

MCMC examples

```
library(MCMCglmm)
library(brms)
library(rstanarm)
library(lme4)
options(brms.backend = "cmdstanr")
library(broom.mixed)
library(purrr)
library(dplyr)
library(tidybayes)
library(bayesplot)
library(bayestestR)
library(ggplot2); theme_set(theme_bw())
library(shinystan)
library(tidyverse)
```

- a little more on priors:

– parameter-expanded priors: $y_j | \mu, \xi_j \sim N(\mu + \alpha \sigma_j, \sigma_j^2)$, $\sigma_j \sim N(0, \sigma_\xi^2)$;
 $\alpha \sim N(\alpha_0, \sigma_\alpha)$, $\sigma_\alpha \sim \text{inverse-Gamma}(\nu)$

```
df(v/alpha.V, df1 = 1, df2 = nu, ncp = (alpha.mu^2)/alpha.V)
2 * dt(sqrt(v)/sqrt(alpha.V), df = nu, ncp = alpha.mu/sqrt(alpha.V))
```

... always set `alpha.mu=0`, can set `V = 1` (or `diag()` in more complex cases) wlog;
`sqrt(alpha.V)` (scale) and `nu` are the only relevant parameters

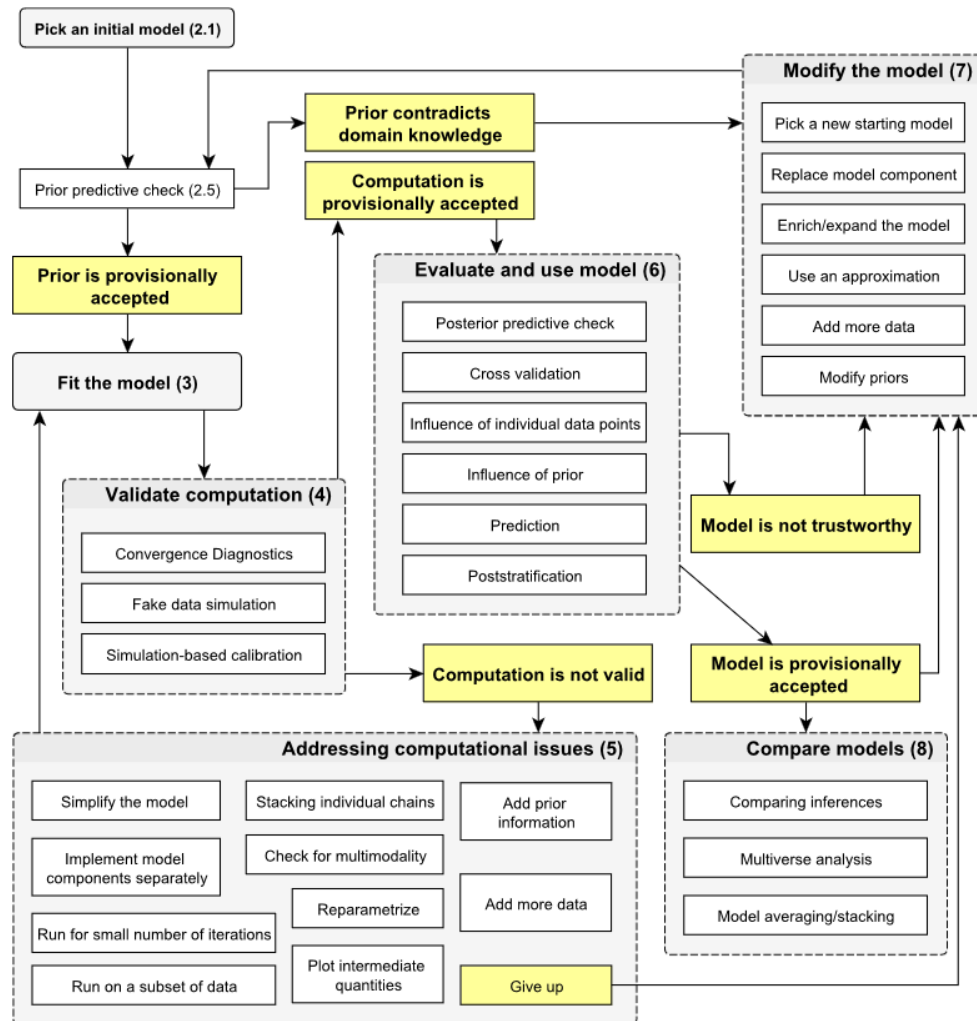
effective sample size

- number of samples, corrected for autocorrelation
- ESS may be > sample size! (e.g. *antithetic sampling*)

- efficiency of a sampler is not (samples/time), but (effective samples/time)
- effective sample size >1000 for both tail and bulk quantities (Vehtari et al. 2021)

Bayesian workflow

Gelman et al. (2020)



simulation-based calibration

Talts et al. (2020)

default priors/prior predictive simulations:

- rstanarm default priors: <https://cran.r-project.org/web/packages/rstanarm/vignettes/priors.html>

Using the good old `sleepstudy` example:

```
priorpred <- stan_lmer(Reaction ~ Days + (Days|Subject),  
                      prior_PD = TRUE, data = sleepstudy, chains = 1,  
                      refresh = 0)  
  
prior_summary(priorpred)
```

Priors for model 'priorpred'

Intercept (after predictors centered)

Specified prior:

~ normal(location = 299, scale = 2.5)

Adjusted prior:

~ normal(location = 299, scale = 141)

Coefficients

Specified prior:

~ normal(location = 0, scale = 2.5)

Adjusted prior:

~ normal(location = 0, scale = 49)

Auxiliary (sigma)

Specified prior:

~ exponential(rate = 1)

Adjusted prior:

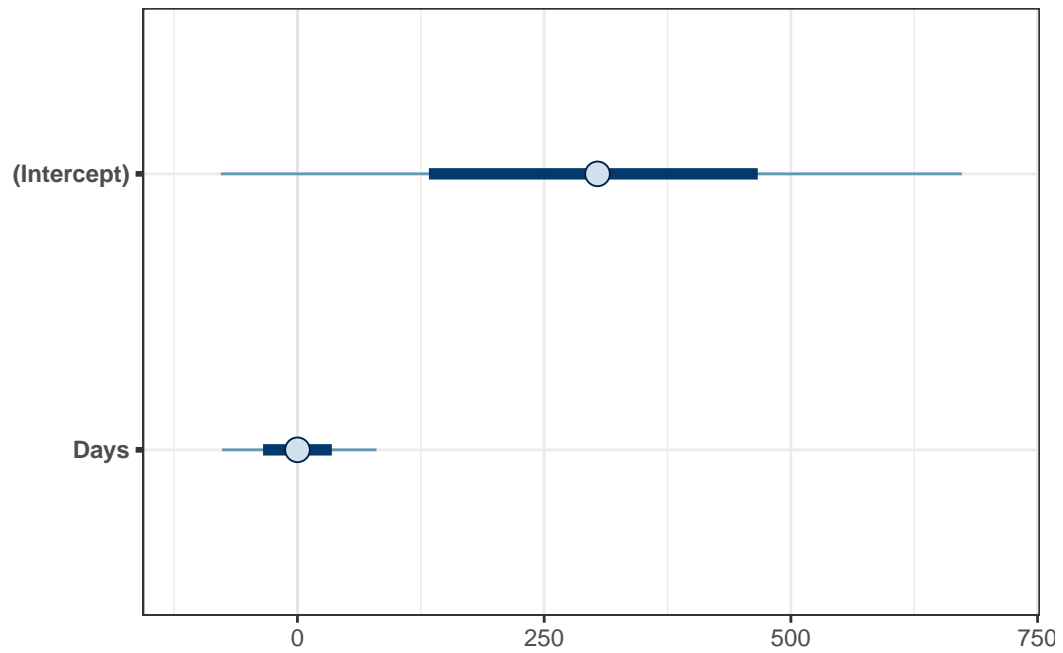
~ exponential(rate = 0.018)

Covariance

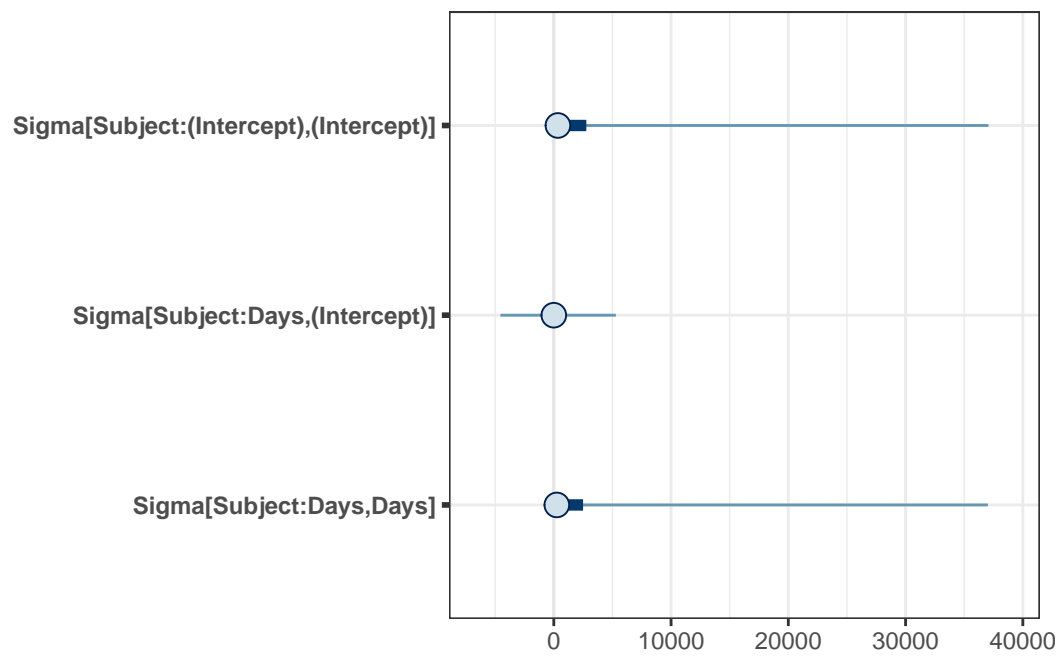
~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)

See `help('prior_summary.stanreg')` for more details

```
plot(priorpred, pars = c("(Intercept)", "Days"))
```



```
plot(priorpred, regex_pars = "Sigma")
```



```
stanfit <- stan_lmer(Reaction ~ Days + (Days|Subject),
  data = sleepstudy, chains = 4)
```

```
print(bayestestR::diagnostic_posterior(stanfit), digits = 4)
```

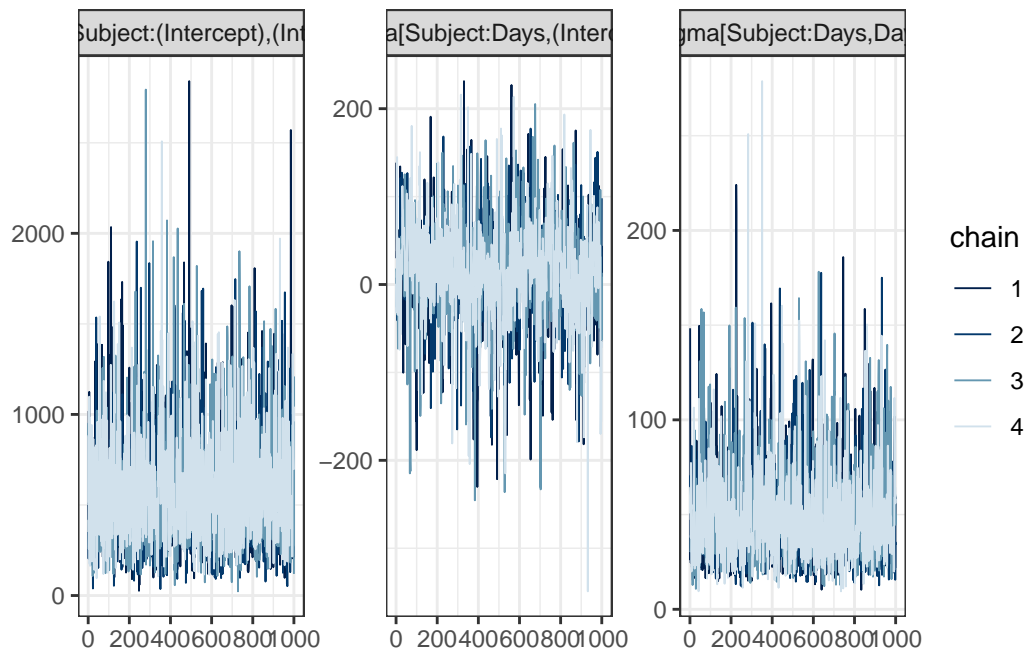
```

      Parameter Rhat  ESS    MCSE
1 (Intercept) 1.001 1765 0.15964
38      Days 1.002 1315 0.04827

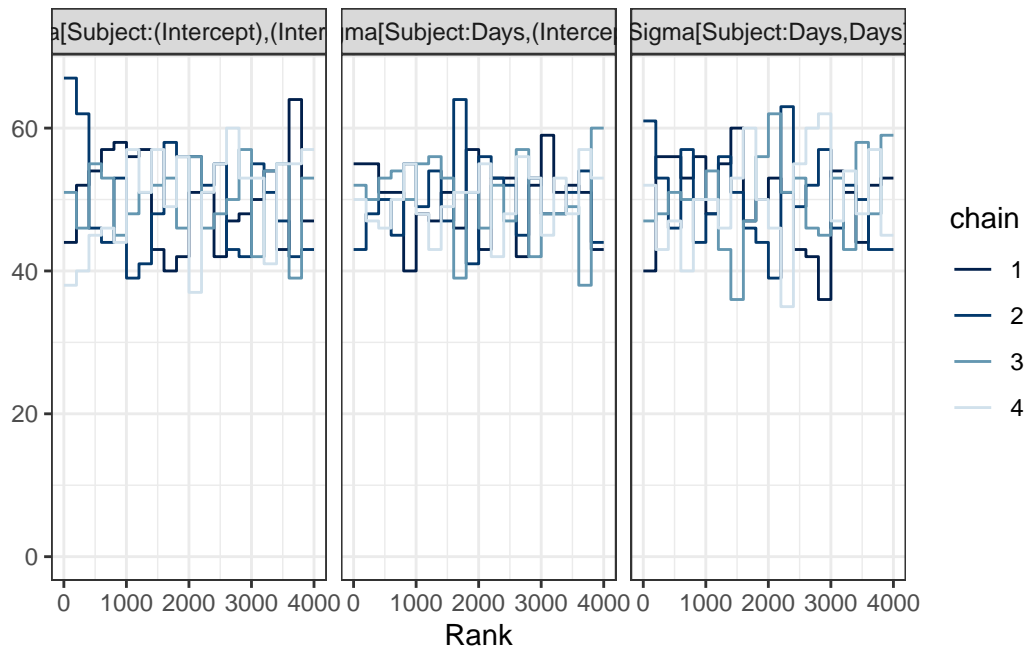
```

```
launch_shinystan(stanfit)
```

```
mcmc_trace(stanfit, regex_pars= "Sigma")
```



```
mcmc_rank_overlay(stanfit, regex_pars= "Sigma")
```



- MCMC diagnostics
 - trace plots, improved trace plots
 - R-hat Vehtari et al. (2021)
 - divergences (HMC only)

See <http://bbolker.github.io/bbmisc/bayes/examples.html>

doing stuff with the results

```
tidy(stanfit, effects=c("fixed", "ran_pars"), conf.int = TRUE)
```

```
# A tibble: 6 x 6
  term                estimate std.error conf.low conf.high group
  <chr>                <dbl>    <dbl>   <dbl>   <dbl> <chr>
1 (Intercept)         251.        6.34   240.    262. <NA>
2 Days                10.5        1.65    7.52   13.2 <NA>
3 sd_(Intercept).Subject 23.8        NA      NA      NA   Subject
4 sd_Days.Subject       6.94        NA      NA      NA   Subject
5 cor_(Intercept).Days.Subject 0.0806    NA      NA      NA   Subject
6 sd_Observation.Residual 26.0        NA      NA      NA   Residual
```

❖ why don't we get confidence intervals ?? Do it by hand ...

```
(as_draws(stanfit)
  |> tidyr::pivot_longer(everything())
  |> group_by(name)
  |> summarise(estimate = median(value),
              lwr = quantile(value, 0.025),
              upr = quantile(value, 0.975))
  |> filter(!stringr::str_detect(name, "~b\\\\"))
)
```

```
# A tibble: 9 x 4
  name                estimate    lwr    upr
  <chr>              <dbl>   <dbl> <dbl>
1 (Intercept)        251.    238.  265.
2 .chain              2.5      1     4
3 .draw              2000.   101. 3900.
4 .iteration           500.    26.0  975.
5 Days                10.5     6.86  13.8
6 Sigma[Subject:(Intercept),(Intercept)] 510.    156. 1295.
7 Sigma[Subject:Days,(Intercept)]        16.0 -106.  112.
8 Sigma[Subject:Days,Days]                42.9   18.1  108.
9 sigma                26.0    23.2  29.4
```

```
form1 <- Reaction ~ Days + (Days|Subject)
get_prior(form1, sleepstudy)
```

	prior	class	coef	group	resp	dpar	nlpar	lb	ub
	(flat)	b							
	(flat)	b	Days						
	lkj(1)	cor							
	lkj(1)	cor		Subject					
student_t(3, 288.7, 59.3)		Intercept							
student_t(3, 0, 59.3)		sd							0
student_t(3, 0, 59.3)		sd		Subject					0
student_t(3, 0, 59.3)		sd	Days	Subject					0
student_t(3, 0, 59.3)		sd	Intercept	Subject					0
student_t(3, 0, 59.3)		sigma							0
source									
default									

```
(vectorized)
  default
(vectorized)
  default
  default
(vectorized)
(vectorized)
(vectorized)
  default
```

```
b_prior <- c(set_prior("normal(200, 50)", "Intercept"),
             set_prior("normal(0, 10)", "b"),
             set_prior("normal(0, 1)", "sigma")
            )
```

```
b <- brm(form1, sleepstudy,
         prior = b_prior,
         seed = 101,          ## reproducibility
         sample_prior = 'only', ## for prior predictive sim
         chains = 1, iter = 500, ## very short sample for convenience
         silent = 2, refresh = 0 ## be vewy vewy quiet ...
        )
p_df <- sleepstudy |> add_predicted_draws(b)
```

‘spaghetti plot’ of prior preds

```
gg0 <- ggplot(p_df, aes(Days, .prediction, group=interaction(Subject, .draw))) +
  geom_line(alpha = 0.1)
```

```
b_prior4 <- c(set_prior("normal(200, 5)", "Intercept"),
             set_prior("normal(0, 2)", "b"),
             set_prior("normal(0, 1)", "sd"),
             set_prior("normal(0, 1)", "sigma")
            )
cc <- capture.output(
  b_reg <- brm(form1, sleepstudy,
              prior = b_prior4,
              seed = 101,
              init = 0,
              control = list(adapt_delta = 0.95)
```



```
)  
)
```

Start sampling

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like `integer`,

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

Chain 1

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like `integer`,

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

Chain 1

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like `integer`,

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

Chain 1

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types 1.

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

Chain 1

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types 1.

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

Chain 1

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types 1.

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

Chain 1

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like integer, it is probably OK.

Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized. In the latter case, the model may still be useful, but you will have to be careful about interpreting the results.

Chain 1

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like integer, it is probably OK.

Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized. In the latter case, the model may still be useful, but you will have to be careful about interpreting the results.

Chain 1

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like integer, it is probably OK.

Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized. In the latter case, the model may still be useful, but you will have to be careful about interpreting the results.

Chain 1

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

Chain 1 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 1 If this warning occurs sporadically, such as for highly constrained variable types like integer, it is probably OK.

Chain 1 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized. In the latter case, the model may still be useful, but you will have to be careful about interpreting the results.

Chain 1

Chain 1

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the following reason(s):

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types (e.g. integer values), this warning is not serious.

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized (too many parameters).

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the following reason(s):

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types (e.g. integer values), this warning is not serious.

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized (too many parameters).

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the following reason(s):

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types (e.g. integer values), this warning is not serious.

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized (too many parameters).

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the following reason(s):

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types (e.g. integer values), this warning is not serious.

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types like

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types like

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types like

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned or

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 2

Chain 2 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 2 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 2 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 2 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 2

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 3 but if this warning occurs often then your model may be either severely ill-condition

Chain 3

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 3 but if this warning occurs often then your model may be either severely ill-condition

Chain 3

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 3 but if this warning occurs often then your model may be either severely ill-condition

Chain 3

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types l

Chain 3 but if this warning occurs often then your model may be either severely ill-condition

Chain 3

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types l

Chain 3 but if this warning occurs often then your model may be either severely ill-condition

Chain 3

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types l

Chain 3 but if this warning occurs often then your model may be either severely ill-condition

Chain 3

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types l

Chain 3 but if this warning occurs often then your model may be either severely ill-condition

Chain 3

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because of the following reason(s):

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types like integer data, it is not a problem.

Chain 3 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized.

Chain 3

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because of the following reason(s):

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types like integer data, it is not a problem.

Chain 3 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized.

Chain 3

Chain 3 Informational Message: The current Metropolis proposal is about to be rejected because of the following reason(s):

Chain 3 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 3 If this warning occurs sporadically, such as for highly constrained variable types like integer data, it is not a problem.

Chain 3 but if this warning occurs often then your model may be either severely ill-conditioned or over-parameterized.

Chain 3

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of the following reason(s):

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (infinite values are not allowed)

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types like integer data, it is not a problem.

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types like

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types like

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types like

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned or

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned or

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned or

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned or

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because of the following reasons:

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 4

Chain 4 Informational Message: The current Metropolis proposal is about to be rejected because

Chain 4 Exception: normal_id_glm_lpdf: Scale vector is inf, but must be positive finite! (in

Chain 4 If this warning occurs sporadically, such as for highly constrained variable types 1.

Chain 4 but if this warning occurs often then your model may be either severely ill-conditioned

Chain 4

```
print(bayestestR::diagnostic_posterior(b_reg), digits = 4)
```

	Parameter	Rhat	ESS	MCSE
1	b_Days	1.0002	3744	0.01764
2	b_Intercept	0.9997	3297	0.05154

```
## debug(MCMCglmm::priorformat)
m <- MCMCglmm(Reaction ~ Days, random = ~us(1+Days):Subject,
             data = sleepstudy,
             verbose=FALSE,
             prior = list(G=list(G1=list(V=diag(2), nu = 0.1))))
broom.mixed::tidy(m)
```

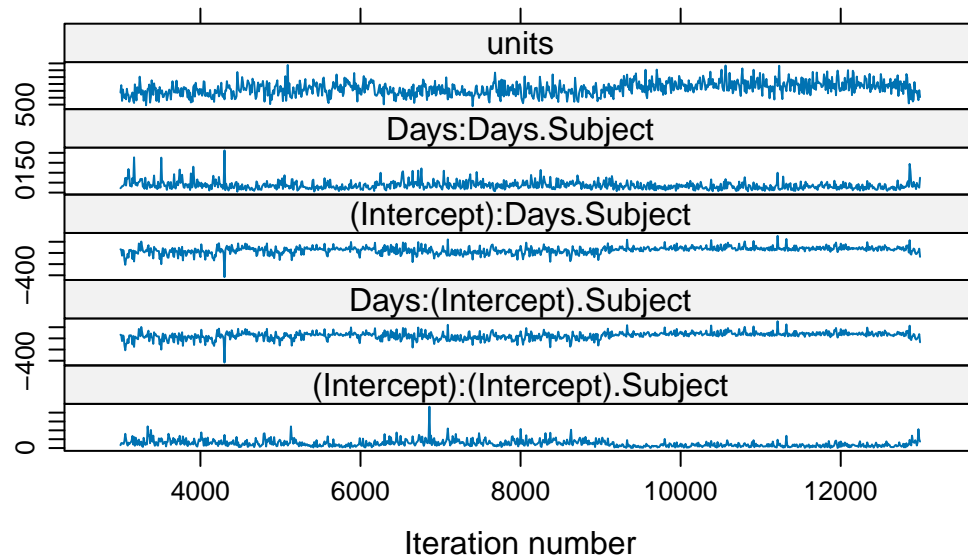
```
# A tibble: 6 x 5
  effect    group    term                estimate std.error
  <chr>    <chr>    <chr>                <dbl>    <dbl>
1 fixed   <NA>      (Intercept)          252.      6.65
2 fixed   <NA>      Days                 10.5      1.61
3 ran_pars Subject var__(Intercept)    508.     357.
4 ran_pars Subject cov__(Intercept).Days  49.1     63.5
5 ran_pars Subject var__Days          33.3     19.9
6 ran_pars Residual var__Observation  700.     98.6
```

```
try(MCMCglmm(Reaction ~ Days, random = ~us(1+Days):Subject,
            data = sleepstudy,
            verbose=FALSE,
            prior = list(G=list(G1=list(V=diag(2), nu = 0.1,
                                         alpha.mu = 0, alpha.V = diag(2))))))
```

```
Error in priorformat(if (NOPriorG) { :
  alpha.mu is the wrong length for some prior$G/prior$R elements
```

```
m2 <- MCMCglmm(Reaction ~ Days, random = ~us(1+Days):Subject,
              data = sleepstudy,
              verbose=FALSE,
              prior = list(G=list(G1=list(V=diag(2), nu = 0.1,
                                           alpha.mu = rep(0,2),
                                           alpha.V = diag(2)))))
```

```
lattice::xyplot(m2$VCV)
```



Run longer (and thin)? Strengthen prior?

Gelman, Andrew, Aki Vehtari, Daniel Simpson, Charles C. Margossian, Bob Carpenter, Yuling Yao, Lauren Kennedy, Jonah Gabry, Paul-Christian Bürkner, and Martin Modrák. 2020. “Bayesian Workflow.” *arXiv:2011.01808 [Stat]*, November. <http://arxiv.org/abs/2011.01808>.

Talts, Sean, Michael Betancourt, Daniel Simpson, Aki Vehtari, and Andrew Gelman. 2020. “Validating Bayesian Inference Algorithms with Simulation-Based Calibration.” *arXiv:1804.06788 [Stat]*, October. <http://arxiv.org/abs/1804.06788>.

Vehtari, Aki, Andrew Gelman, Daniel Simpson, Bob Carpenter, and Paul-Christian Bürkner. 2021. “Rank-Normalization, Folding, and Localization: An Improved R-hat for Assessing Convergence of MCMC (with Discussion).” *Bayesian Analysis* 16 (2): 667–718. <https://doi.org/10.1214/20-BA1221>.