

What's in a Bayesian Model?

BAYESIAN REGRESSION MODELING WITH RSTANARM

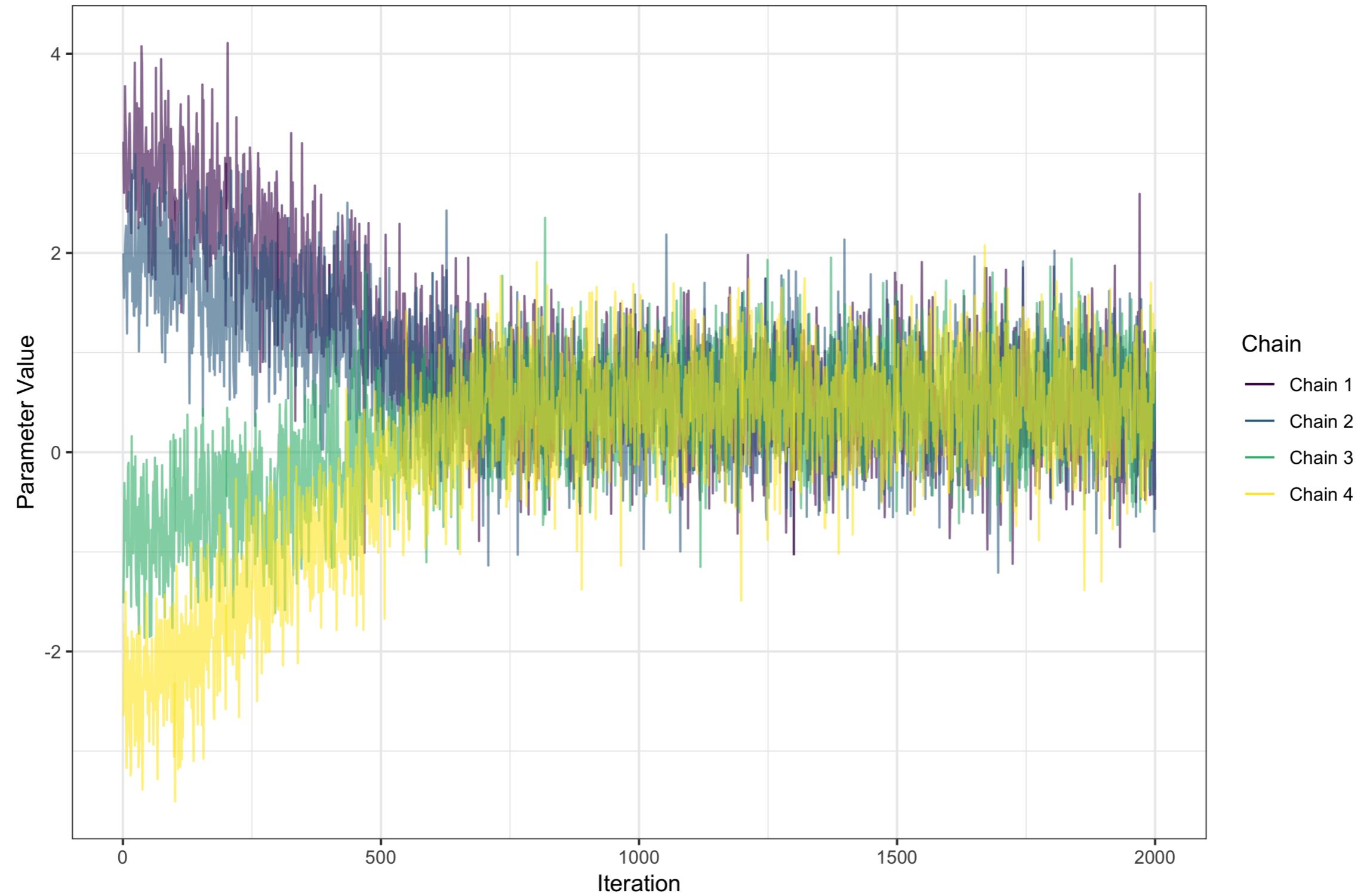


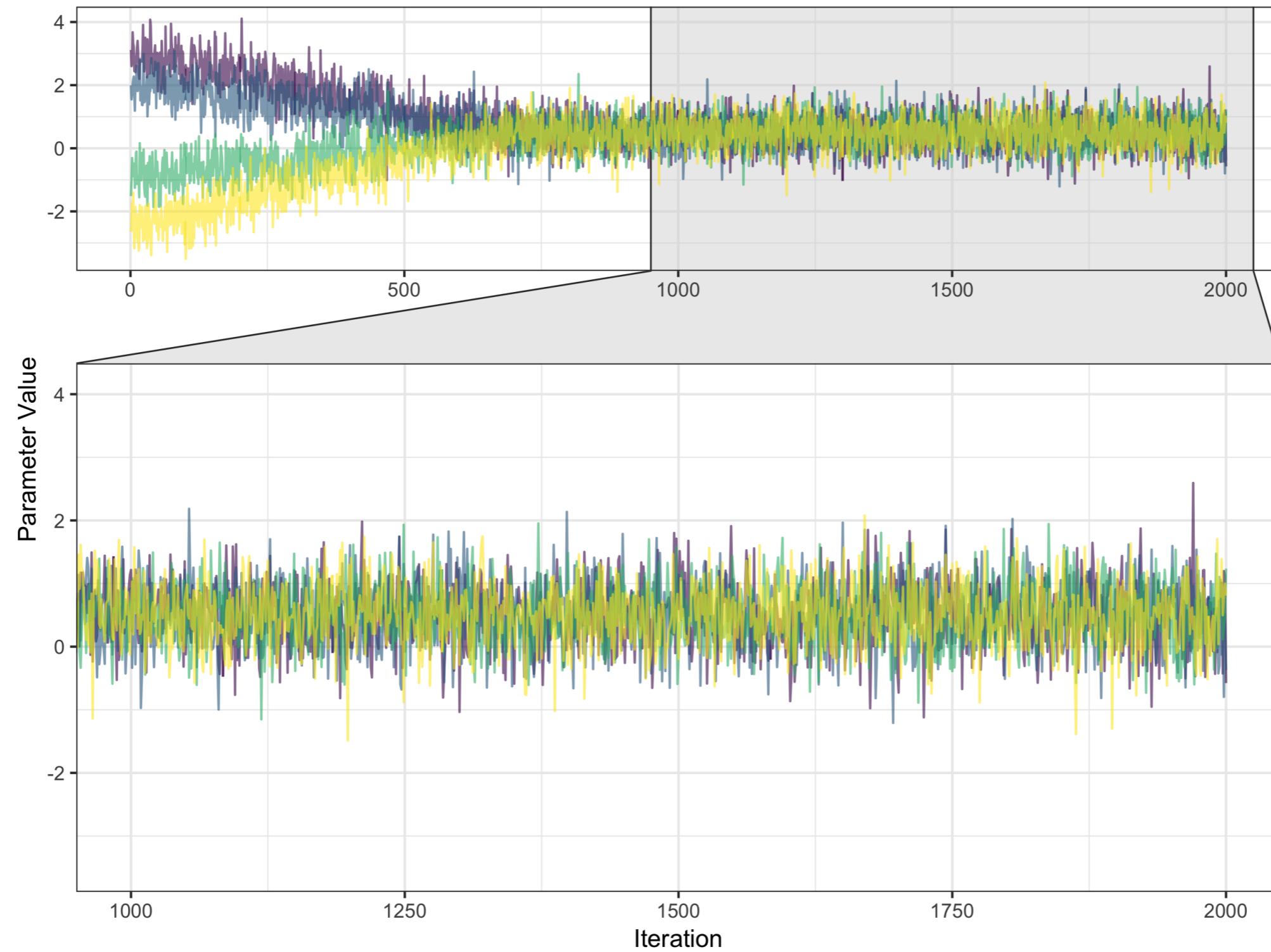
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Posterior distributions

- Posterior distributions sampled in groups called chains
- Each sample in a chain is an iteration





Changing the number and length of chains

```
stan_model <- stan_glm(kid_score ~ mom_iq, data = kidiq,  
chains = 3, iter = 1000, warmup = 500)
```

```
summary(stan_model)
```

Model Info:

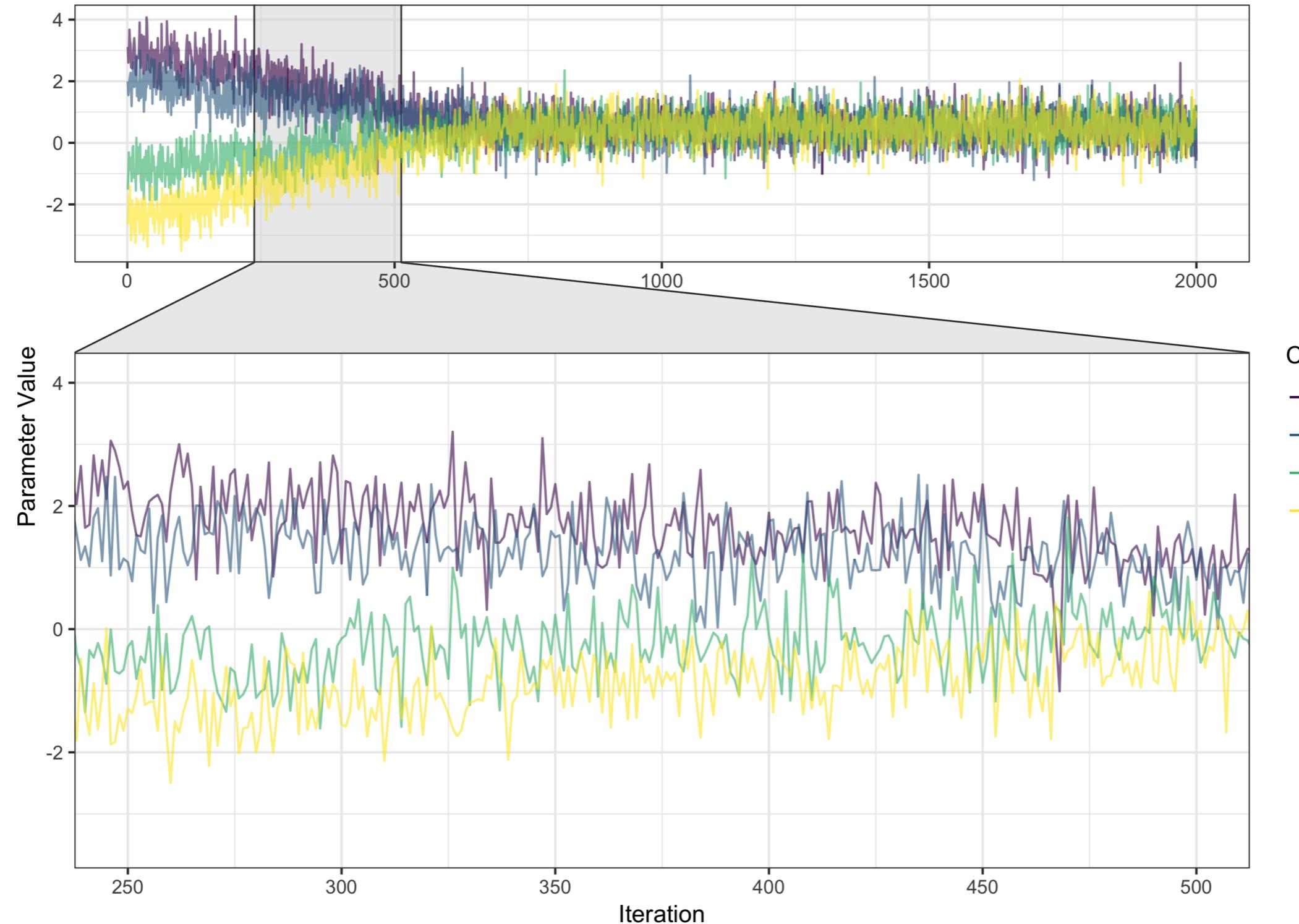
```
function: stan_glm
family: gaussian [identity]
formula: kid_score ~ mom_iq
algorithm: sampling
priors: see help('prior_summary')
sample: 1500 (posterior sample size)
observations: 434
predictors: 2
```

Estimates:

	mean	sd	2.5%	25%	50%	75%	97.5%
(Intercept)	25.8	6.0	14.1	21.7	25.6	29.9	37.5
mom_iq	0.6	0.1	0.5	0.6	0.6	0.7	0.7
sigma	18.3	0.6	17.2	17.9	18.3	18.7	19.6
mean_PPD	86.9	1.3	84.5	86.0	86.9	87.7	89.2
log-posterior	-1885.4		1.2	-1888.4	-1885.9	-1885.1	-1884.5
							-1884.0

Diagnostics:

```
mcse Rhat n_eff
```



How many iterations?

- Fewer iterations = shorter estimation time
- Not enough iteration = convergence problems

Let's practice!

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Prior distributions

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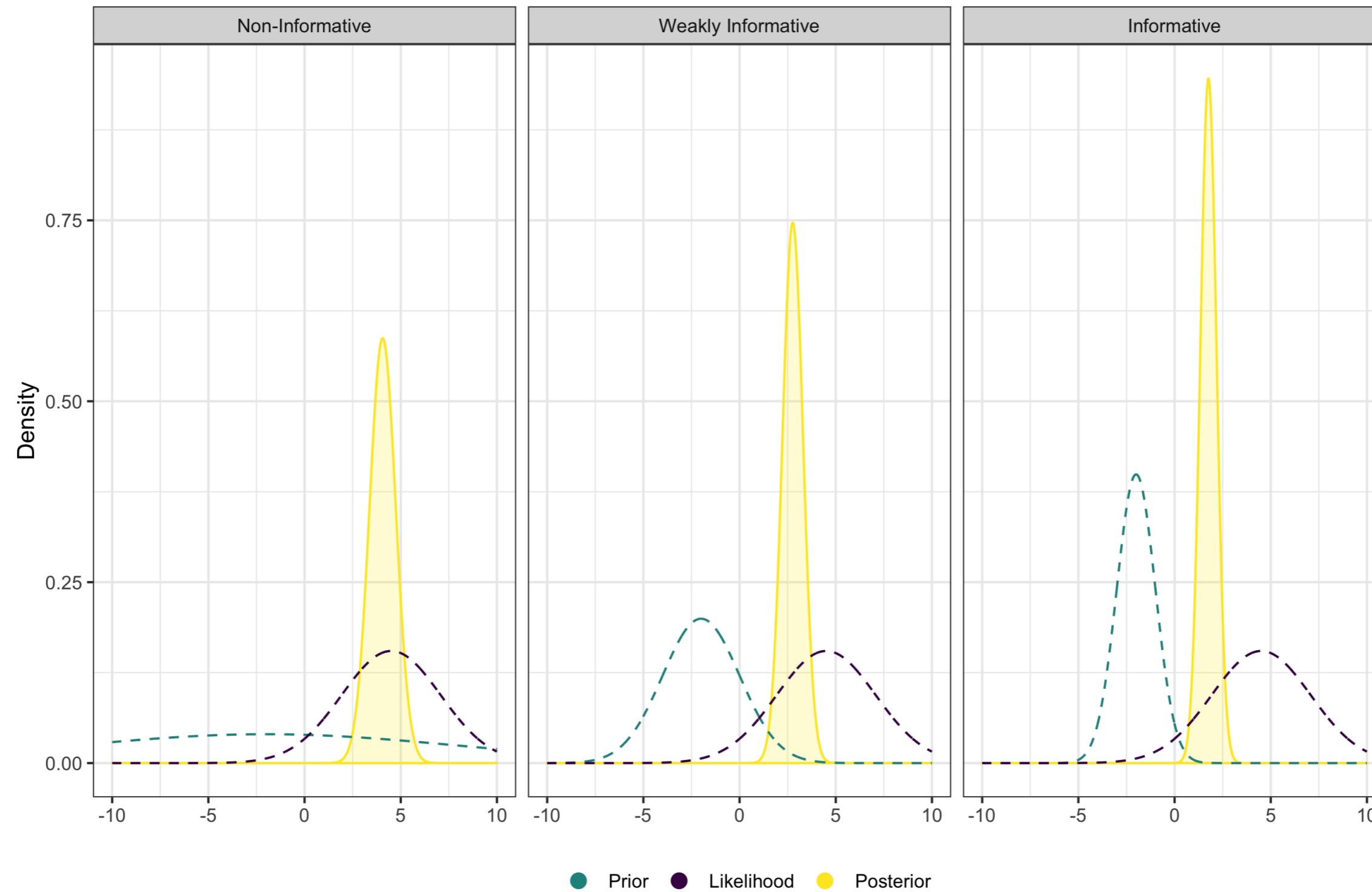


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What's a prior distribution?

- Information that we bring to the model
- Likelihood + prior = posterior



Prior distributions in rstanarm

```
stan_model <- stan_glm(kid_score ~ mom_iq, data = kidiq)
prior_summary(stan_model)
```

Priors for model 'stan_model'

Intercept (after predictors centered)

```
~ normal(location = 0, scale = 10)
  **adjusted scale = 204.11
```

Coefficients

```
~ normal(location = 0, scale = 2.5)
  **adjusted scale = 3.40
```

Auxiliary (sigma)

```
~ exponential(rate = 1)
  **adjusted scale = 20.41 (adjusted rate = 1/adjusted scale)
```

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

Calculating adjusted scales

- Intercept: $10 * \text{sd}(y)$
- Coefficients: $(2.5 / \text{sd}(x)) * \text{sd}(y)$

```
prior_summary(stan_model)
```

Priors for model 'stan_model'

Intercept (after predictors centered)

```
~ normal(location = 0, scale = 10)  
  **adjusted scale = 204.11
```

Coefficients

```
~ normal(location = 0, scale = 2.5)  
  **adjusted scale = 3.40
```

```
10 * sd(kidiq$kid_score)
```

204.1069

```
(2.5 / sd(kidiq$mom_iq)) * sd(kidiq$kid_score)
```

3.401781

```
no_scale <- stan_glm(kid_score ~ mom_iq, data = kidiq,  
prior_intercept = normal(autoscale = FALSE),  
prior = normal(autoscale = FALSE),  
prior_aux = exponential(autoscale = FALSE))  
prior_summary(no_scale)
```

Priors for model 'no_scale'

Intercept (after predictors centered)

$\sim \text{normal}(\text{location} = 0, \text{scale} = 10)$

Coefficients

$\sim \text{normal}(\text{location} = 0, \text{scale} = 2.5)$

Auxiliary (sigma)

$\sim \text{exponential}(\text{rate} = 1)$

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

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User Specified Priors

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Why change the default prior?

- Good reason to believe the parameter will take a given value
- Constraints on parameter

Specify a prior

```
stan_model <- stan_glm(kid_score ~ mom_iq, data = kidiq,  
prior_intercept = normal(location = 0, scale = 10),  
prior = normal(location = 0, scale = 2.5),  
prior_aux = exponential(rate = 1)  
)
```

Specify a prior

```
stan_model <- stan_glm(kid_score ~ mom_iq, data = kidiq,  
prior_intercept = normal(location = 0, scale = 10, autoscale = FALSE),  
prior = normal(location = 0, scale = 2.5, autoscale = FALSE),  
prior_aux = exponential(rate = 1, autoscale = FALSE)  
)
```

Specify a prior

```
stan_model <- stan_glm(kid_score ~ mom_iq, data = kidiq,  
  prior_intercept = normal(location = 3, scale = 2),  
  prior = cauchy(location = 0, scale = 1))
```

- Many different priors
 - `normal()`
 - `exponential()`
 - `student_t()`
 - `cauchy()`
- `?priors`

Flat priors

```
stan_model <- stan_glm(kid_score ~ mom_iq, data = kidiq,  
prior_intercept = NULL,  
prior = NULL,  
prior_aux = NULL)  
prior_summary(stan_model)
```

Priors for model 'stan_model'

Intercept (after predictors centered)

~ flat

Coefficients

~ flat

Auxiliary (sigma)

~ flat

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

Let's practice!

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Altering the estimation process

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Divergent transitions

1: There were 15 divergent transitions after warmup. Increasing adapt_delta above 0.8 may help.

- Too big of steps in the estimator
- Adjust step size

```
stan_model <- stan_glm(popularity ~ song_age, data = songs,  
control = list(adapt_delta = 0.95))
```

```
stan_model <- stan_glm(popularity ~ song_age, data = songs,  
control = list(adapt_delta = 0.99))
```

Exceeding the Maximum Treedepth

Chain 1 reached the maximum tree depth

- Sample evaluates branches and looks for a good place to "U-Turn"
- Max tree depth indicates poor efficiency

```
stan_model <- stan_glm(popularity ~ song_age, data = songs,  
control = list(max_treedepth = 10))
```

```
stan_model <- stan_glm(popularity ~ song_age, data = songs,  
control = list(max_treedepth = 15))
```

Tuning the estimation

- Estimation errors are threats to the validity of the model
- Although complicated, these errors can be addressed easily

Let's practice!

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