y_continuous(name = "Response Proportions",
                     limits = c(0, 1),
                     breaks = seq(0,1,0.25)) +
  scale_color_manual(values = cbbPalette) +
  guides(colour = guide_legend(title="Vowel Duration")) +
  theme_bw()+
  theme(axis.text=element_text(size=12),
        axis.title=element_text(size=18),
        plot.title=element_text(size=28),
        strip.text=element_text(size=16),
        strip.background=element_rect(colour="black", fill="white"),
        legend.text=element_text(size=16),
        legend.title=element_text(size=18),
        legend.position = "bottom",
        legend.direction = "horizontal")

tmp1
```




```
ggsave(filename = "exp02RspsByTransitionVowelDuration_13may21.pdf",
       device = "pdf")
```

```
## Saving 8 x 9 in image
```

```
tmp0a <- exp2 %>% group_by(fVDuration,
                           cRsp,
                           sRsp) %>%
  summarise(mean(rspProp))
```

```
## `summarise()` has grouped output by 'fVDuration', 'cRsp'. You can override using the `.groups` argume
```

```r
# head(tmp0)

colnames(tmp0a) <- c("vowelDuration",
                     "consonantRsp",
                     "syllableRsp",
                     "xProp")

# speed

tmp10 <- exp2 %>% group_by(speed,
                           tDuration,
                           cRsp,
                           sRsp) %>%
  summarise(mean(rspProp))
```

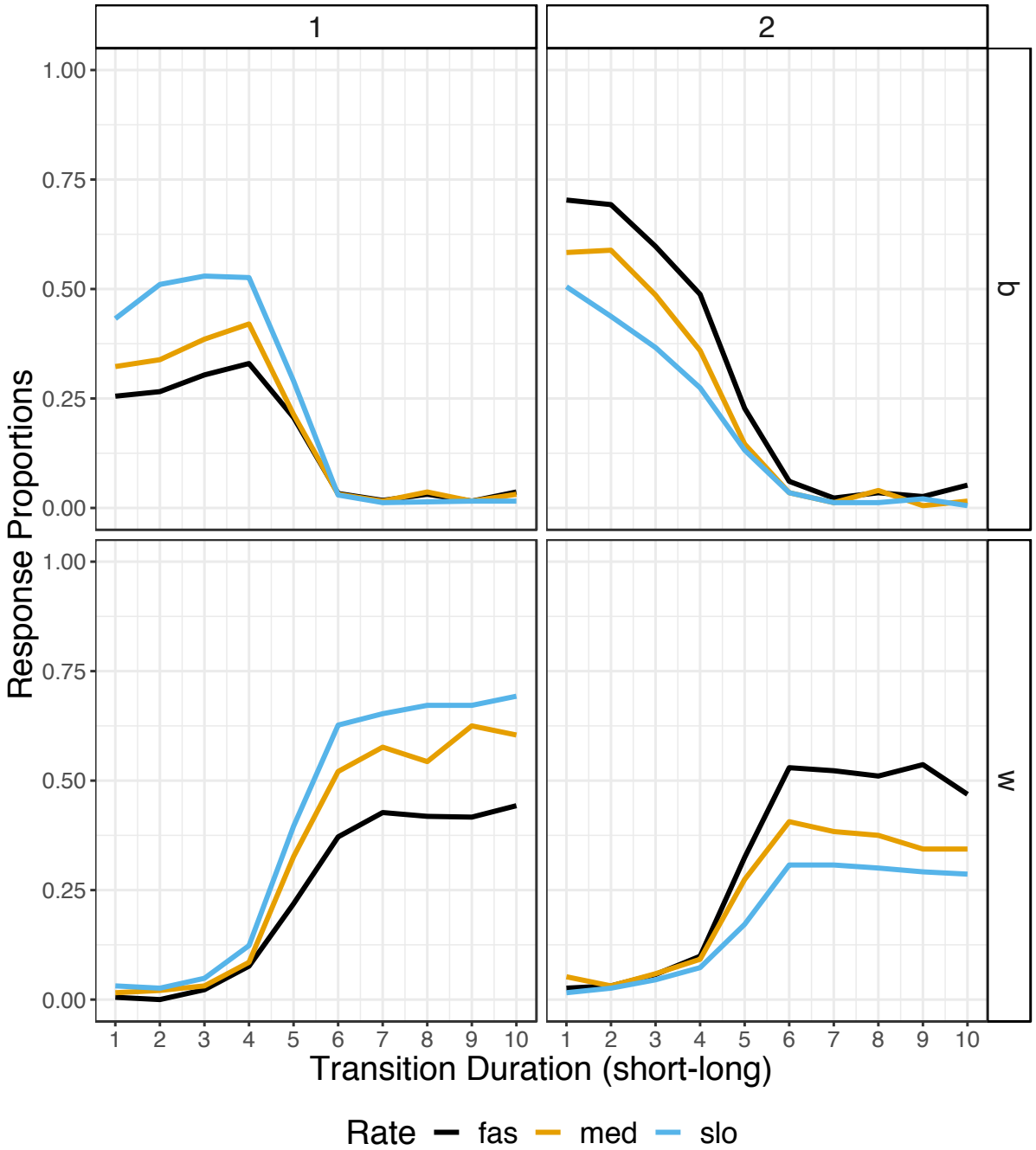
```
## `summarise()` has grouped output by 'speed', 'tDuration', 'cRsp'. You can override using the `.groups
```

```r
head(tmp10)
```

```
## # A tibble: 6 x 5
## # Groups:   speed, tDuration, cRsp [3]
##   speed tDuration cRsp   sRsp `mean(rspProp)`
##   <fct>     <dbl> <chr> <dbl>           <dbl>
## 1 fas           1 b         1         0.255
## 2 fas           1 b         2         0.703
## 3 fas           1 w         1         0.00521
## 4 fas           1 w         2         0.0260
## 5 fas           2 b         1         0.266
## 6 fas           2 b         2         0.693
```

```r
colnames(tmp10) <- c("speed",
                     "transitionDuration",
                     "consonantRsp",
                     "syllableRsp",
                     "xProp")

tmp11 <- ggplot(tmp10,
                aes(transitionDuration, xProp,
                    colour = speed)) +
  geom_line(size = 1) +
  facet_grid(consonantRsp ~ syllableRsp) +
  scale_x_continuous(name = "Transition Duration (short-long)",
                     limits = c(1,10),
                     breaks = seq(1, 10, 1)) +
  scale_y_continuous(name = "Response Proportions",
                     limits = c(0, 1),
                     breaks = seq(0,1,0.25)) +
  scale_color_manual(values = cbbPalette) +
  guides(colour = guide_legend(title="Rate")) +
  theme_bw()+
  theme(axis.text=element_text(size=12),
        axis.title=element_text(size=18),
        plot.title=element_text(size=28),
        strip.text=element_text(size=16),
        strip.background=element_rect(colour="black", fill="white"),
```

```
        legend.text=element_text(size=16),
        legend.title=element_text(size=18),
        legend.position = "bottom",
        legend.direction = "horizontal")

tmp11
```




```
ggsave(filename = "exp02RspsByTransitionSpeed_13may21.pdf",
       device = "pdf")

## Saving 8 x 9 in image
```

1.2 Bayesian model, using the brms package.

```
# library(brms)

exp2l$scTDuration <- scale(exp2l$tDuration)
exp2l$scVDuration <- scale(exp2l$vDuration)
exp2l$scSpeed <- scale(exp2l$nSpeed)

exp2l$scCondition <- scale(exp2l$nCondition)

exp2l$ncRsp <- ifelse(exp2l$cRsp == "b", 0, 1)
exp2l$nsRsp <- ifelse(exp2l$sRsp == "1", 0, 1)
```

Condition alone.

```
# exp2l0 <- brm(mvbind(ncRsp, nsRsp) ~ 1 + scCondition + (1 | scCondition/subject),
#           family = bernoulli(),
#           data = exp2l,
#           control = list(max_treedepth = 20, adapt_delta = 0.99),
#   # prior = c(prior(normal(0.5, 0.1), class = Intercept),
#   #           prior(cauchy(0, 1), class = sd)),
#   iter = 8000,
#   warmup = 1000,
#   chains = 4,
#   cores = 4,
#   seed = 12
# )
#
# plot(exp2l0)
#
# summary(exp2l0)
```

Transition duration, vowel duration, rate.

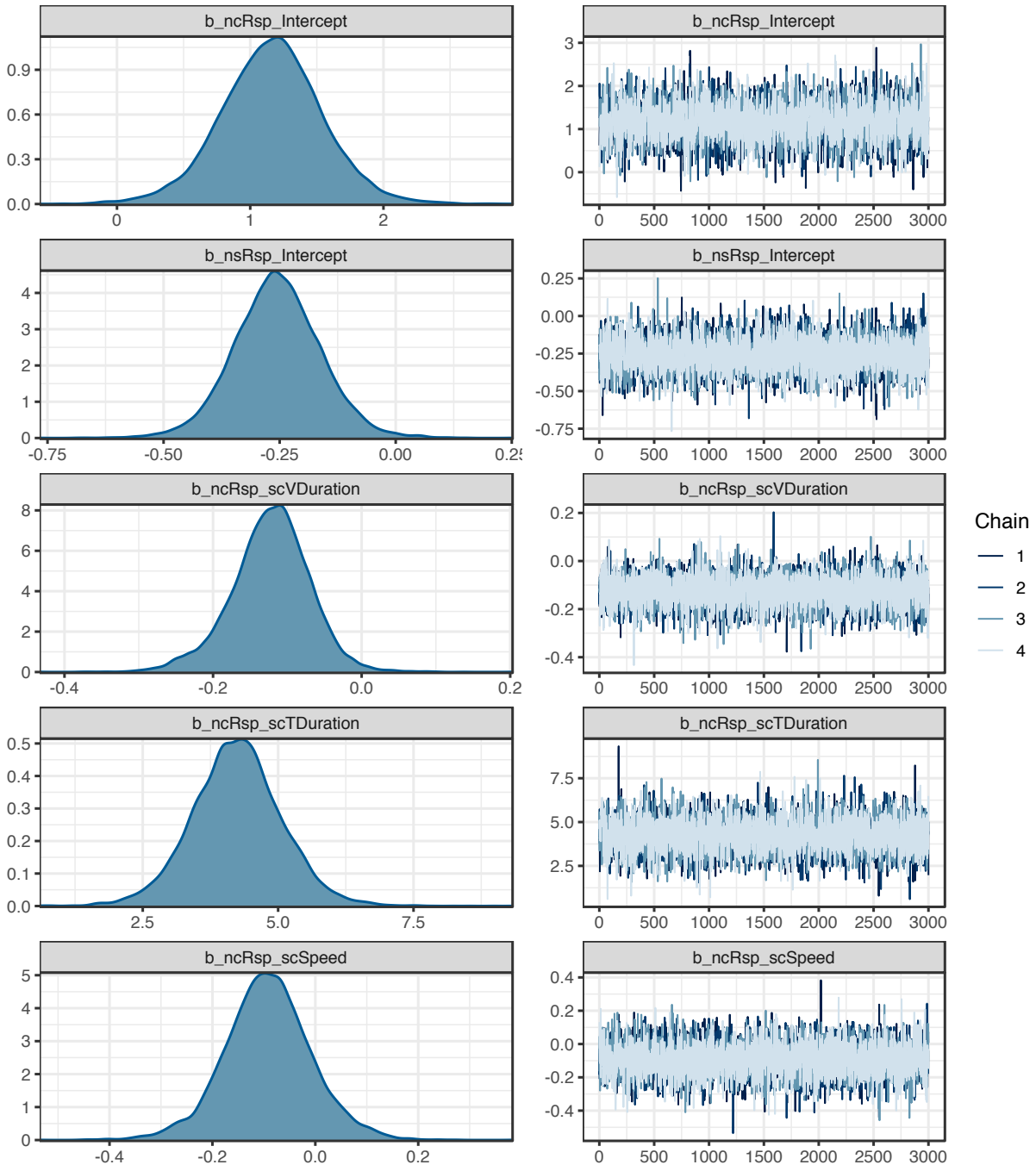
```
exp2l1 <- brm(mvbind(ncRsp, nsRsp) ~ scVDuration +
            scTDuration +
            scSpeed +
            (1 | q | subject) +
              (0 + scVDuration | q | subject) +
              (0 + scTDuration | q | subject) +
              (0 + scSpeed | q | subject),
          family = bernoulli(link = "logit"),
          data = exp2l,
  control = list(max_treedepth = 20, adapt_delta = 0.99),
  iter = 4000,
  warmup = 1000,
  chains = 4,
  cores = 4,
  seed = 12)
```

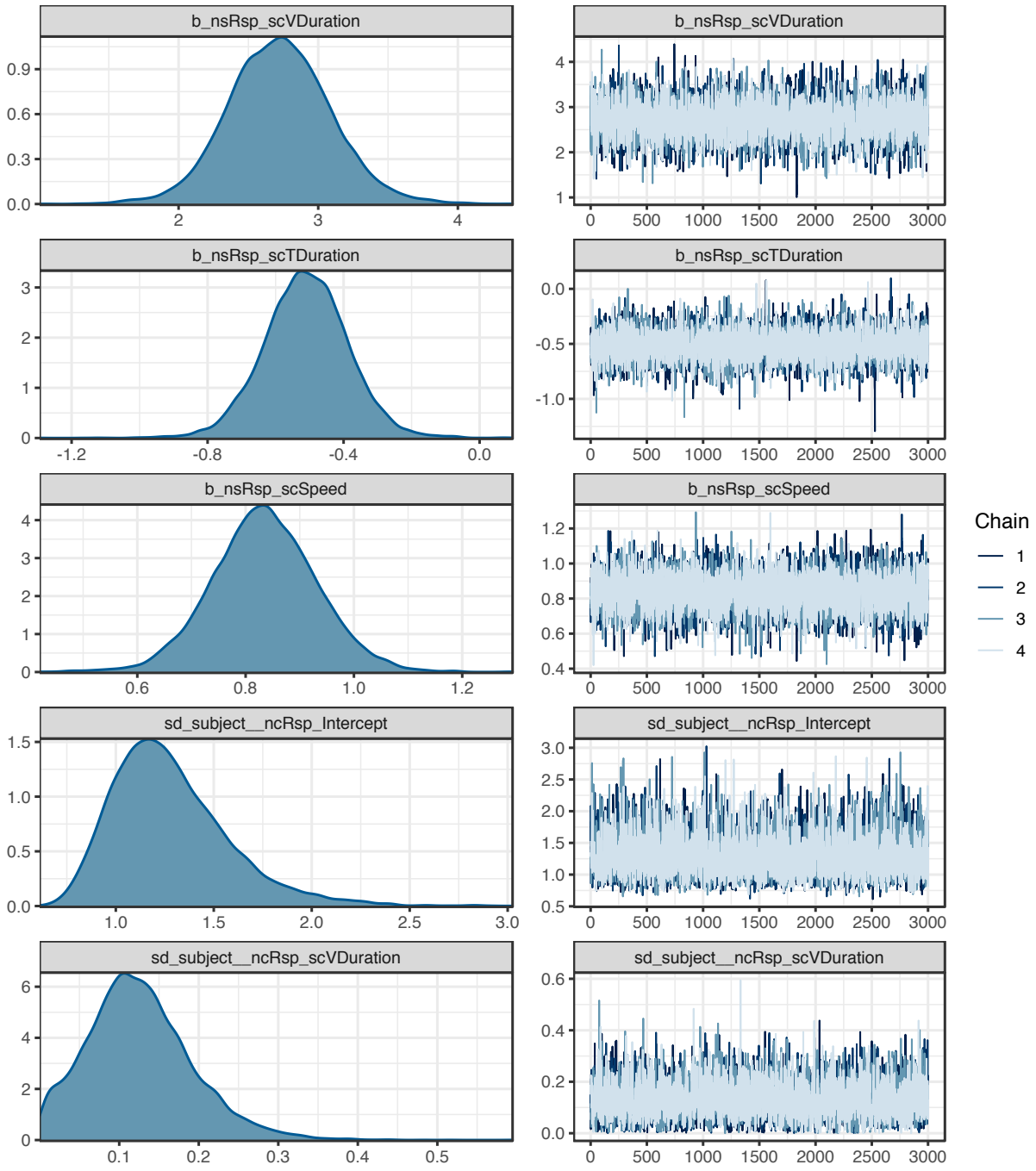
```
## Setting 'rescor' to FALSE by default for this model

## Compiling Stan program...

## Start sampling
```

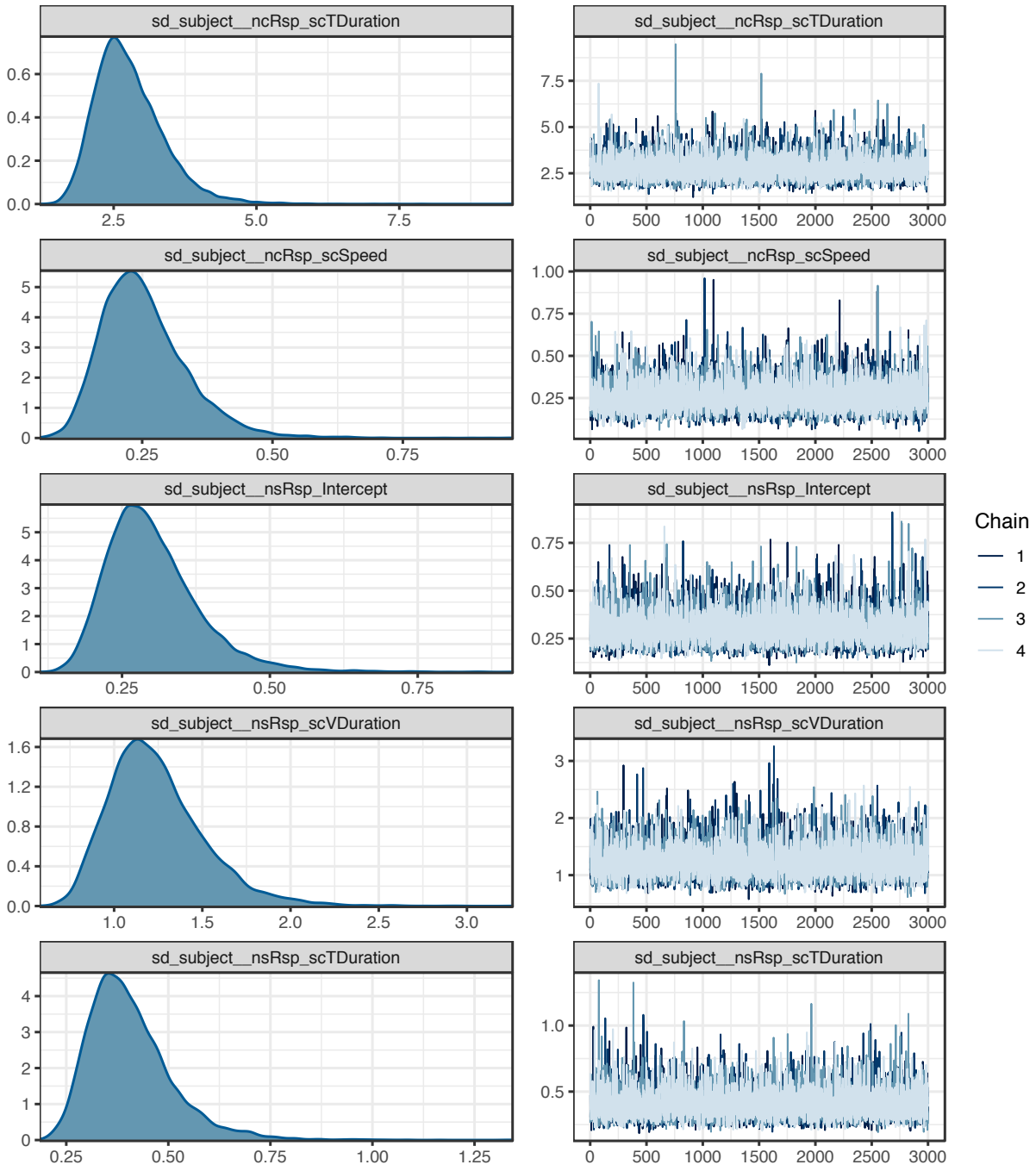
```r
exp2l2 <- brm(mvbind(ncRsp, nsRsp) ~ scVDuration *
            scTDuration *
            scSpeed +
            (1 | q | subject) +
              (0 + scVDuration | q | subject) +
              (0 + scTDuration | q | subject) +
              (0 + scSpeed | q | subject),
          family = bernoulli(link = "logit"),
          data = exp2l,
  control = list(max_treedepth = 20, adapt_delta = 0.99),
  iter = 4000,
  warmup = 1000,
  chains = 4,
  cores = 4,
  seed = 12)
```

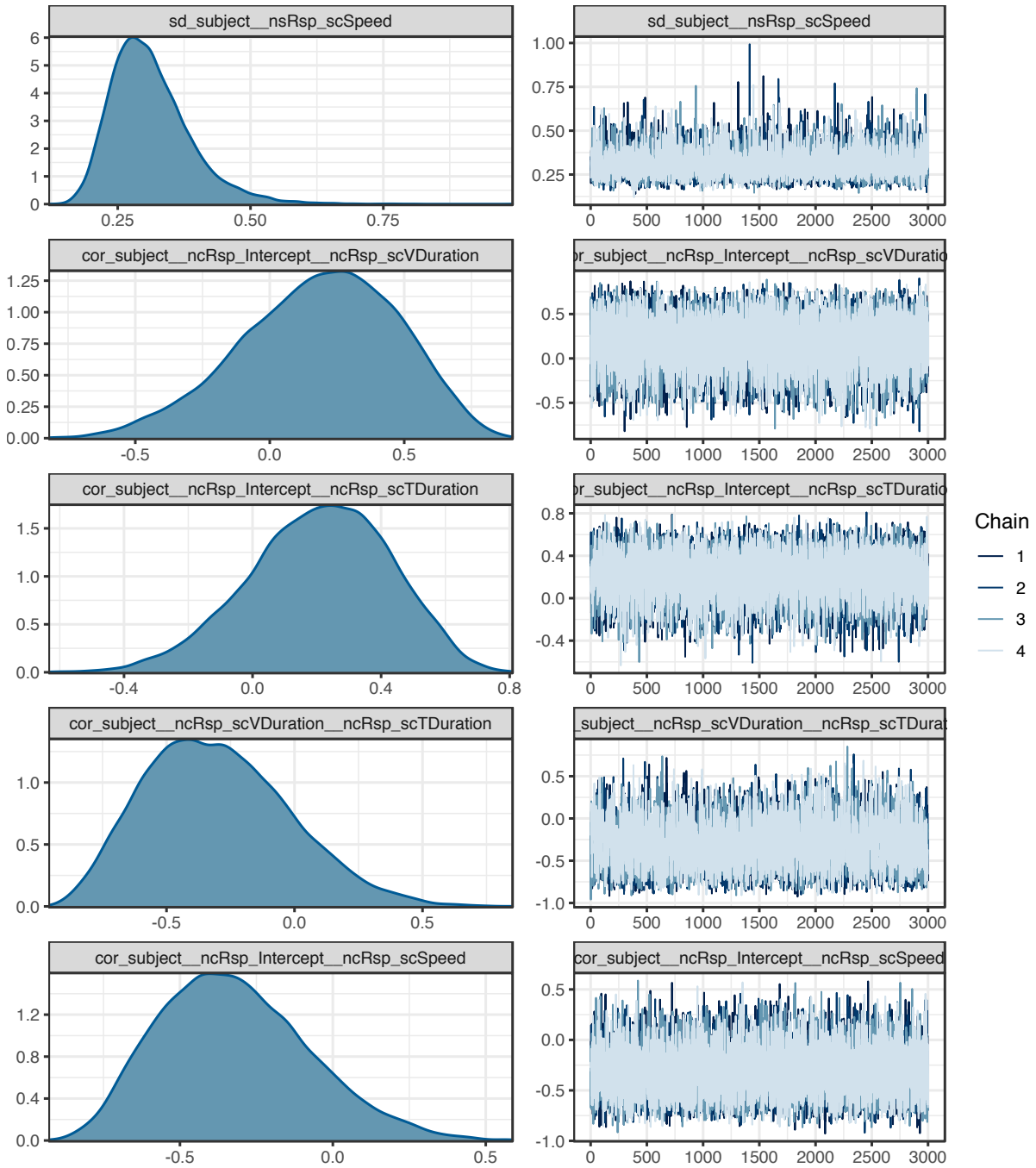
```
## Setting 'rescor' to FALSE by default for this model

## Compiling Stan program...

## recompiling to avoid crashing R session

## Start sampling
```

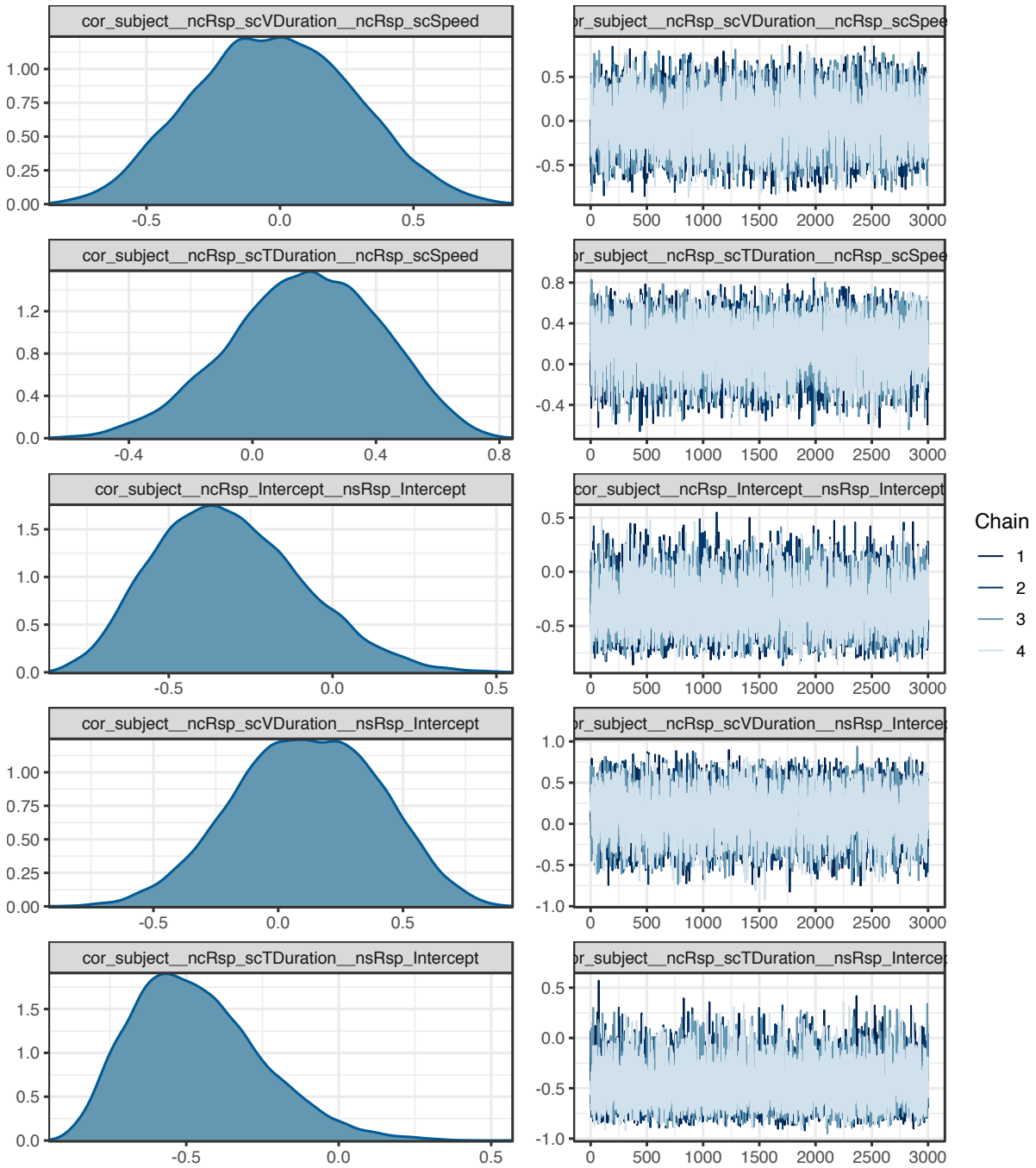
```r
# fixef(exp2l1) %>%
#   inv_logit_scaled()

plot(exp2l1)
```

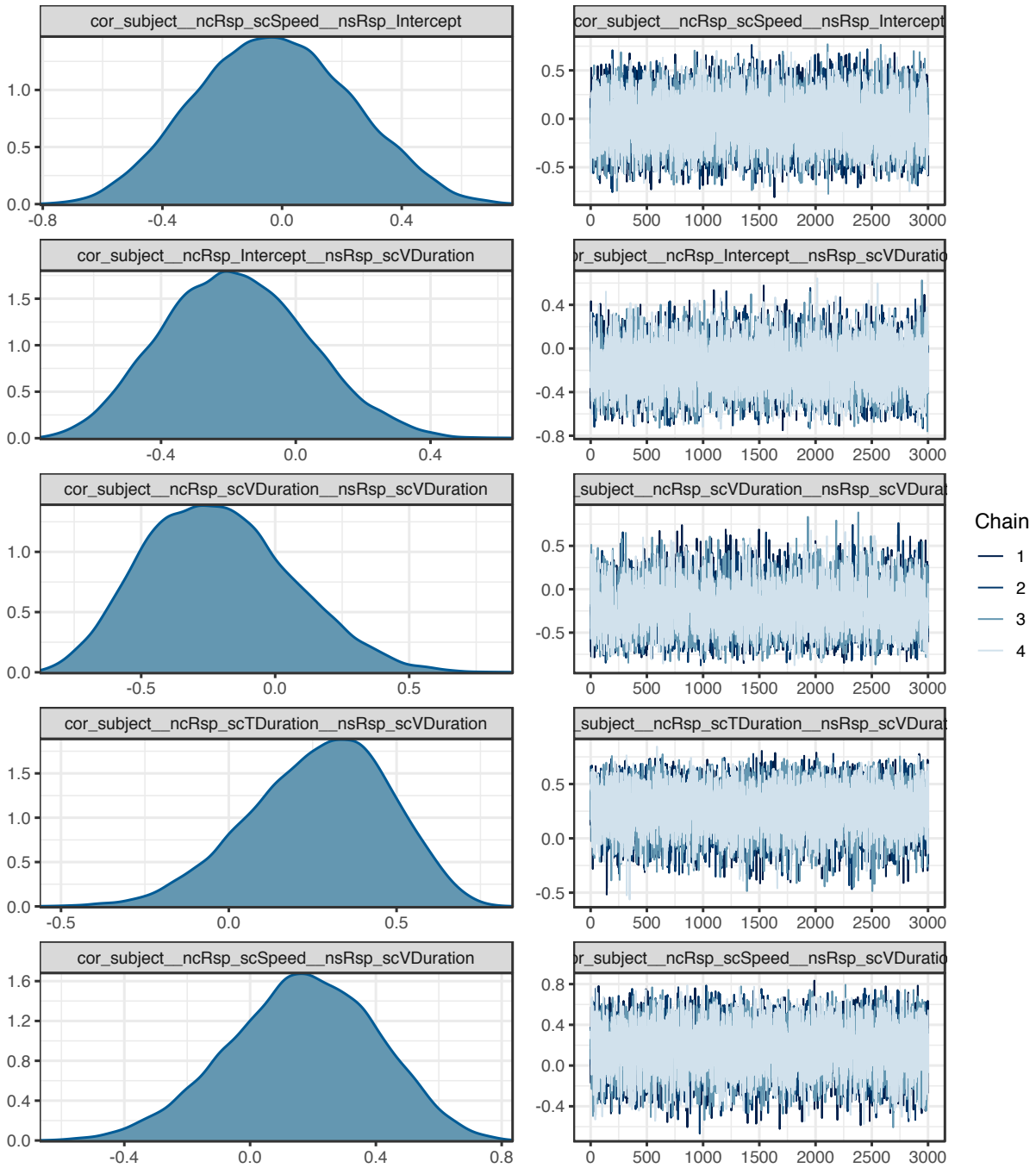

b_ncRsp_Intercept
b_nsRsp_Intercept
b_ncRsp_scVDuration
b_ncRsp_scTDuration
b_ncRsp_scSpeed
Chain
1
2
3
4

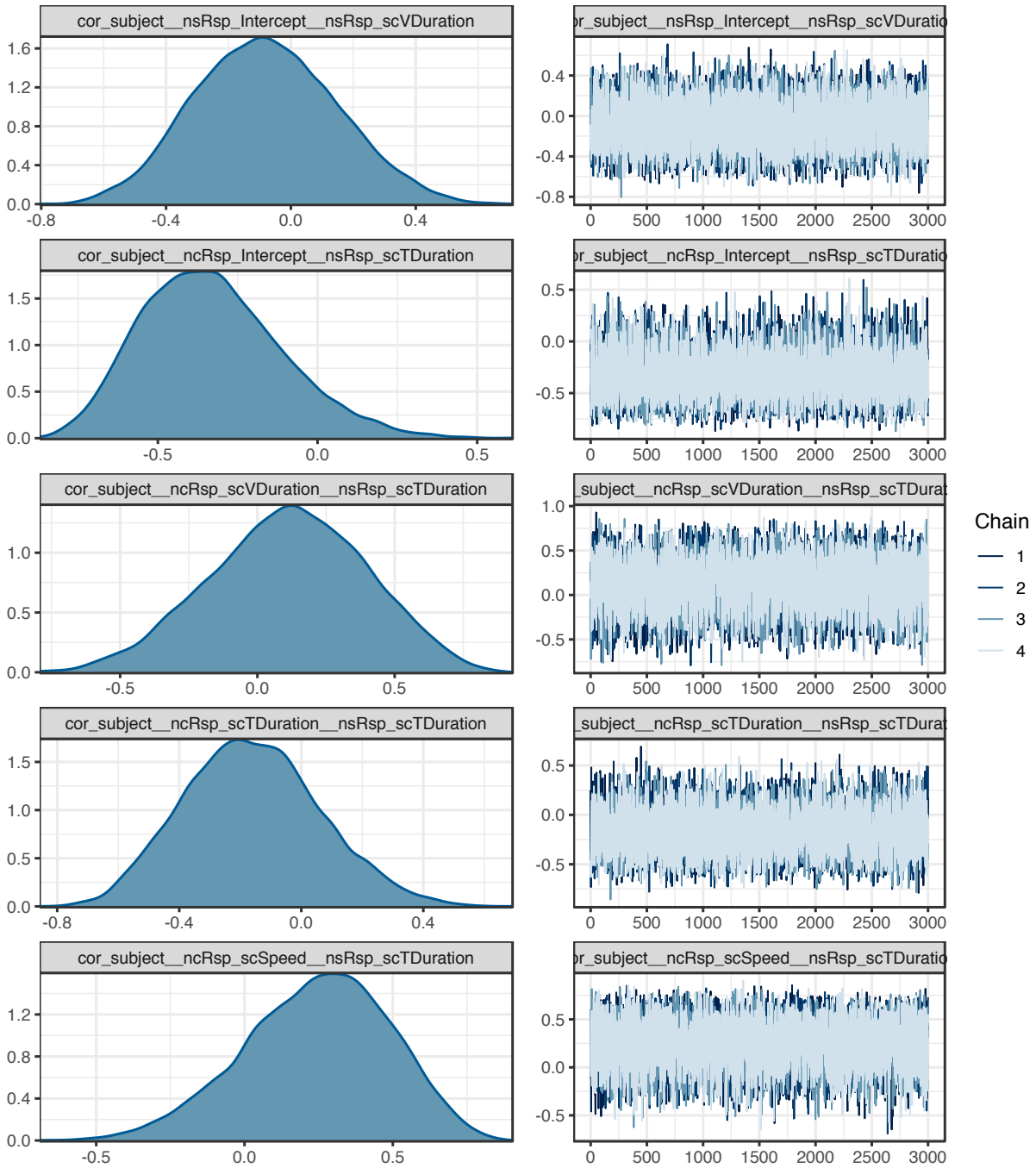

b_nsRsp_scVDuration
b_nsRsp_scTDuration
b_nsRsp_scSpeed
sd_subject__ncRsp_Intercept
sd_subject__ncRsp_scVDuration
Chain
1
2
3
4

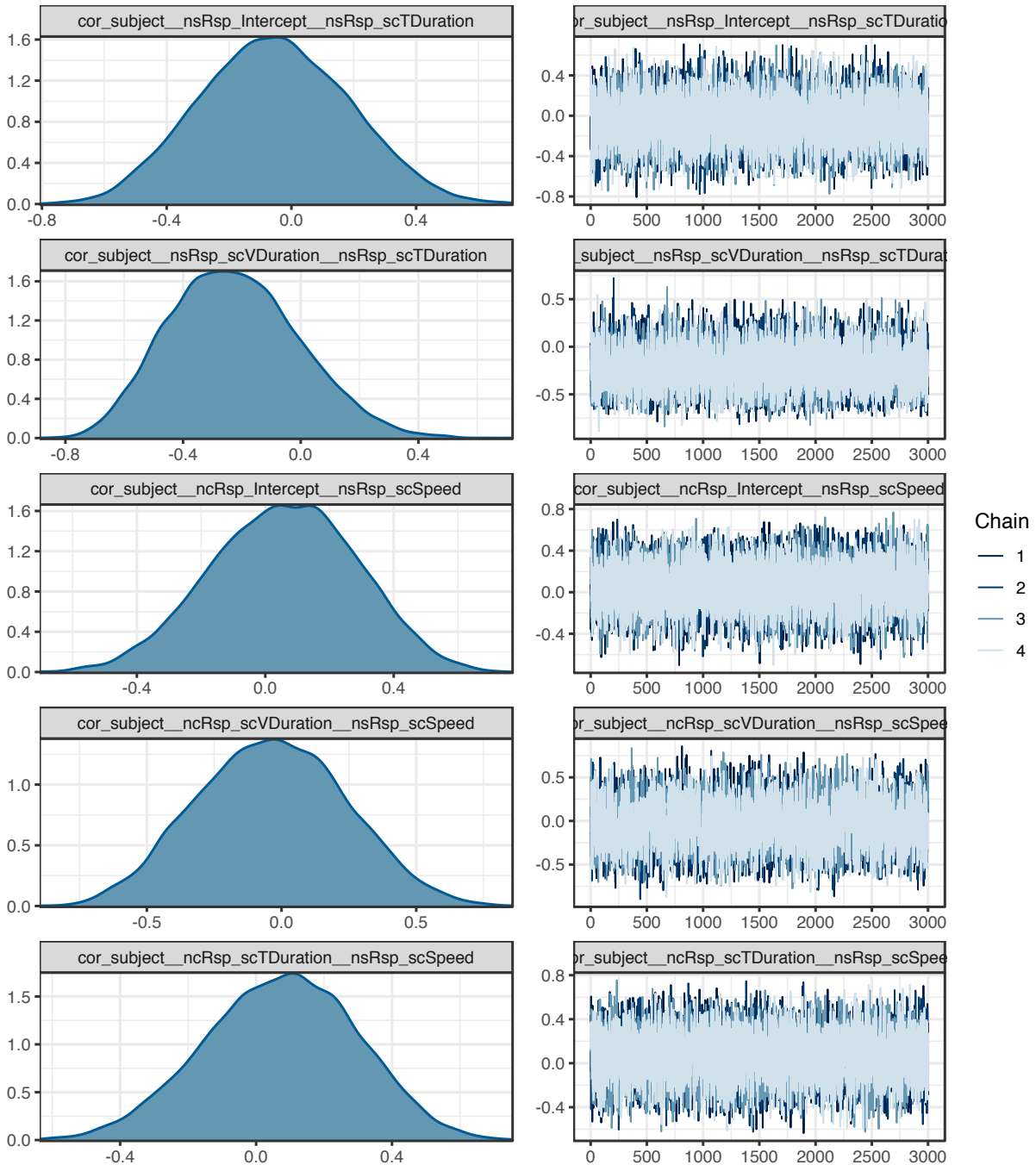

sd_subject__ncRsp_scTDuration
sd_subject__ncRsp_scSpeed
sd_subject__nsRsp_Intercept
sd_subject__nsRsp_scVDuration
sd_subject__nsRsp_scTDuration
Chain
1
2
3
4

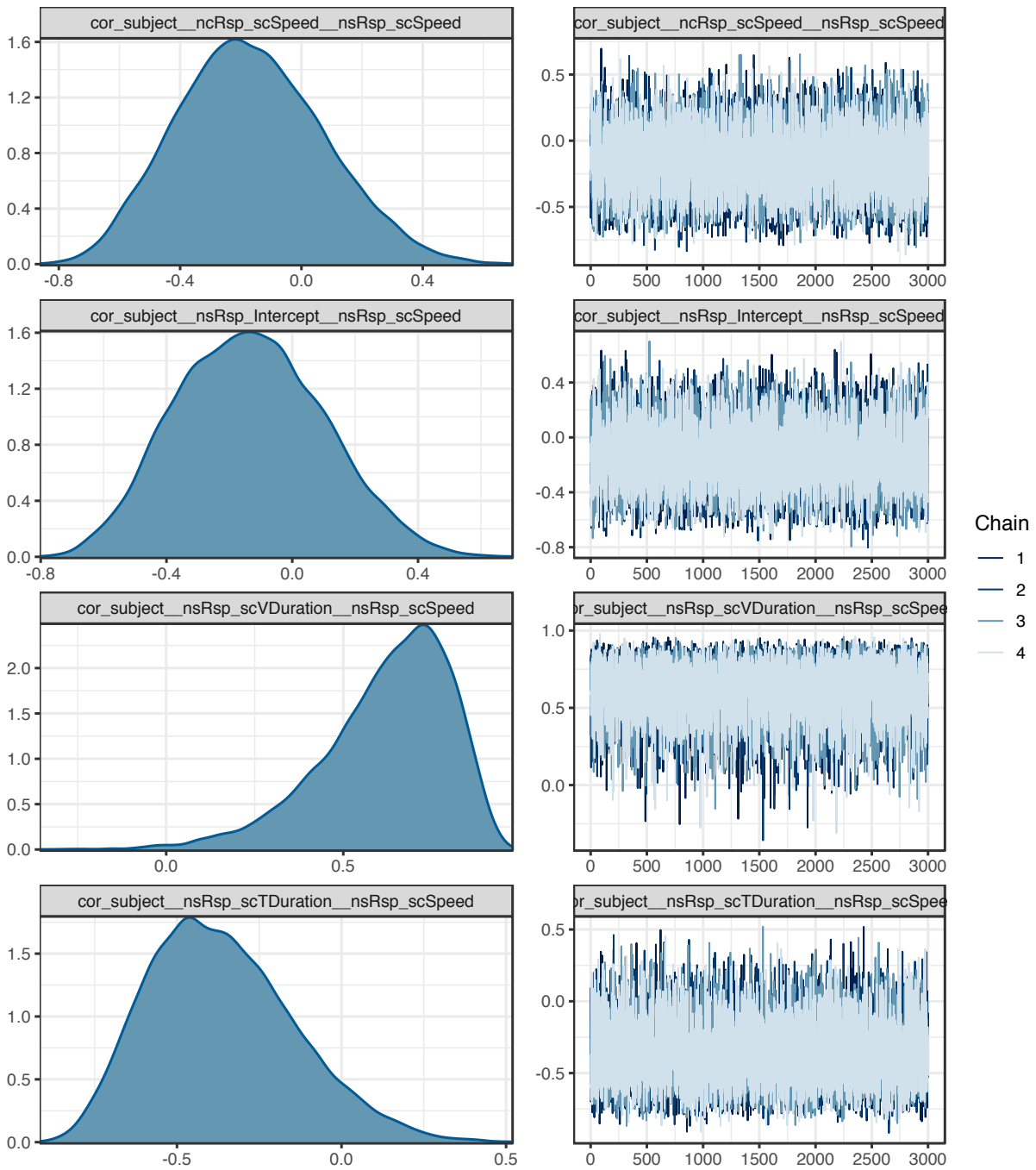

sd_subject__nsRsp_scSpeed
sd_subject__nsRsp_scSpeed
cor_subject__ncRsp_Intercept__ncRsp_scVDuration
r_subject__ncRsp_Intercept__ncRsp_scVDuratio
cor_subject__ncRsp_Intercept__ncRsp_scTDuration
r_subject__ncRsp_Intercept__ncRsp_scTDuratio
cor_subject__ncRsp_scVDuration__ncRsp_scTDuration
_subject__ncRsp_scVDuration__ncRsp_scTDura
cor_subject__ncRsp_Intercept__ncRsp_scSpeed
cor_subject__ncRsp_Intercept__ncRsp_scSpeed
Chain
1
2
3
4


cor_subject__ncRsp_scVDuration__ncRsp_scSpeed
cor_subject__ncRsp_scTDuration__ncRsp_scSpeed
cor_subject__ncRsp_Intercept__nsRsp_Intercept
cor_subject__ncRsp_scVDuration__nsRsp_Intercept
cor_subject__ncRsp_scTDuration__nsRsp_Intercept
Chain
1
2
3
4

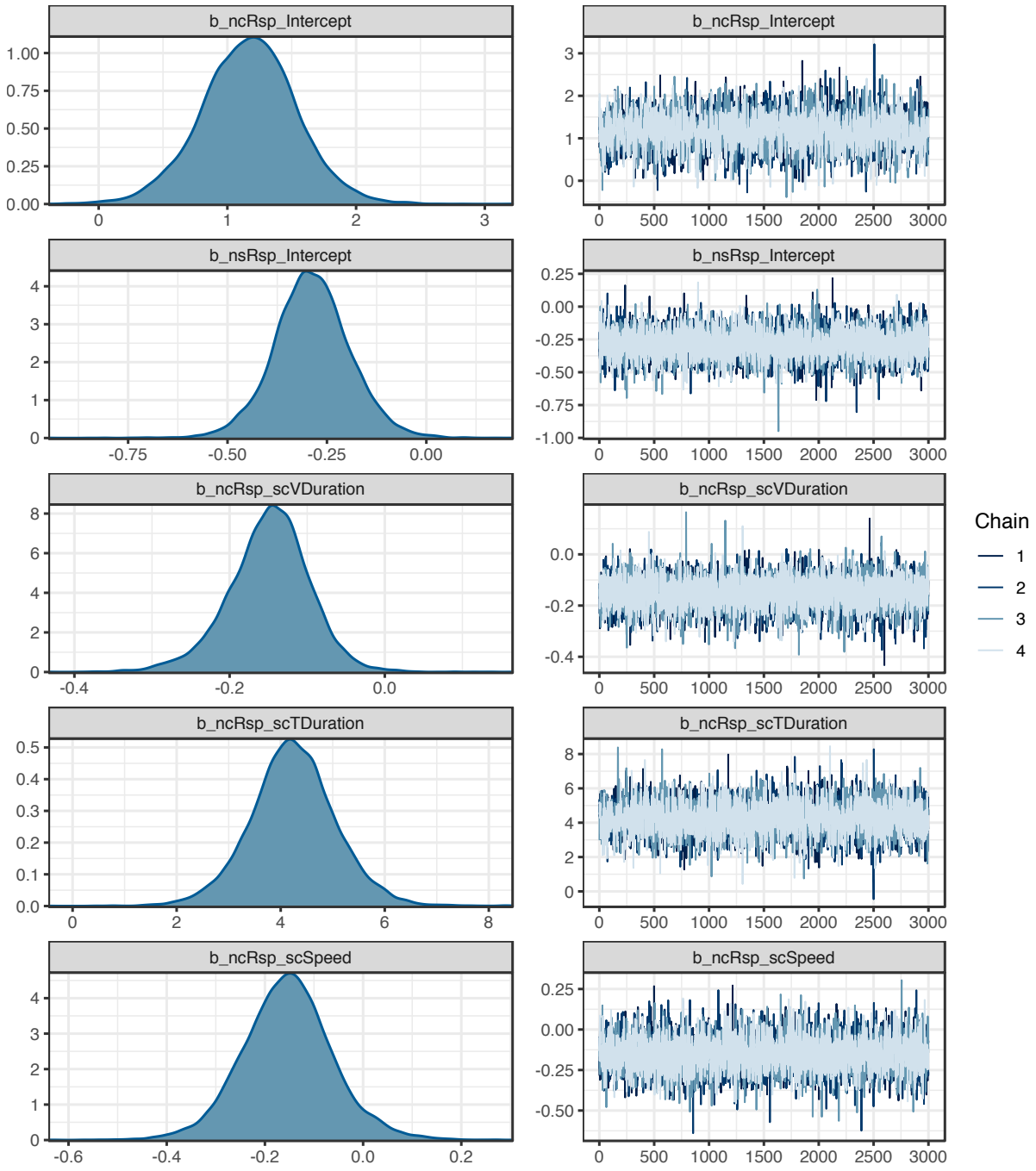

cor_subject__ncRsp_scSpeed__nsRsp_Intercept
cor_subject__ncRsp_Intercept__nsRsp_scVDuration
cor_subject__ncRsp_scVDuration__nsRsp_scVDuration
cor_subject__ncRsp_scTDuration__nsRsp_scVDuration
cor_subject__ncRsp_scSpeed__nsRsp_scVDuration
Chain
1
2
3
4

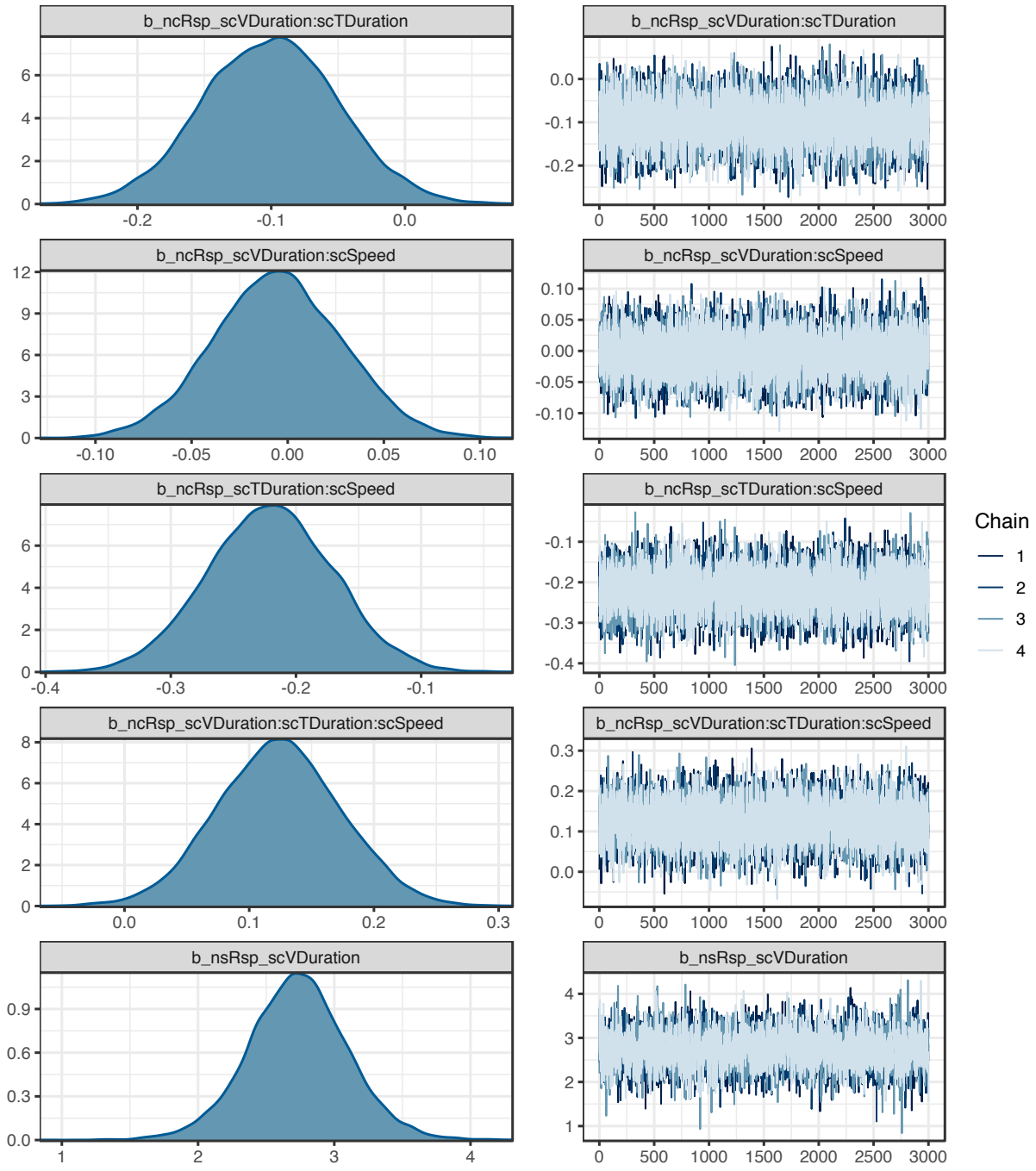

cor_subject__nsRsp_Intercept__nsRsp_scVDuration
cor_subject__ncRsp_Intercept__nsRsp_scTDuration
cor_subject__ncRsp_scVDuration__nsRsp_scTDuration
cor_subject__ncRsp_scTDuration__nsRsp_scTDuration
cor_subject__ncRsp_scSpeed__nsRsp_scTDuration
Chain
1
2
3
4

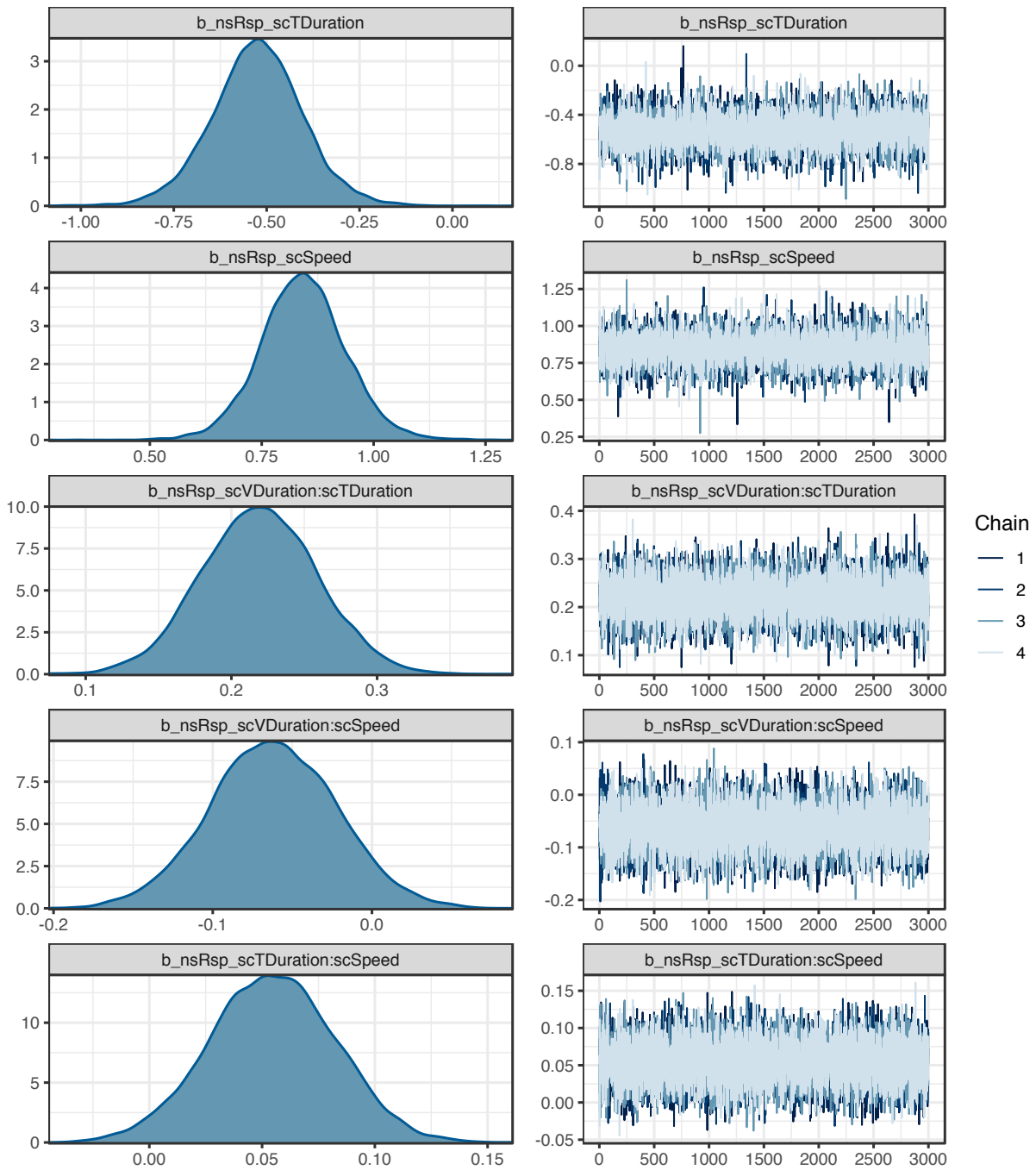

cor_subject__nsRsp_Intercept__nsRsp_scTDuration
cor_subject__nsRsp_scVDuration__nsRsp_scTDuration
cor_subject__ncRsp_Intercept__nsRsp_scSpeed
cor_subject__ncRsp_scVDuration__nsRsp_scSpeed
cor_subject__ncRsp_scTDuration__nsRsp_scSpeed
Chain
1
2
3
4

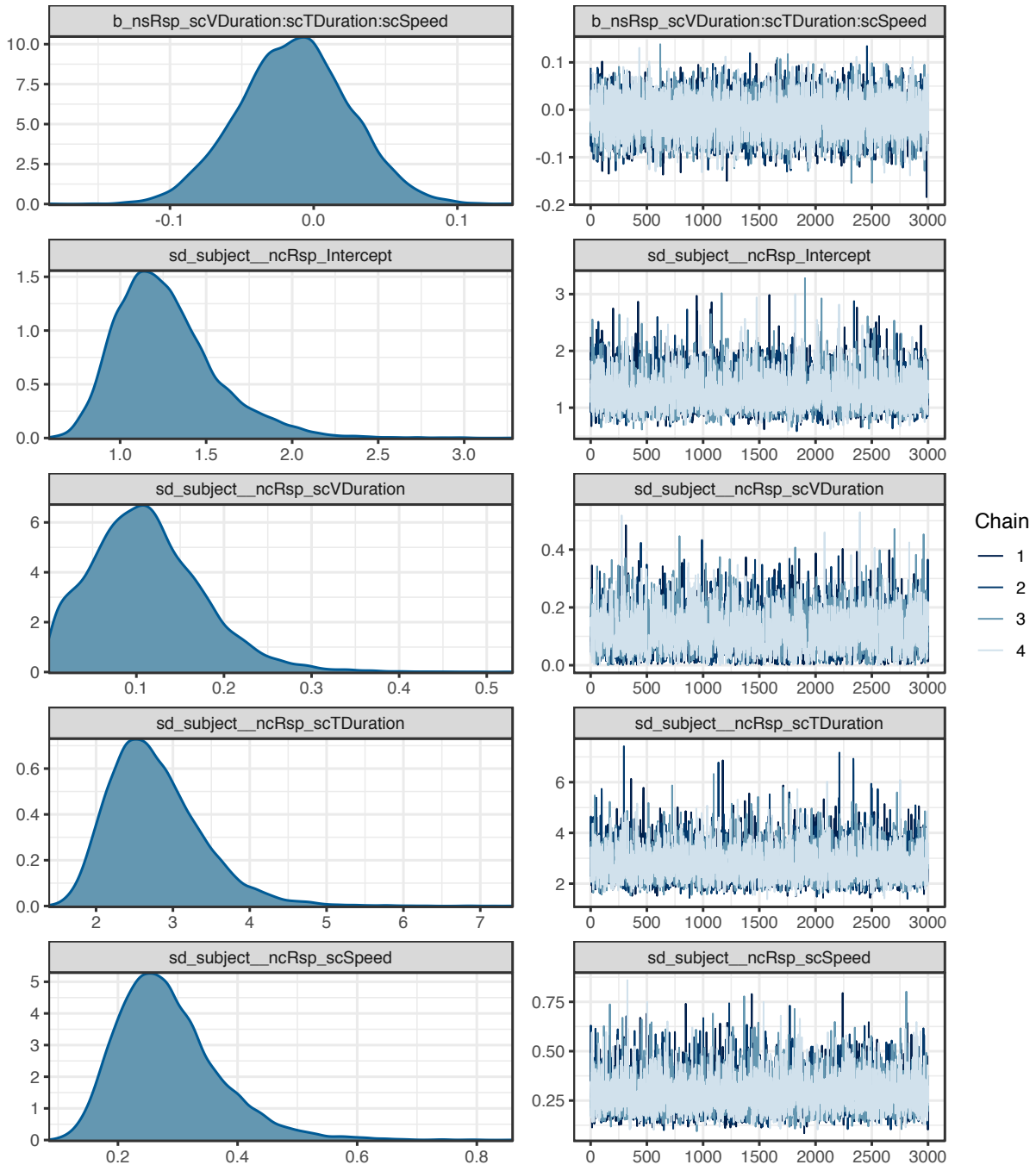


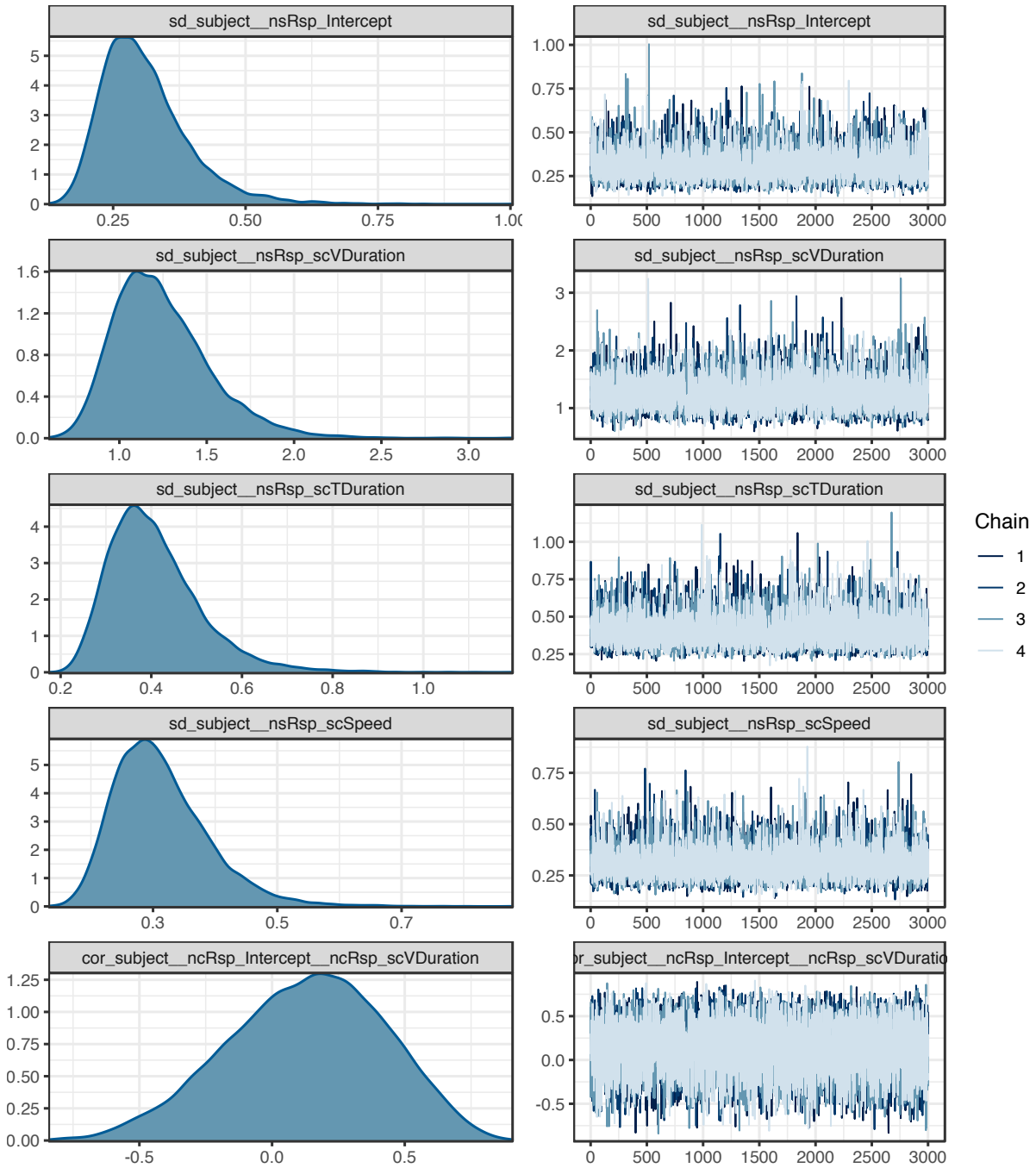

```
# fixef(exp2l2) %>%
#   inv_logit_scaled()

plot(exp2l2)
```

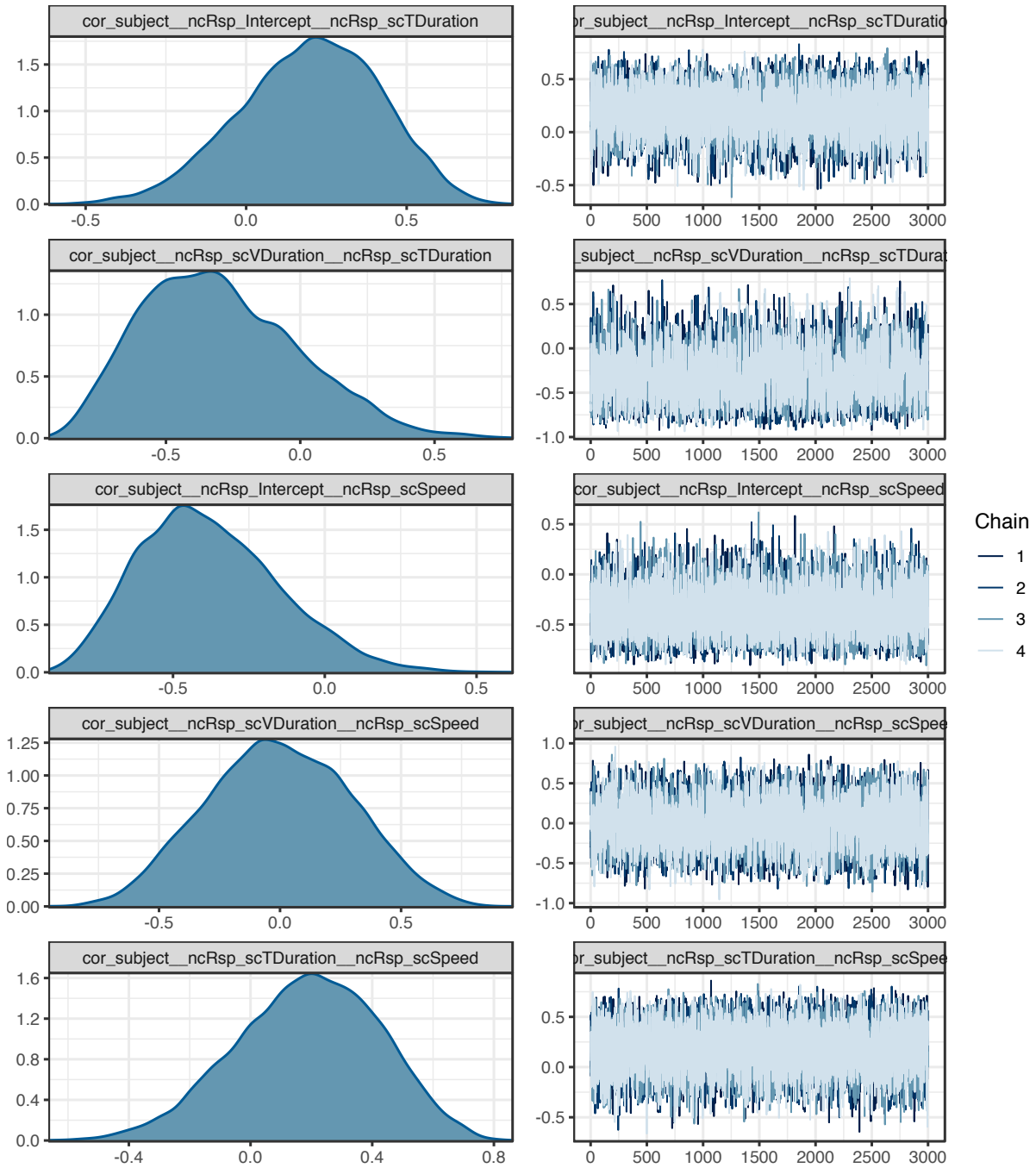

b_ncRsp_Intercept
b_nsRsp_Intercept
b_ncRsp_scVDuration
b_ncRsp_scTDuration
b_ncRsp_scSpeed
Chain
1
2
3
4

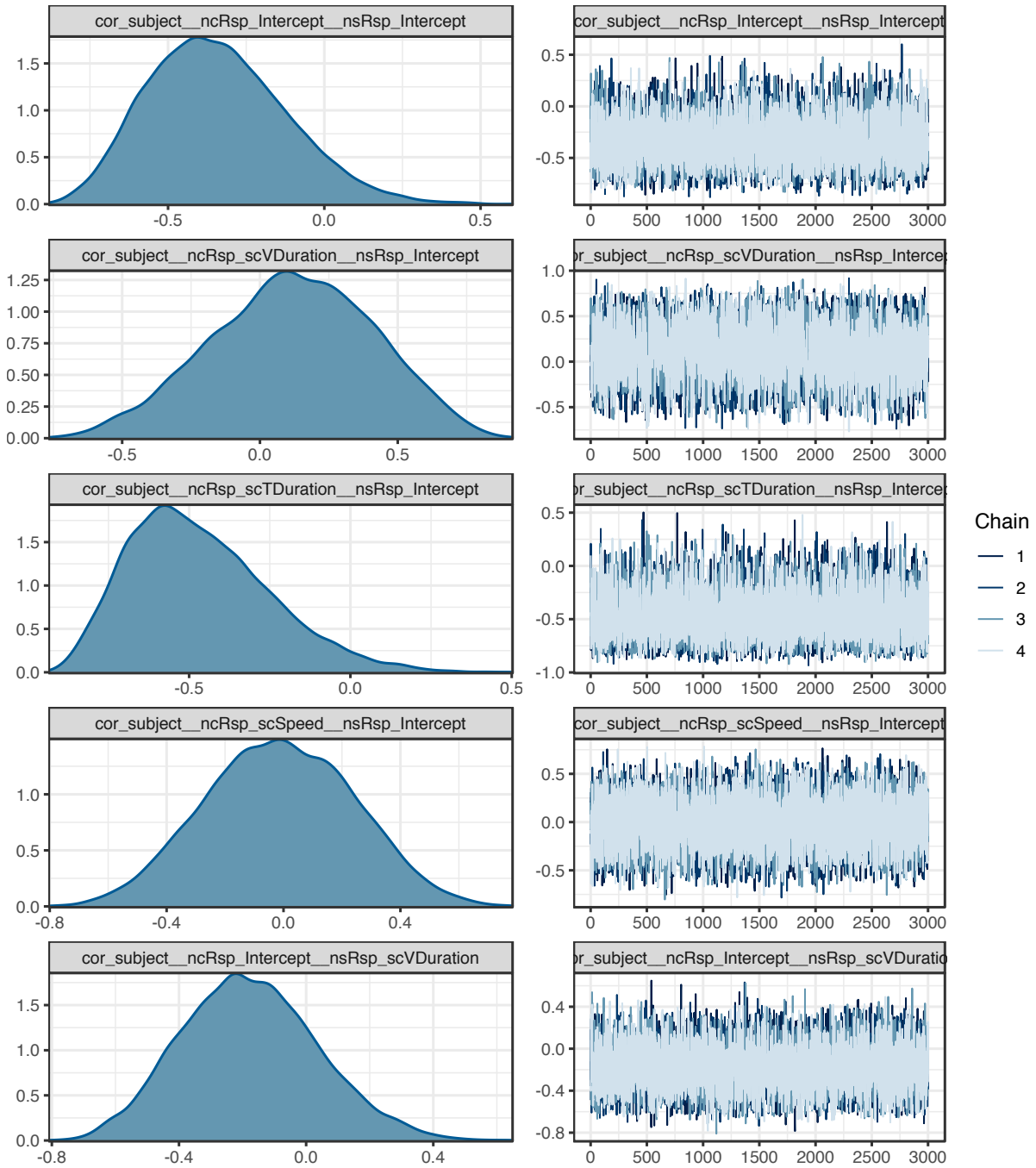

b_ncRsp_scVDuration:scTDuration
b_ncRsp_scVDuration:scTDuration
b_ncRsp_scVDuration:scSpeed
b_ncRsp_scVDuration:scSpeed
b_ncRsp_scTDuration:scSpeed
b_ncRsp_scTDuration:scSpeed
b_ncRsp_scVDuration:scTDuration:scSpeed
b_ncRsp_scVDuration:scTDuration:scSpeed
b_nsRsp_scVDuration
b_nsRsp_scVDuration
Chain
1
2
3
4

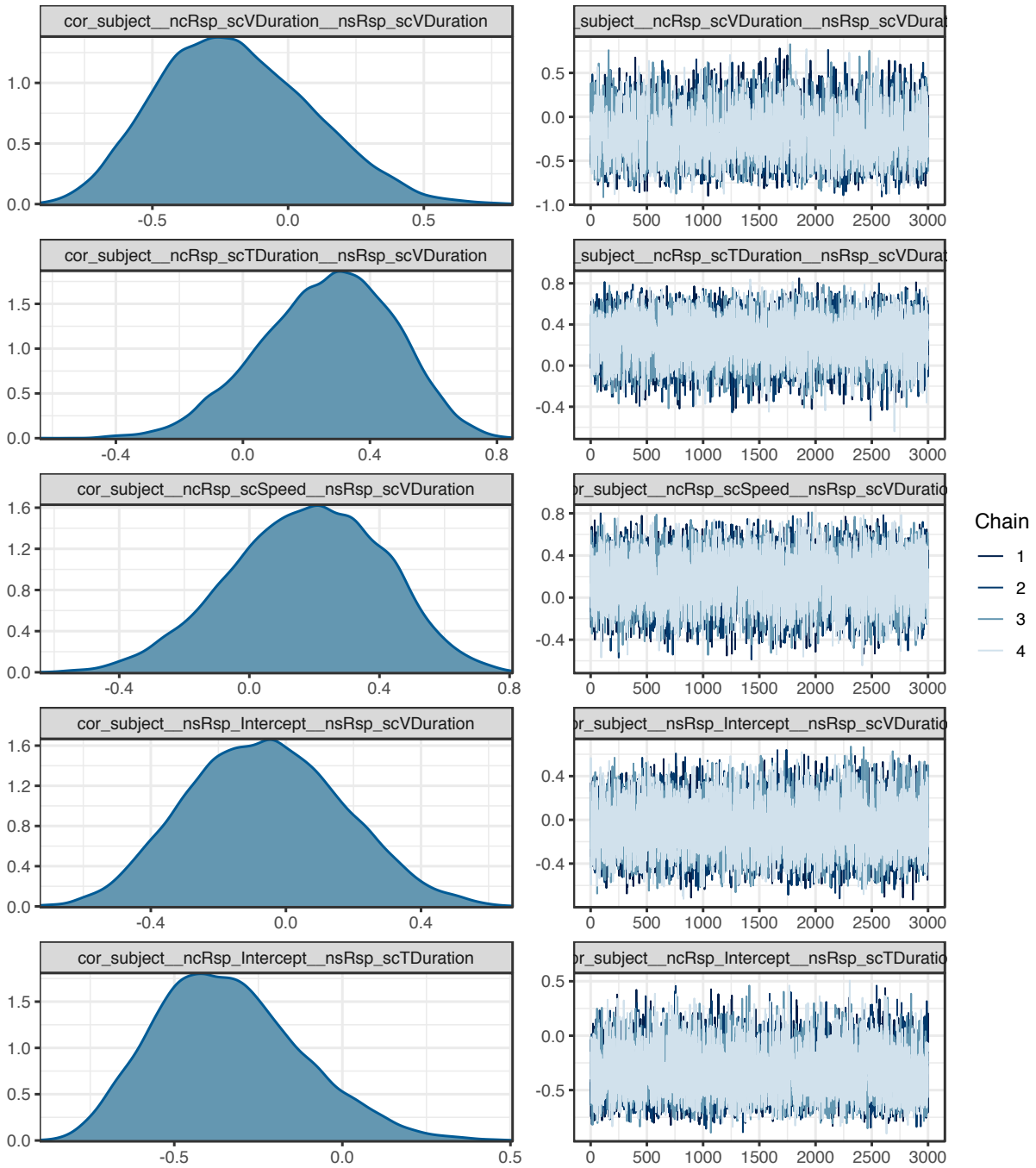

b_nsRsp_scTDuration
b_nsRsp_scSpeed
b_nsRsp_scVDuration:scTDuration
b_nsRsp_scVDuration:scSpeed
b_nsRsp_scTDuration:scSpeed
Chain
1
2
3
4

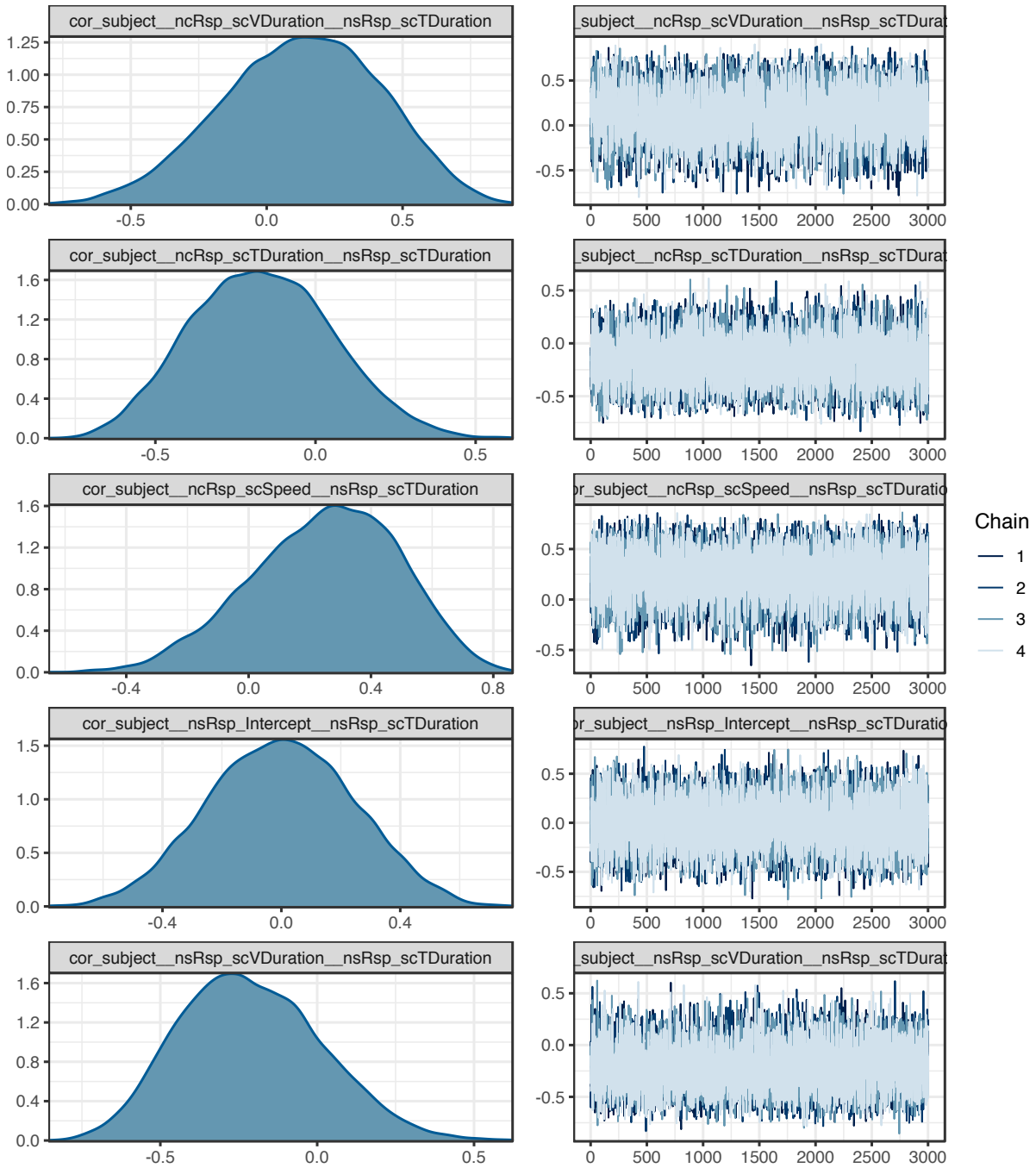

b_nsRsp_scVDuration:scTDuration:scSpeed
sd_subject__ncRsp_Intercept
sd_subject__ncRsp_scVDuration
sd_subject__ncRsp_scTDuration
sd_subject__ncRsp_scSpeed
Chain
1
2
3
4

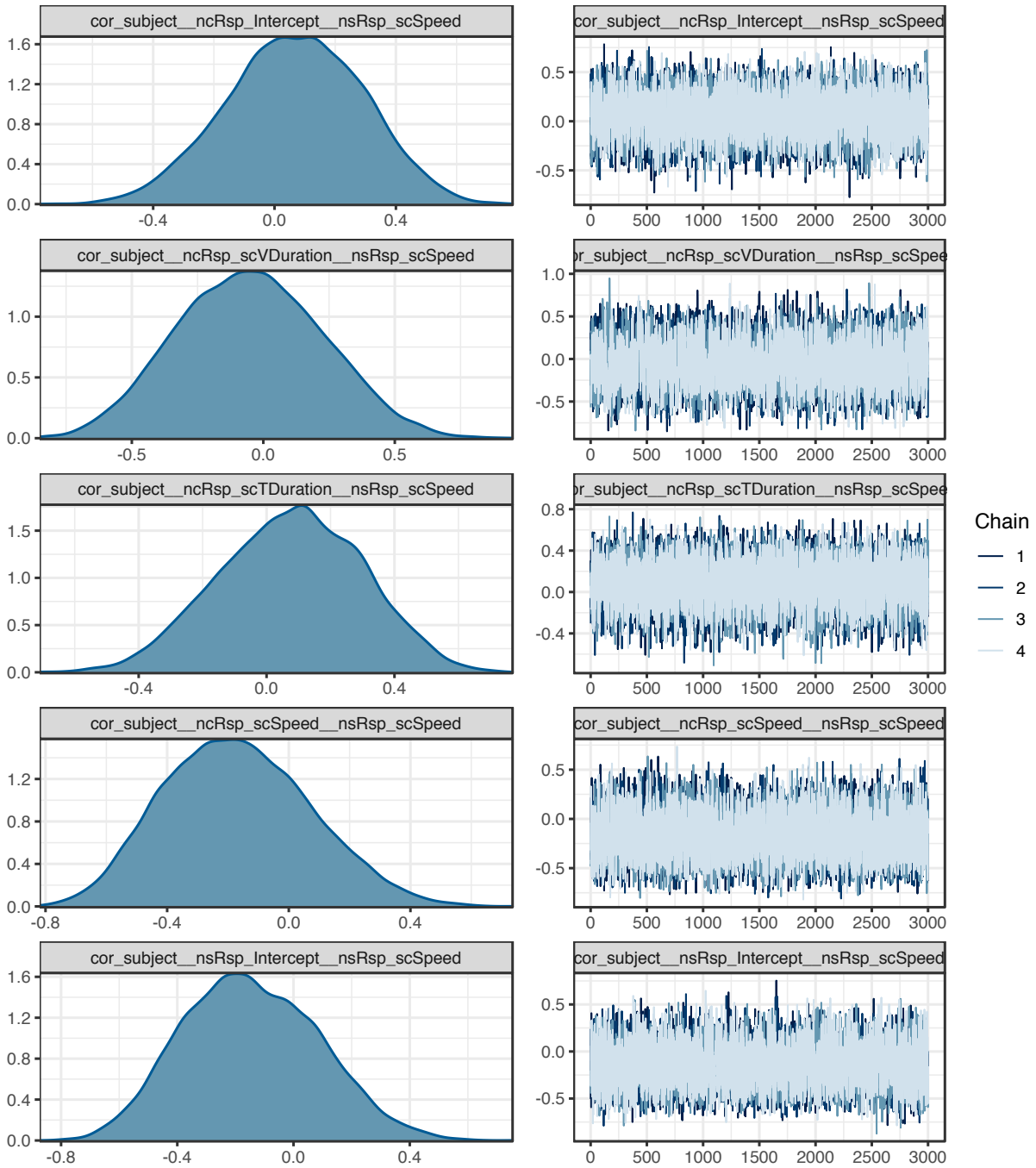

sd_subject__nsRsp_Intercept
sd_subject__nsRsp_Intercept
sd_subject__nsRsp_scVDuration
sd_subject__nsRsp_scVDuration
sd_subject__nsRsp_scTDuration
sd_subject__nsRsp_scTDuration
sd_subject__nsRsp_scSpeed
sd_subject__nsRsp_scSpeed
cor_subject__ncRsp_Intercept__ncRsp_scVDuration
r_subject__ncRsp_Intercept__ncRsp_scVDuratio
Chain
1
2
3
4

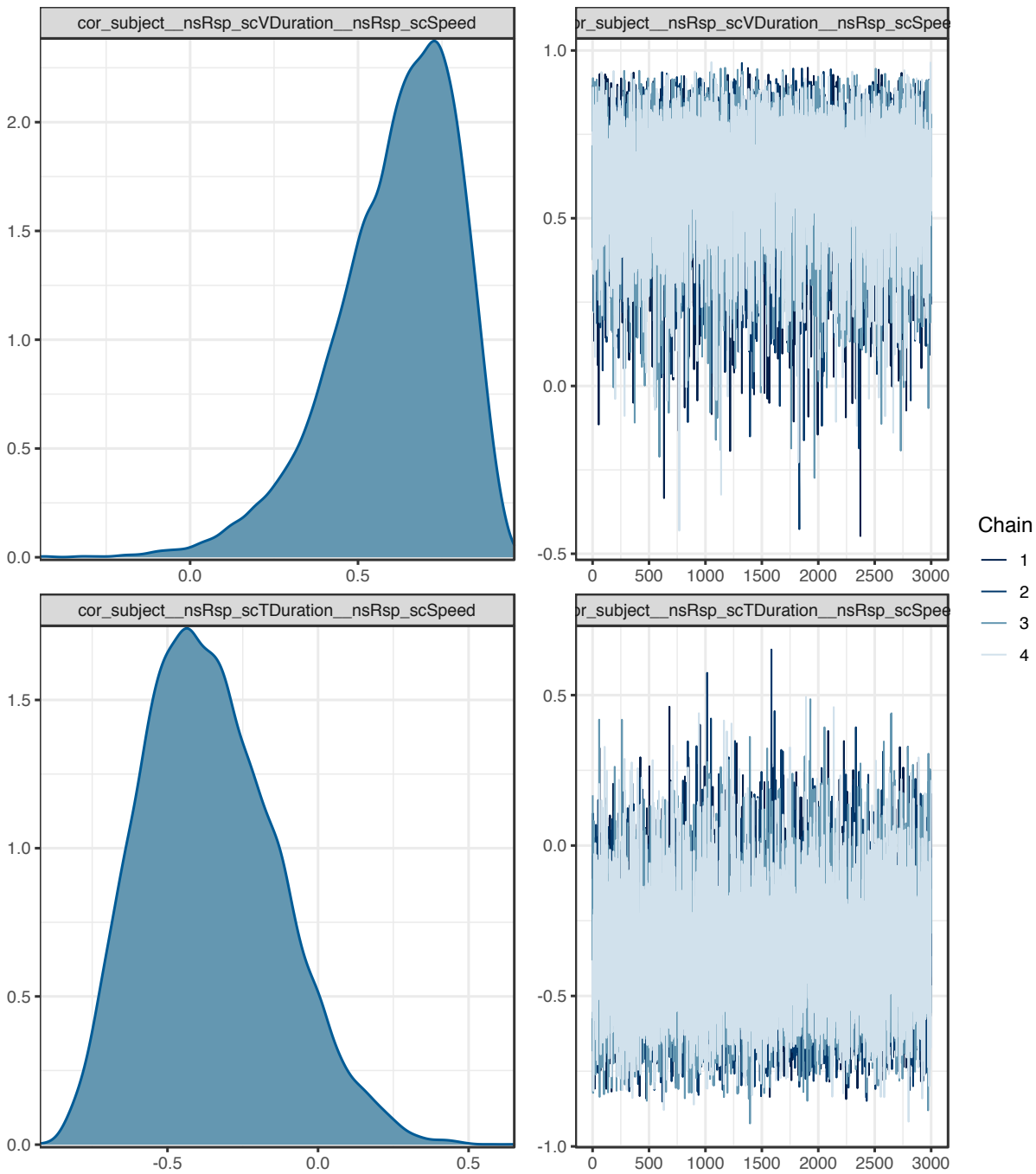

cor_subject__ncRsp_Intercept__ncRsp_scTDuration
cor_subject__ncRsp_scVDuration__ncRsp_scTDuration
cor_subject__ncRsp_Intercept__ncRsp_scSpeed
cor_subject__ncRsp_scVDuration__ncRsp_scSpeed
cor_subject__ncRsp_scTDuration__ncRsp_scSpeed
Chain
1
2
3
4


cor_subject__ncRsp_Intercept__nsRsp_Intercept
cor_subject__ncRsp_Intercept__nsRsp_Intercept
cor_subject__ncRsp_scVDuration__nsRsp_Intercept
r_subject__ncRsp_scVDuration__nsRsp_Interce
cor_subject__ncRsp_scTDuration__nsRsp_Intercept
r_subject__ncRsp_scTDuration__nsRsp_Interce
cor_subject__ncRsp_scSpeed__nsRsp_Intercept
cor_subject__ncRsp_scSpeed__nsRsp_Intercept
cor_subject__ncRsp_Intercept__nsRsp_scVDuration
r_subject__ncRsp_Intercept__nsRsp_scVDuratio
Chain
1
2
3
4


cor_subject__ncRsp_scVDuration__nsRsp_scVDuration
_subject__ncRsp_scVDuration__nsRsp_scVDurat
cor_subject__ncRsp_scTDuration__nsRsp_scVDuration
_subject__ncRsp_scTDuration__nsRsp_scVDurat
cor_subject__ncRsp_scSpeed__nsRsp_scVDuration
r_subject__ncRsp_scSpeed__nsRsp_scVDuratio
cor_subject__nsRsp_Intercept__nsRsp_scVDuration
r_subject__nsRsp_Intercept__nsRsp_scVDuratio
cor_subject__ncRsp_Intercept__nsRsp_scTDuration
r_subject__ncRsp_Intercept__nsRsp_scTDuratio
Chain
1
2
3
4


cor_subject__ncRsp_scVDuration__nsRsp_scTDuration
_subject__ncRsp_scVDuration__nsRsp_scTDurat
cor_subject__ncRsp_scTDuration__nsRsp_scTDuration
_subject__ncRsp_scTDuration__nsRsp_scTDurat
cor_subject__ncRsp_scSpeed__nsRsp_scTDuration
r_subject__ncRsp_scSpeed__nsRsp_scTDuratio
cor_subject__nsRsp_Intercept__nsRsp_scTDuration
r_subject__nsRsp_Intercept__nsRsp_scTDuratio
cor_subject__nsRsp_scVDuration__nsRsp_scTDuration
_subject__nsRsp_scVDuration__nsRsp_scTDurat
Chain
1
2
3
4


cor_subject__ncRsp_Intercept__nsRsp_scSpeed
cor_subject__ncRsp_scVDuration__nsRsp_scSpeed
cor_subject__ncRsp_scTDuration__nsRsp_scSpeed
cor_subject__ncRsp_scSpeed__nsRsp_scSpeed
cor_subject__nsRsp_Intercept__nsRsp_scSpeed
Chain
1
2
3
4



Check the chains.

```
# summary(exp2l1)

#exp2l1Post <- posterior_samples(exp2l1, add_chain = TRUE)

#str(exp2l1Post)

# summary(exp2l2)

#exp2l2Post <- posterior_samples(exp2l2, add_chain = TRUE)
```

```
#str(exp2l2Post)
```

```
# mcmc_trace(exp2l1Post[, c(1:8)],
#            size = 0.25 +
#            scale_color_manual(values = cbbPalette) +
#            theme(legend.position = "bottom",
#                  legend.direction = "horizontal"))
#
# library(GGally)
#
# exp2l1Post %>%
#   select(1:8)  %>%
#   ggpairs(ggplot2::aes(fill = cbbPalette[2],
#                        alpha = 0.5,
#                        size = 0.5))
#
# exp2l2Post <- posterior_samples(exp2l2, add_chain = TRUE)
#
# str(exp2l2Post)
#
# mcmc_trace(exp2l2Post[, c(1:8)],
#            size = 0.25 +
#            scale_color_manual(values = cbbPalette) +
#            theme(legend.position = "bottom",
#                  legend.direction = "horizontal"))
#
# # library(GGally)
#
# exp2l2Post %>%
#   select(1:8)  %>%
#   ggpairs(ggplot2::aes(fill = cbbPalette[2],
#                        alpha = 0.5,
#                        size = 0.5))
```

Model comparison.

```
# plot(conditional_effects(exp2l1,
#                          effects = "scDuration:scSpeed"), ask = FALSE)
# plot(conditional_effects(exp2l2,
#                          effects = "scDuration:scSpeed"), ask = FALSE)
#
# exp2l1Plot <- conditional_effects(exp2l1, "scDuration:scSpeed")
#
# exp2l1Plot <- conditional_effects(exp2l1, "scDuration:scSpeed")
#
# plot(exp2l1Plot,
#      plot = FALSE)[[1]] +
#   scale_color_manual(values = cbbPalette) +
#   scale_fill_manual(values = cbbPalette) +
#   scale_x_continuous(limits = c(-1.75, 1.75),
#                      breaks = seq(-1.5, 1.5, 0.5),
#                      name = "scaled Duration") +
#   scale_y_continuous(limits = c(0, 20),
#                      breaks = seq(0, 20, 5),
```

```r
#                       name = "Fitted Count \"Two\"") +
#   guides(colour = guide_legend(title = "scaled Rate"),
#          fill = FALSE) +
#   theme_bw() +
#   theme(axis.text=element_text(size=12),
#         axis.title=element_text(size=18),
#         plot.title=element_text(size=28),
#         strip.text=element_text(size=16),
#         strip.background=element_rect(colour="black", fill="white"),
#         legend.text=element_text(size=16),
#         legend.title=element_text(size=18),
#         legend.position = "bottom",
#         legend.direction = "horizontal")
#
# ggsave(file = "exp01Fitted.pdf",
#        device = "pdf")

exp2l2 <- add_criterion(exp2l2, c("waic", "loo"))
```

```
## Warning:
## 19 (0.2%) p_waic estimates greater than 0.4. We recommend trying loo instead.
```

```r
exp2l1 <- add_criterion(exp2l1, c("waic", "loo"))
```

```
## Warning:
## 17 (0.1%) p_waic estimates greater than 0.4. We recommend trying loo instead.
```

```r
exp2l2$waic; exp2l1$waic
```

```
## NULL

## NULL
```

```r
exp2l2$loo; exp2l1$loo
```

```
## NULL

## NULL
```

```r
l <- loo_compare(exp2l2, exp2l1, criterion = "loo")

print(l, simplify = FALSE)
```

```
##        elpd_diff se_diff elpd_loo se_elpd_loo p_loo   se_p_loo looic   se_looic
## exp2l2     0.0       0.0 -8412.5    106.6       109.3     4.5  16825.0   213.2
## exp2l1   -23.4       9.3 -8435.9    106.4        99.7     4.3  16871.8   212.7
```

```r
w <- loo_compare(exp2l2, exp2l1, criterion = "waic")

print(w, simplify = FALSE)
```

```
##        elpd_diff se_diff elpd_waic se_elpd_waic p_waic  se_p_waic waic
## exp2l2     0.0       0.0 -8412.3     106.6        109.1     4.5   16824.6
## exp2l1   -23.4       9.3 -8435.7     106.3         99.6     4.3   16871.5
##        se_waic
## exp2l2   213.2
## exp2l1   212.7
```

```r
summary(exp2l1)
```

```
##  Family: MV(bernoulli, bernoulli)
##   Links: mu = logit
##          mu = logit
## Formula: ncRsp ~ scVDuration + scTDuration + scSpeed + (1 | q | subject) + (0 + scVDuration | q | sub
##          nsRsp ~ scVDuration + scTDuration + scSpeed + (1 | q | subject) + (0 + scVDuration | q | sub
##    Data: exp2l (Number of observations: 12503)
## Samples: 4 chains, each with iter = 4000; warmup = 1000; thin = 1;
##          total post-warmup samples = 12000
##
## Group-Level Effects:
## ~subject (Number of levels: 12)
##                                          Estimate Est.Error l-95% CI u-95% CI
## sd(ncRsp_Intercept)                          1.28      0.30     0.83     2.00
## sd(ncRsp_scVDuration)                        0.13      0.07     0.01     0.27
## sd(ncRsp_scTDuration)                        2.78      0.60     1.85     4.18
## sd(ncRsp_scSpeed)                            0.25      0.08     0.13     0.44
## sd(nsRsp_Intercept)                          0.30      0.08     0.18     0.49
## sd(nsRsp_scVDuration)                        1.24      0.27     0.82     1.88
## sd(nsRsp_scTDuration)                        0.41      0.10     0.26     0.66
## sd(nsRsp_scSpeed)                            0.31      0.08     0.20     0.49
## cor(ncRsp_Intercept,ncRsp_scVDuration)       0.18      0.29    -0.43     0.69
## cor(ncRsp_Intercept,ncRsp_scTDuration)       0.21      0.22    -0.25     0.60
## cor(ncRsp_scVDuration,ncRsp_scTDuration)    -0.30      0.28    -0.77     0.30
## cor(ncRsp_Intercept,ncRsp_scSpeed)          -0.32      0.24    -0.73     0.21
## cor(ncRsp_scVDuration,ncRsp_scSpeed)        -0.02      0.30    -0.57     0.56
## cor(ncRsp_scTDuration,ncRsp_scSpeed)         0.17      0.24    -0.33     0.61
## cor(ncRsp_Intercept,nsRsp_Intercept)        -0.31      0.22    -0.70     0.16
## cor(ncRsp_scVDuration,nsRsp_Intercept)       0.12      0.29    -0.45     0.64
## cor(ncRsp_scTDuration,nsRsp_Intercept)      -0.46      0.21    -0.80     0.01
## cor(ncRsp_scSpeed,nsRsp_Intercept)          -0.03      0.26    -0.51     0.48
## cor(ncRsp_Intercept,nsRsp_scVDuration)      -0.18      0.21    -0.57     0.26
## cor(ncRsp_scVDuration,nsRsp_scVDuration)    -0.21      0.27    -0.69     0.35
## cor(ncRsp_scTDuration,nsRsp_scVDuration)     0.27      0.21    -0.17     0.63
## cor(ncRsp_scSpeed,nsRsp_scVDuration)         0.17      0.23    -0.31     0.60
## cor(nsRsp_Intercept,nsRsp_scVDuration)      -0.08      0.23    -0.51     0.37
## cor(ncRsp_Intercept,nsRsp_scTDuration)      -0.33      0.22    -0.70     0.15
## cor(ncRsp_scVDuration,nsRsp_scTDuration)     0.11      0.28    -0.46     0.64
## cor(ncRsp_scTDuration,nsRsp_scTDuration)    -0.16      0.22    -0.57     0.29
## cor(ncRsp_scSpeed,nsRsp_scTDuration)         0.24      0.24    -0.27     0.67
## cor(nsRsp_Intercept,nsRsp_scTDuration)      -0.05      0.24    -0.51     0.41
## cor(nsRsp_scVDuration,nsRsp_scTDuration)    -0.22      0.22    -0.62     0.23
## cor(ncRsp_Intercept,nsRsp_scSpeed)           0.06      0.23    -0.39     0.48
## cor(ncRsp_scVDuration,nsRsp_scSpeed)        -0.04      0.27    -0.56     0.50
## cor(ncRsp_scTDuration,nsRsp_scSpeed)         0.07      0.22    -0.37     0.49
## cor(ncRsp_scSpeed,nsRsp_scSpeed)            -0.17      0.24    -0.60     0.32
## cor(nsRsp_Intercept,nsRsp_scSpeed)          -0.13      0.23    -0.56     0.33
## cor(nsRsp_scVDuration,nsRsp_scSpeed)         0.62      0.18     0.19     0.88
## cor(nsRsp_scTDuration,nsRsp_scSpeed)        -0.36      0.22    -0.74     0.12
##                                          Rhat Bulk_ESS Tail_ESS
## sd(ncRsp_Intercept)                      1.00     5941     7610
## sd(ncRsp_scVDuration)                    1.00     3514     3181
## sd(ncRsp_scTDuration)                    1.00     6461     8351
```

```
## sd(ncRsp_scSpeed)                        1.00     6848     8600
## sd(nsRsp_Intercept)                      1.00     8139     8759
## sd(nsRsp_scVDuration)                    1.00     7786     8321
## sd(nsRsp_scTDuration)                    1.00     8222     8721
## sd(nsRsp_scSpeed)                        1.00     7948     9444
## cor(ncRsp_Intercept,ncRsp_scVDuration)   1.00    14228     9444
## cor(ncRsp_Intercept,ncRsp_scTDuration)   1.00     9922     8709
## cor(ncRsp_scVDuration,ncRsp_scTDuration) 1.00     4824     4925
## cor(ncRsp_Intercept,ncRsp_scSpeed)       1.00    12912     9355
## cor(ncRsp_scVDuration,ncRsp_scSpeed)     1.00     6536     8562
## cor(ncRsp_scTDuration,ncRsp_scSpeed)     1.00    12533     9783
## cor(ncRsp_Intercept,nsRsp_Intercept)     1.00    10971     9838
## cor(ncRsp_scVDuration,nsRsp_Intercept)   1.00     5947     7265
## cor(ncRsp_scTDuration,nsRsp_Intercept)   1.00    10446     9492
## cor(ncRsp_scSpeed,nsRsp_Intercept)       1.00    10048    10054
## cor(ncRsp_Intercept,nsRsp_scVDuration)   1.00    10189     9207
## cor(ncRsp_scVDuration,nsRsp_scVDuration) 1.00     4470     6195
## cor(ncRsp_scTDuration,nsRsp_scVDuration) 1.00    11291    10113
## cor(ncRsp_scSpeed,nsRsp_scVDuration)     1.00     9281     9098
## cor(nsRsp_Intercept,nsRsp_scVDuration)   1.00    10165    10062
## cor(ncRsp_Intercept,nsRsp_scTDuration)   1.00    11888     9558
## cor(ncRsp_scVDuration,nsRsp_scTDuration) 1.00     5914     7414
## cor(ncRsp_scTDuration,nsRsp_scTDuration) 1.00    12068     9395
## cor(ncRsp_scSpeed,nsRsp_scTDuration)     1.00    10941    10489
## cor(nsRsp_Intercept,nsRsp_scTDuration)   1.00    10106    10571
## cor(nsRsp_scVDuration,nsRsp_scTDuration) 1.00    11737     9989
## cor(ncRsp_Intercept,nsRsp_scSpeed)       1.00    11768     9794
## cor(ncRsp_scVDuration,nsRsp_scSpeed)     1.00     5058     6894
## cor(ncRsp_scTDuration,nsRsp_scSpeed)     1.00    11821     9608
## cor(ncRsp_scSpeed,nsRsp_scSpeed)         1.00    10234    10703
## cor(nsRsp_Intercept,nsRsp_scSpeed)       1.00    10477    10340
## cor(nsRsp_scVDuration,nsRsp_scSpeed)     1.00    10494     9919
## cor(nsRsp_scTDuration,nsRsp_scSpeed)     1.00    11890    11214
##
## Population-Level Effects:
##                    Estimate Est.Error l-95% CI u-95% CI Rhat Bulk_ESS Tail_ESS
## ncRsp_Intercept        1.16      0.38     0.38     1.91 1.00     3154     5187
## nsRsp_Intercept       -0.26      0.09    -0.44    -0.07 1.00     6806     7821
## ncRsp_scVDuration     -0.12      0.05    -0.24    -0.02 1.00     7704     8375
## ncRsp_scTDuration      4.24      0.83     2.60     5.89 1.00     5670     6973
## ncRsp_scSpeed         -0.09      0.08    -0.27     0.08 1.00     6944     7404
## nsRsp_scVDuration      2.72      0.37     2.00     3.47 1.00     5807     7727
## nsRsp_scTDuration     -0.51      0.12    -0.75    -0.27 1.00     6405     7840
## nsRsp_scSpeed          0.83      0.10     0.65     1.03 1.00     7037     7406
##
## Samples were drawn 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).
```

```r
summary(exp2l2)
```

```
##  Family: MV(bernoulli, bernoulli)
##   Links: mu = logit
##          mu = logit
## Formula: ncRsp ~ scVDuration * scTDuration * scSpeed + (1 | q | subject) + (0 + scVDuration | q | su
```

```
##          nsRsp ~ scVDuration * scTDuration * scSpeed + (1 | q | subject) + (0 + scVDuration | q | sub
##    Data: exp2l (Number of observations: 12503)
## Samples: 4 chains, each with iter = 4000; warmup = 1000; thin = 1;
##          total post-warmup samples = 12000
##
## Group-Level Effects:
## ~subject (Number of levels: 12)
##                                          Estimate Est.Error l-95% CI u-95% CI
## sd(ncRsp_Intercept)                          1.27      0.29     0.82     1.97
## sd(ncRsp_scVDuration)                        0.11      0.06     0.01     0.26
## sd(ncRsp_scTDuration)                        2.78      0.61     1.85     4.19
## sd(ncRsp_scSpeed)                            0.28      0.09     0.16     0.49
## sd(nsRsp_Intercept)                          0.31      0.08     0.19     0.51
## sd(nsRsp_scVDuration)                        1.25      0.28     0.82     1.90
## sd(nsRsp_scTDuration)                        0.41      0.10     0.26     0.65
## sd(nsRsp_scSpeed)                            0.31      0.08     0.20     0.49
## cor(ncRsp_Intercept,ncRsp_scVDuration)       0.13      0.30    -0.48     0.66
## cor(ncRsp_Intercept,ncRsp_scTDuration)       0.20      0.22    -0.25     0.59
## cor(ncRsp_scVDuration,ncRsp_scTDuration)    -0.30      0.29    -0.77     0.32
## cor(ncRsp_Intercept,ncRsp_scSpeed)          -0.38      0.23    -0.77     0.11
## cor(ncRsp_scVDuration,ncRsp_scSpeed)        -0.00      0.30    -0.57     0.57
## cor(ncRsp_scTDuration,ncRsp_scSpeed)         0.19      0.24    -0.29     0.61
## cor(ncRsp_Intercept,nsRsp_Intercept)        -0.34      0.22    -0.72     0.13
## cor(ncRsp_scVDuration,nsRsp_Intercept)       0.12      0.29    -0.47     0.66
## cor(ncRsp_scTDuration,nsRsp_Intercept)      -0.47      0.22    -0.81     0.02
## cor(ncRsp_scSpeed,nsRsp_Intercept)          -0.01      0.25    -0.50     0.47
## cor(ncRsp_Intercept,nsRsp_scVDuration)      -0.18      0.21    -0.57     0.27
## cor(ncRsp_scVDuration,nsRsp_scVDuration)    -0.19      0.28    -0.68     0.39
## cor(ncRsp_scTDuration,nsRsp_scVDuration)     0.27      0.21    -0.16     0.64
## cor(ncRsp_scSpeed,nsRsp_scVDuration)         0.18      0.23    -0.29     0.60
## cor(nsRsp_Intercept,nsRsp_scVDuration)      -0.06      0.23    -0.48     0.39
## cor(ncRsp_Intercept,nsRsp_scTDuration)      -0.34      0.22    -0.71     0.13
## cor(ncRsp_scVDuration,nsRsp_scTDuration)     0.13      0.29    -0.45     0.65
## cor(ncRsp_scTDuration,nsRsp_scTDuration)    -0.17      0.22    -0.57     0.27
## cor(ncRsp_scSpeed,nsRsp_scTDuration)         0.25      0.24    -0.24     0.67
## cor(nsRsp_Intercept,nsRsp_scTDuration)       0.00      0.24    -0.47     0.47
## cor(nsRsp_scVDuration,nsRsp_scTDuration)    -0.21      0.23    -0.61     0.25
## cor(ncRsp_Intercept,nsRsp_scSpeed)           0.07      0.22    -0.38     0.49
## cor(ncRsp_scVDuration,nsRsp_scSpeed)        -0.05      0.28    -0.57     0.49
## cor(ncRsp_scTDuration,nsRsp_scSpeed)         0.08      0.22    -0.36     0.49
## cor(ncRsp_scSpeed,nsRsp_scSpeed)            -0.17      0.24    -0.60     0.32
## cor(nsRsp_Intercept,nsRsp_scSpeed)          -0.15      0.23    -0.57     0.32
## cor(nsRsp_scVDuration,nsRsp_scSpeed)         0.61      0.19     0.17     0.88
## cor(nsRsp_scTDuration,nsRsp_scSpeed)        -0.36      0.22    -0.73     0.13
##                                          Rhat Bulk_ESS Tail_ESS
## sd(ncRsp_Intercept)                      1.00     5524     7415
## sd(ncRsp_scVDuration)                    1.00     2892     3097
## sd(ncRsp_scTDuration)                    1.00     5804     7755
## sd(ncRsp_scSpeed)                        1.00     7353     9518
## sd(nsRsp_Intercept)                      1.00     7380     8083
## sd(nsRsp_scVDuration)                    1.00     6349     7949
## sd(nsRsp_scTDuration)                    1.00     7826     8879
## sd(nsRsp_scSpeed)                        1.00     7513     8485
## cor(ncRsp_Intercept,ncRsp_scVDuration)   1.00    14551     9044
```

```
## cor(ncRsp_Intercept,ncRsp_scTDuration)   1.00     8976     8943
## cor(ncRsp_scVDuration,ncRsp_scTDuration) 1.00     3355     4748
## cor(ncRsp_Intercept,ncRsp_scSpeed)       1.00    10874     9930
## cor(ncRsp_scVDuration,ncRsp_scSpeed)     1.00     5610     8148
## cor(ncRsp_scTDuration,ncRsp_scSpeed)     1.00    11573    10461
## cor(ncRsp_Intercept,nsRsp_Intercept)     1.00     9931     9233
## cor(ncRsp_scVDuration,nsRsp_Intercept)   1.00     5166     6364
## cor(ncRsp_scTDuration,nsRsp_Intercept)   1.00     9366     9541
## cor(ncRsp_scSpeed,nsRsp_Intercept)       1.00    10510    10474
## cor(ncRsp_Intercept,nsRsp_scVDuration)   1.00     9028     8416
## cor(ncRsp_scVDuration,nsRsp_scVDuration) 1.00     3604     5292
## cor(ncRsp_scTDuration,nsRsp_scVDuration) 1.00    10428     9220
## cor(ncRsp_scSpeed,nsRsp_scVDuration)     1.00     9607     8858
## cor(nsRsp_Intercept,nsRsp_scVDuration)   1.00     9622    10062
## cor(ncRsp_Intercept,nsRsp_scTDuration)   1.00     9767     8592
## cor(ncRsp_scVDuration,nsRsp_scTDuration) 1.00     4703     6078
## cor(ncRsp_scTDuration,nsRsp_scTDuration) 1.00    10619     9763
## cor(ncRsp_scSpeed,nsRsp_scTDuration)     1.00     9264    10194
## cor(nsRsp_Intercept,nsRsp_scTDuration)   1.00    10606    10258
## cor(nsRsp_scVDuration,nsRsp_scTDuration) 1.00     9931     9336
## cor(ncRsp_Intercept,nsRsp_scSpeed)       1.00    10338     8431
## cor(ncRsp_scVDuration,nsRsp_scSpeed)     1.00     4499     6753
## cor(ncRsp_scTDuration,nsRsp_scSpeed)     1.00    11530     9538
## cor(ncRsp_scSpeed,nsRsp_scSpeed)         1.00     9478     9657
## cor(nsRsp_Intercept,nsRsp_scSpeed)       1.00     9392    10346
## cor(nsRsp_scVDuration,nsRsp_scSpeed)     1.00    10047    10073
## cor(nsRsp_scTDuration,nsRsp_scSpeed)     1.00    11345    10256
##
## Population-Level Effects:
##                                       Estimate Est.Error l-95% CI u-95% CI Rhat
## ncRsp_Intercept                           1.17      0.37     0.42     1.90 1.00
## nsRsp_Intercept                          -0.29      0.10    -0.48    -0.09 1.00
## ncRsp_scVDuration                        -0.15      0.05    -0.26    -0.05 1.00
## ncRsp_scTDuration                         4.24      0.83     2.59     5.91 1.00
## ncRsp_scSpeed                            -0.15      0.09    -0.34     0.04 1.00
## ncRsp_scVDuration:scTDuration            -0.10      0.05    -0.20    -0.00 1.00
## ncRsp_scVDuration:scSpeed                -0.01      0.03    -0.07     0.06 1.00
## ncRsp_scTDuration:scSpeed                -0.22      0.05    -0.32    -0.12 1.00
## ncRsp_scVDuration:scTDuration:scSpeed     0.12      0.05     0.03     0.22 1.00
## nsRsp_scVDuration                         2.73      0.37     2.00     3.47 1.00
## nsRsp_scTDuration                        -0.53      0.12    -0.77    -0.28 1.00
## nsRsp_scSpeed                             0.84      0.10     0.66     1.03 1.00
## nsRsp_scVDuration:scTDuration             0.22      0.04     0.14     0.30 1.00
## nsRsp_scVDuration:scSpeed                -0.06      0.04    -0.14     0.02 1.00
## nsRsp_scTDuration:scSpeed                 0.05      0.03    -0.00     0.11 1.00
## nsRsp_scVDuration:scTDuration:scSpeed    -0.01      0.04    -0.09     0.06 1.00
##                                       Bulk_ESS Tail_ESS
## ncRsp_Intercept                           2801     4491
## nsRsp_Intercept                           5859     7113
## ncRsp_scVDuration                         6528     7129
## ncRsp_scTDuration                         4735     6342
## ncRsp_scSpeed                             5601     7303
## ncRsp_scVDuration:scTDuration            18920     9172
## ncRsp_scVDuration:scSpeed                18998     9739
```

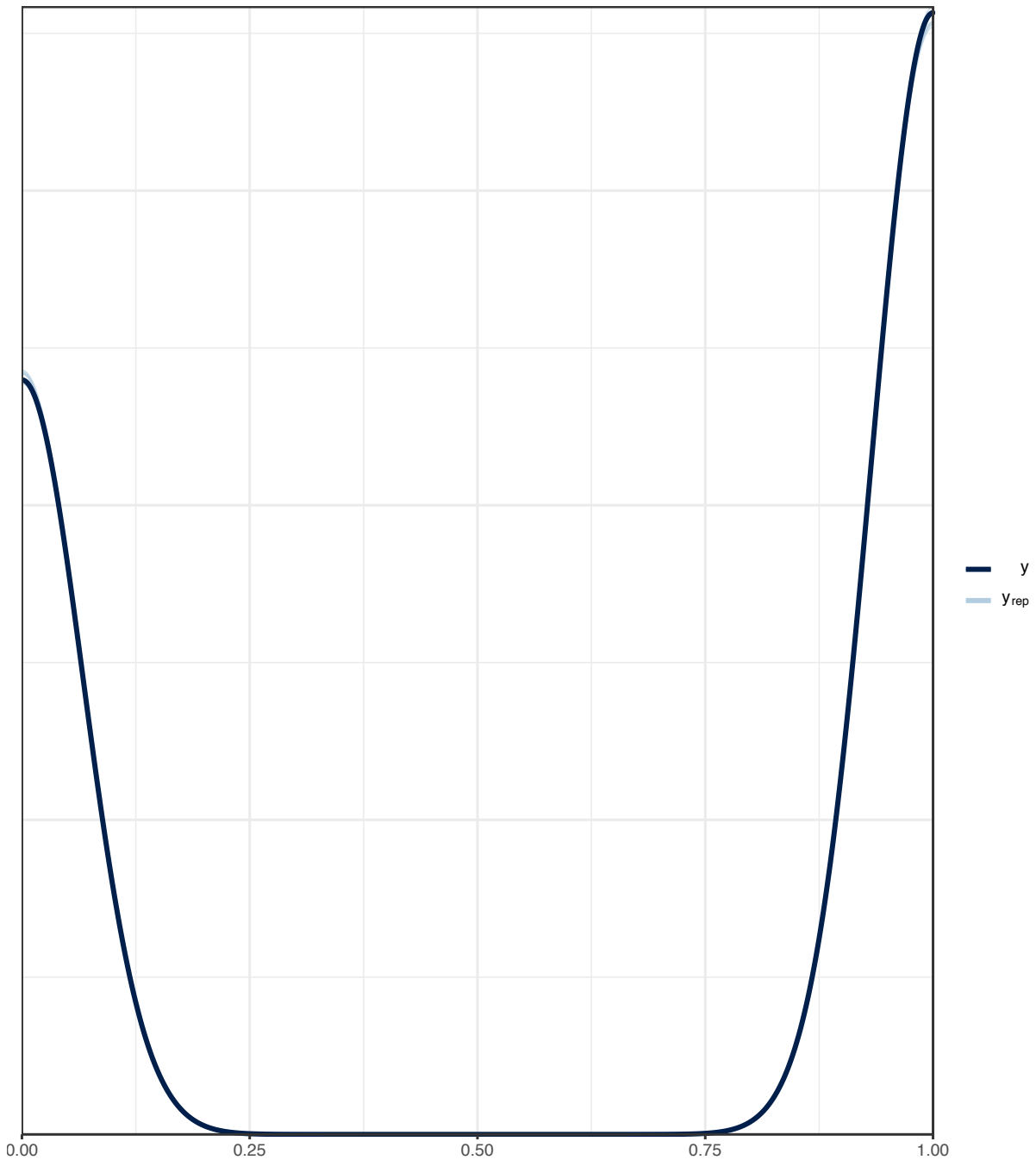
```
## ncRsp_scTDuration:scSpeed                18930     8721
## ncRsp_scVDuration:scTDuration:scSpeed    18633     9311
## nsRsp_scVDuration                         5869     7471
## nsRsp_scTDuration                         6601     7547
## nsRsp_scSpeed                             7086     7919
## nsRsp_scVDuration:scTDuration            21288     8969
## nsRsp_scVDuration:scSpeed                22476     9582
## nsRsp_scTDuration:scSpeed                19316     8996
## nsRsp_scVDuration:scTDuration:scSpeed    20251     9213
##
## Samples were drawn 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).
```

```
# cbind(waic_diff = w[, 1] * -2,
#       se = w[, 2] * 2) %>%
#   round(digits = 2)
#
# library(ggthemes)
# library(bayesplot)
#
# theme_set(theme_default()+
#             theme_tufte())
#
# w %>%
#   data.frame() %>%
#   rownames_to_column(var = "model") %>%
#
#   ggplot() +
#   geom_pointrange(aes(x = reorder(model, -waic), y = waic,
#                       ymin = waic - se_waic,
#                       ymax = waic + se_waic,
#                       color = model),
#                   shape = 16) +
#   scale_color_manual(values = cbbPalette) +
#   coord_flip() +
#   labs(x = NULL, y = NULL,
#        title = "WAIC") +
#   theme(axis.ticks.y    = element_blank(),
#         legend.position = "none")
```

Posterior predictive check.

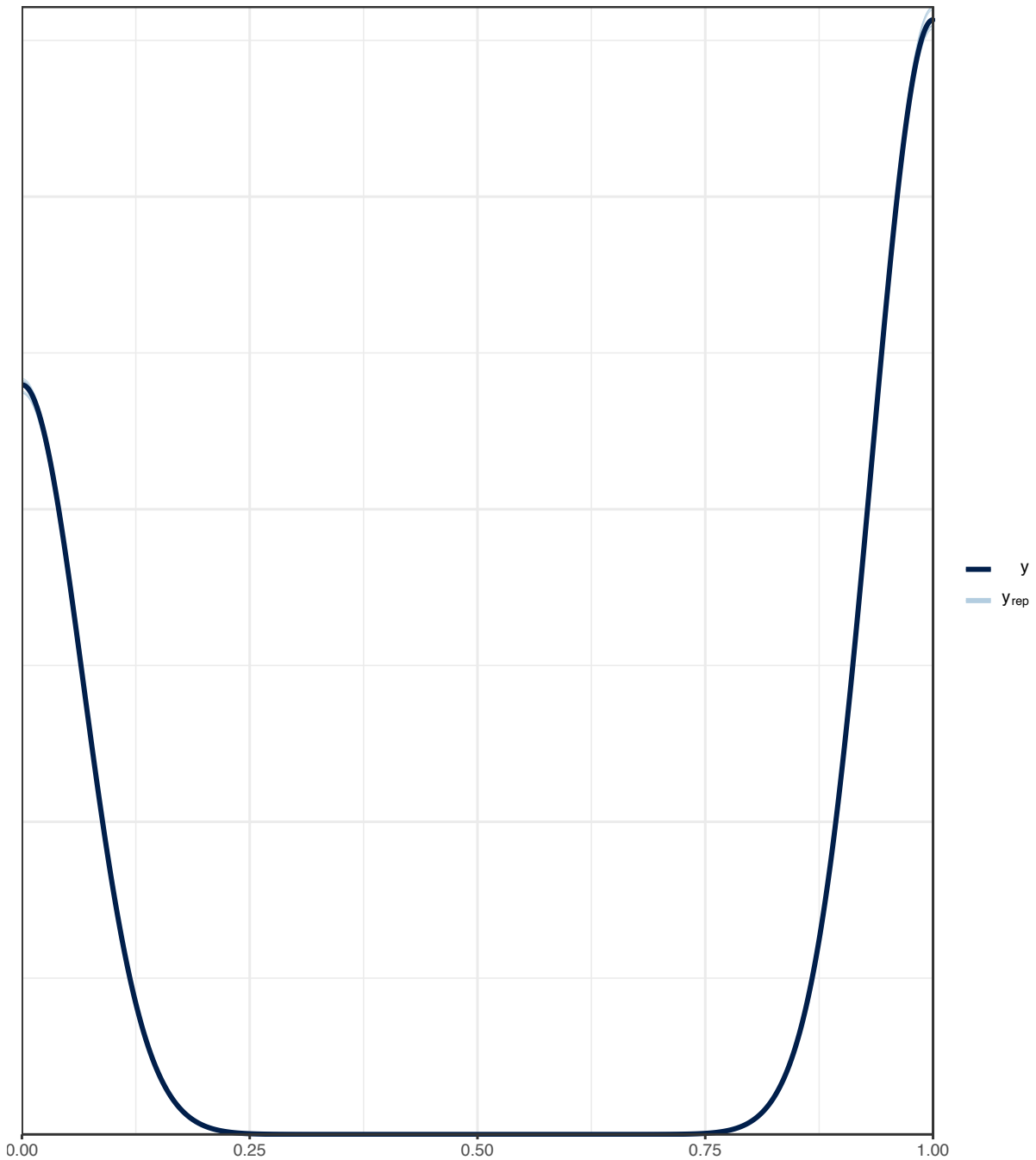
```
pp_check(exp2l1, resp = "ncRsp")
```

```
## Using 10 posterior samples for ppc type 'dens_overlay' by default.
```



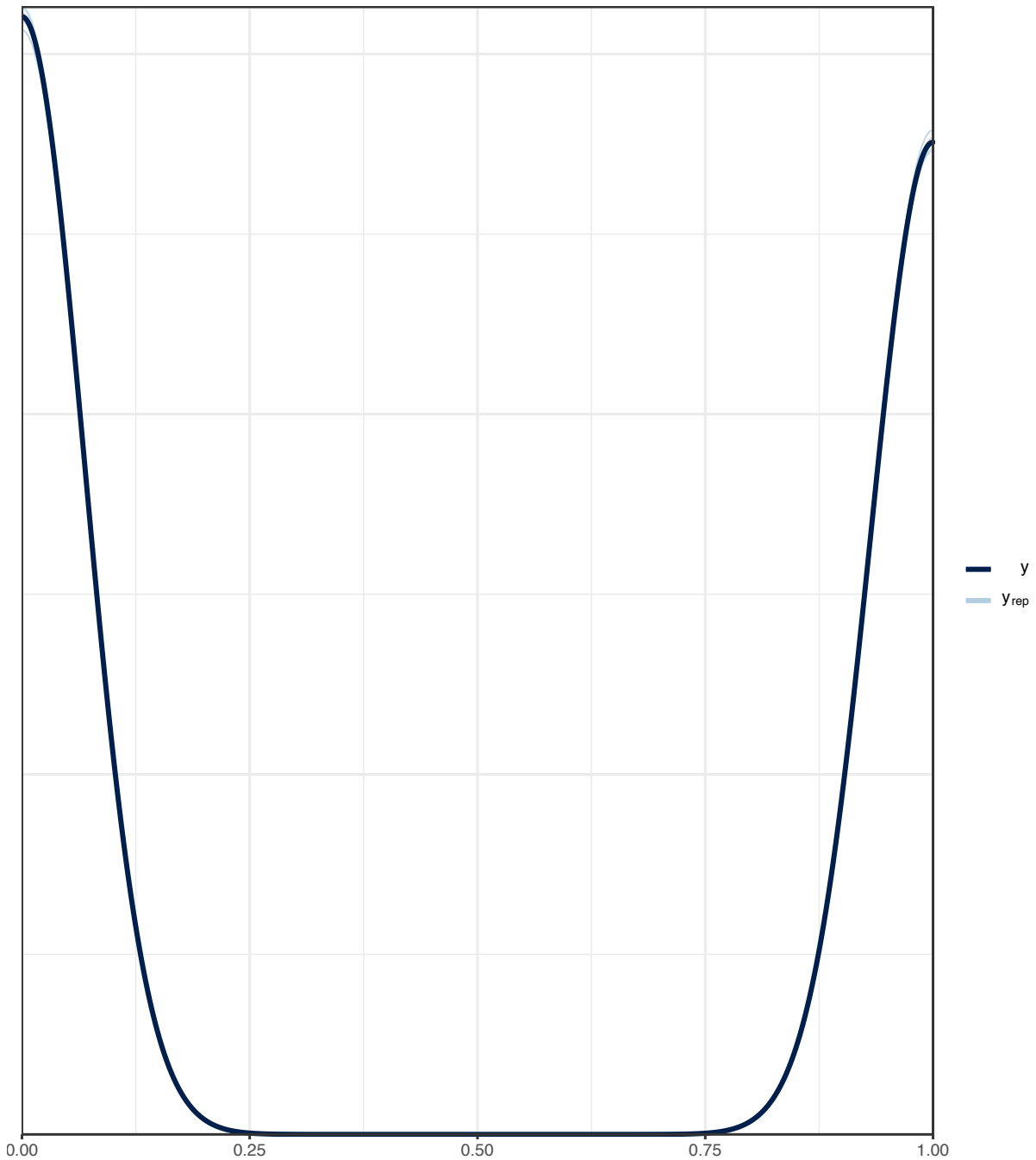

```
pp_check(exp212, resp = "ncRsp")
```

```
## Using 10 posterior samples for ppc type 'dens_overlay' by default.
```



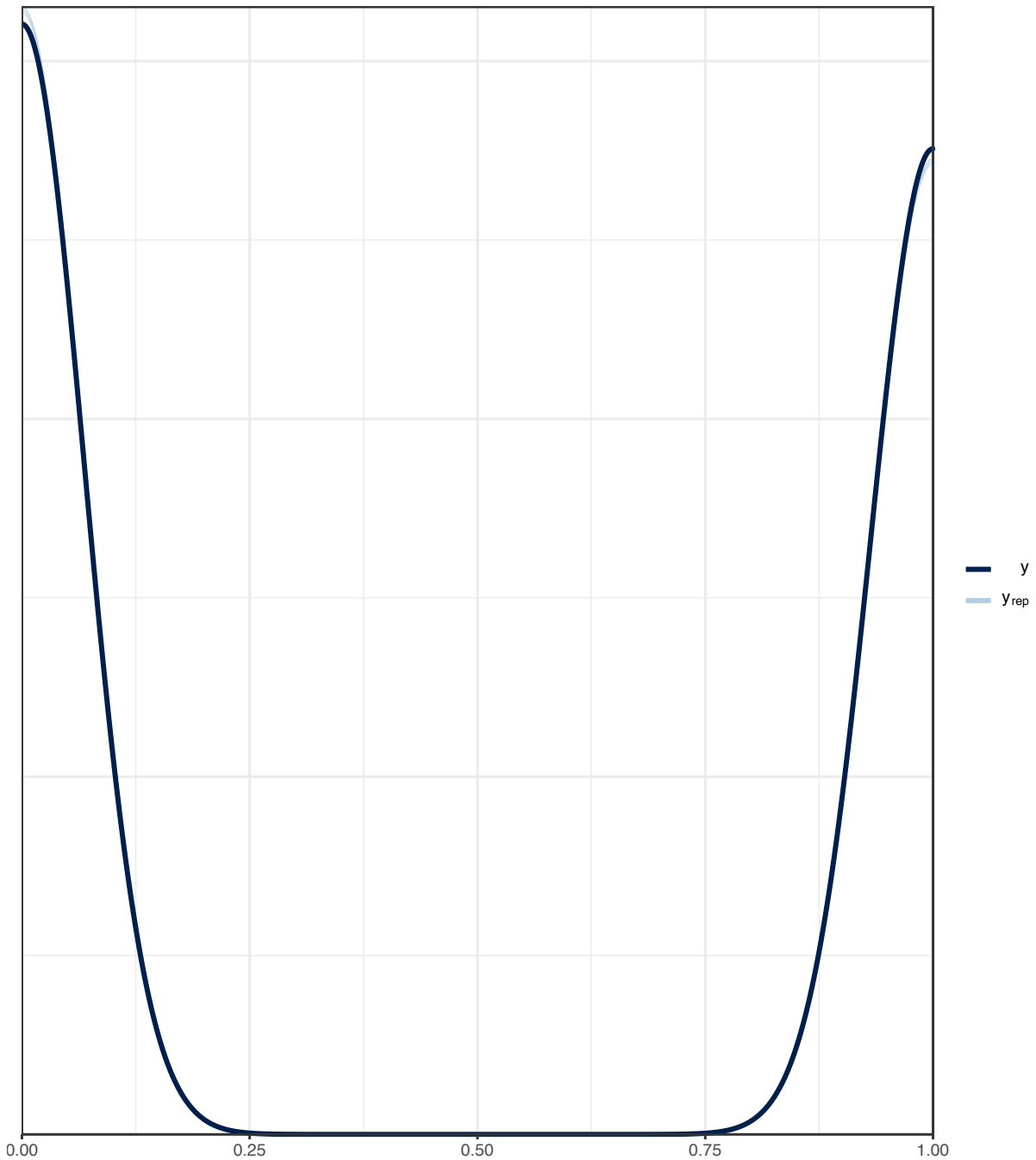

```
pp_check(exp2l1, resp = "nsRsp")
```

```
## Using 10 posterior samples for ppc type 'dens_overlay' by default.
```

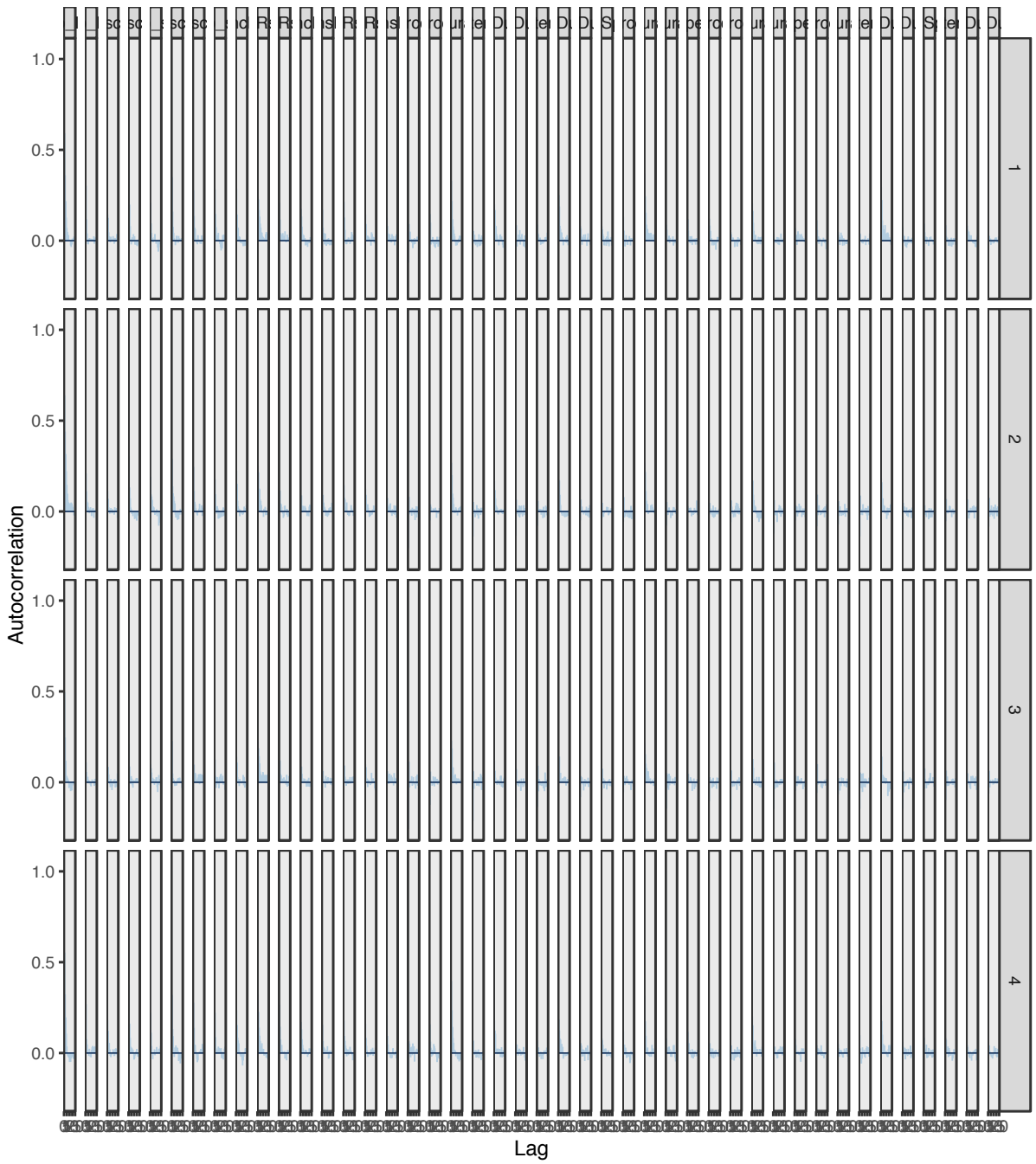



```r
pp_check(exp212, resp = "nsRsp")
```

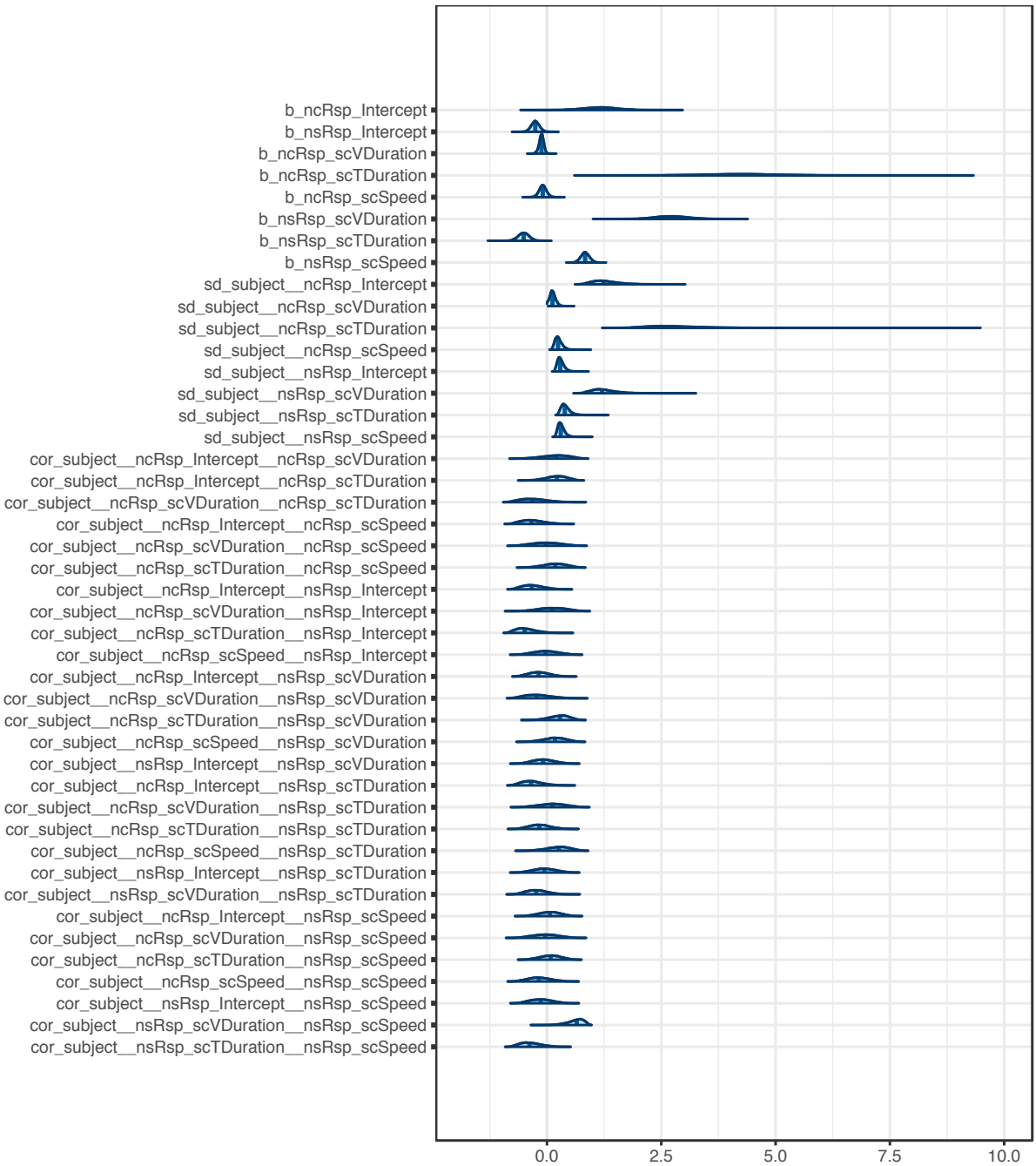
```
## Using 10 posterior samples for ppc type 'dens_overlay' by default.
```



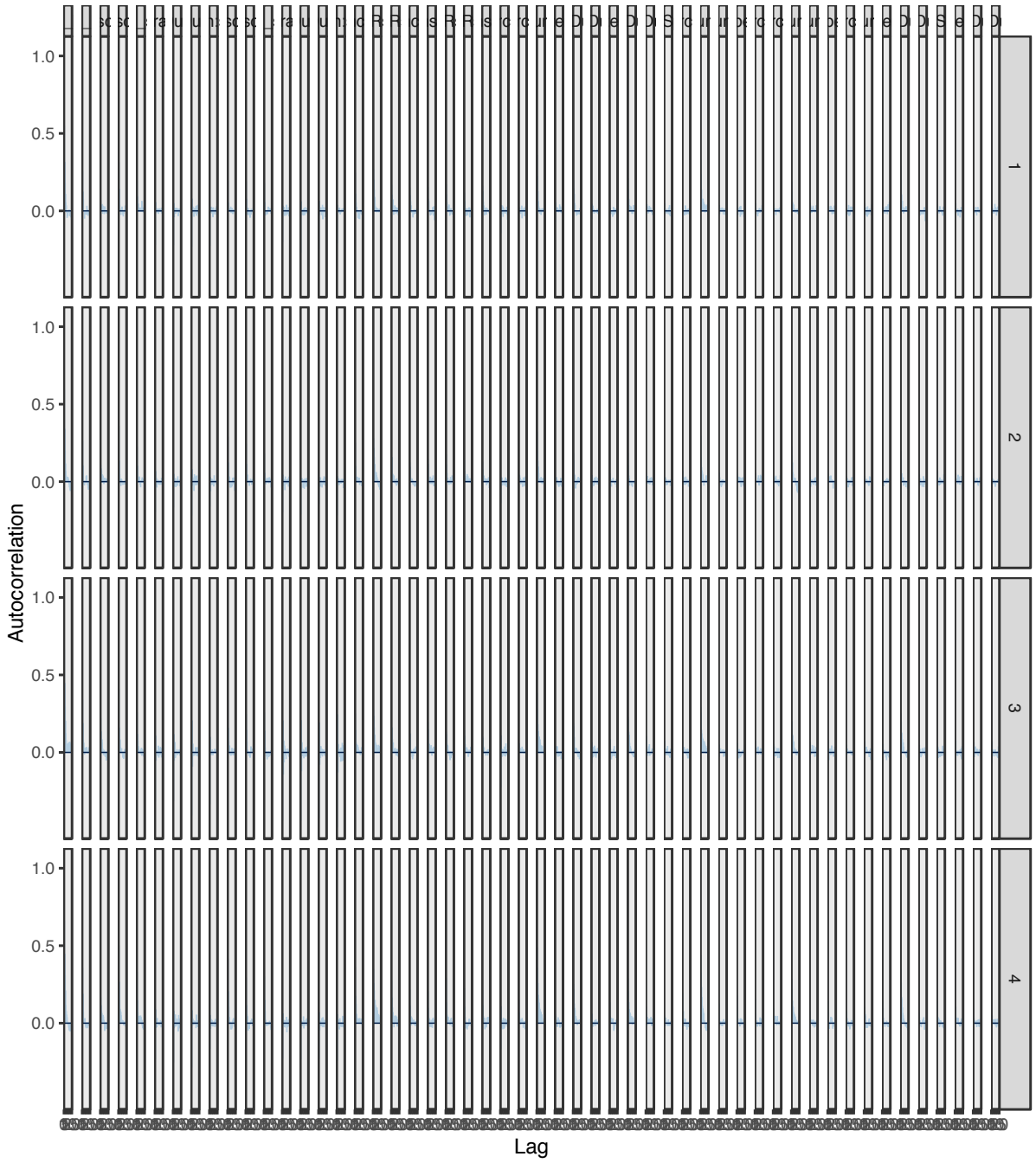

```r
mcmc_plot(exp211,
          type = "acf_bar")
```



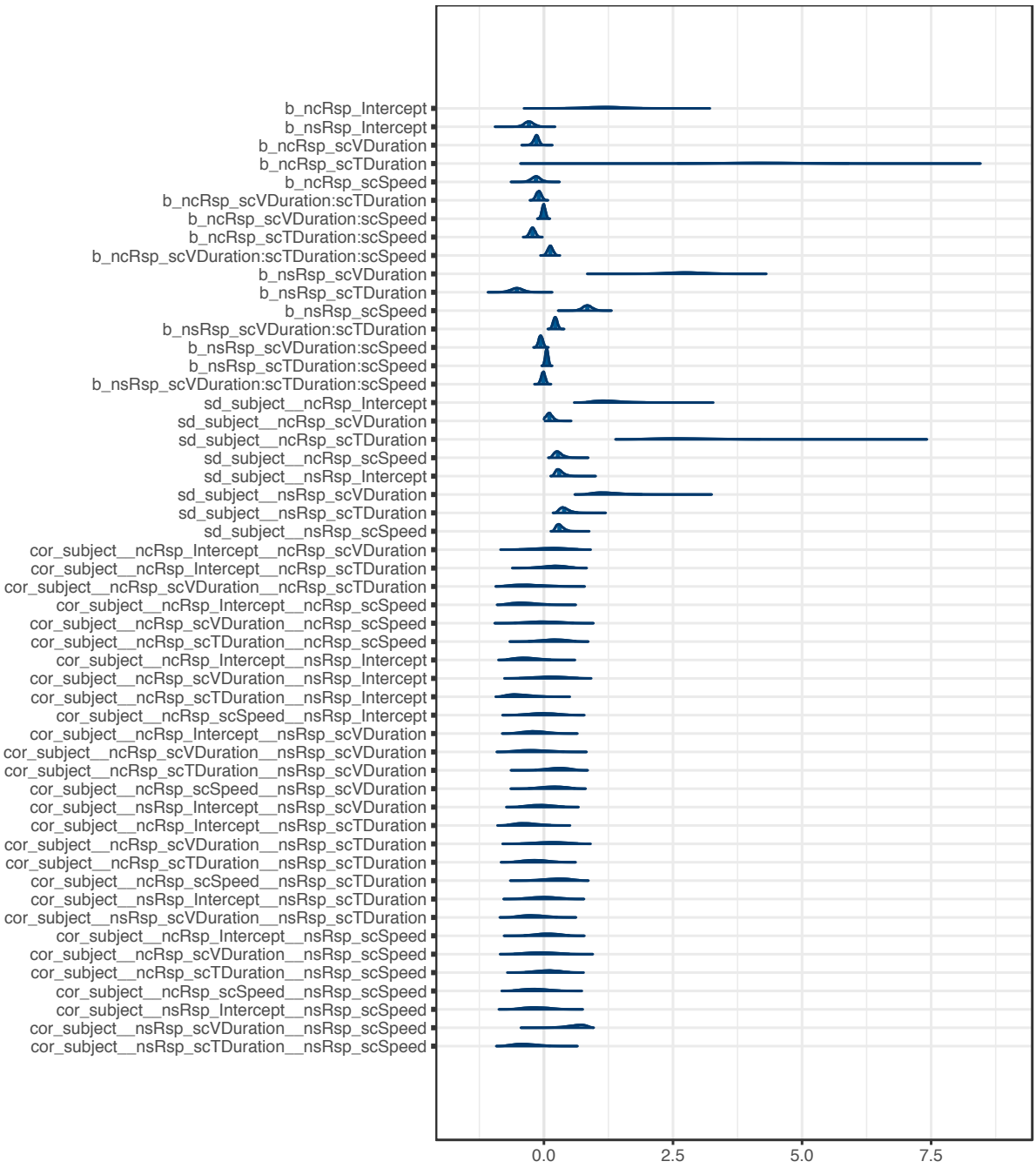

```
mcmc_plot(exp211,
          type = "areas",
          prob = 0.95)
```




```
mcmc_plot(exp212,
          type = "acf_bar")
```




```
mcmc_plot(exp212,
          type = "areas",
          prob = 0.95)
```


b_ncRsp_Intercept
b_nsRsp_Intercept
b_ncRsp_scVDuration
b_ncRsp_scTDuration
b_ncRsp_scSpeed
b_ncRsp_scVDuration:scTDuration
b_ncRsp_scVDuration:scSpeed
b_ncRsp_scTDuration:scSpeed
b_ncRsp_scVDuration:scTDuration:scSpeed
b_nsRsp_scVDuration
b_nsRsp_scTDuration
b_nsRsp_scSpeed
b_nsRsp_scVDuration:scTDuration
b_nsRsp_scVDuration:scSpeed
b_nsRsp_scTDuration:scSpeed
b_nsRsp_scVDuration:scTDuration:scSpeed
sd_subject__ncRsp_Intercept
sd_subject__ncRsp_scVDuration
sd_subject__ncRsp_scTDuration
sd_subject__ncRsp_scSpeed
sd_subject__nsRsp_Intercept
sd_subject__nsRsp_scVDuration
sd_subject__nsRsp_scTDuration
sd_subject__nsRsp_scSpeed
cor_subject__ncRsp_Intercept__ncRsp_scVDuration
cor_subject__ncRsp_Intercept__ncRsp_scTDuration
cor_subject__ncRsp_scVDuration__ncRsp_scTDuration
cor_subject__ncRsp_Intercept__ncRsp_scSpeed
cor_subject__ncRsp_scVDuration__ncRsp_scSpeed
cor_subject__ncRsp_scTDuration__ncRsp_scSpeed
cor_subject__ncRsp_Intercept__nsRsp_Intercept
cor_subject__ncRsp_scVDuration__nsRsp_Intercept
cor_subject__ncRsp_scTDuration__nsRsp_Intercept
cor_subject__ncRsp_scSpeed__nsRsp_Intercept
cor_subject__ncRsp_Intercept__nsRsp_scVDuration
cor_subject__ncRsp_scVDuration__nsRsp_scVDuration
cor_subject__ncRsp_scTDuration__nsRsp_scVDuration
cor_subject__ncRsp_scSpeed__nsRsp_scVDuration
cor_subject__nsRsp_Intercept__nsRsp_scVDuration
cor_subject__ncRsp_Intercept__nsRsp_scTDuration
cor_subject__ncRsp_scVDuration__nsRsp_scTDuration
cor_subject__ncRsp_scTDuration__nsRsp_scTDuration
cor_subject__ncRsp_scSpeed__nsRsp_scTDuration
cor_subject__nsRsp_Intercept__nsRsp_scTDuration
cor_subject__nsRsp_scVDuration__nsRsp_scTDuration
cor_subject__ncRsp_Intercept__nsRsp_scSpeed
cor_subject__ncRsp_scVDuration__nsRsp_scSpeed
cor_subject__ncRsp_scTDuration__nsRsp_scSpeed
cor_subject__ncRsp_scSpeed__nsRsp_scSpeed
cor_subject__nsRsp_Intercept__nsRsp_scSpeed
cor_subject__nsRsp_scVDuration__nsRsp_scSpeed
cor_subject__nsRsp_scTDuration__nsRsp_scSpeed
0.0
2.5
5.0
7.5