

Individual Homework 09

```
library(bayesrules) # R package for our textbook
library(tidyverse) # Collection of packages for tidying and plotting data
library(janitor) # Helper functions like tabyl
library(rstan) # for fitting models
library(rstanarm) # for fitting standard regression models
library(broom.mixed) # for tidy() function
library(bayesplot) # helpful plotting functions
library(tidybayes) # helpful for wrangling Bayesian model output
library(patchwork)
```

1 BR 16.6 (Big words: getting to know the data)

Recall from Section 16.7 the Abdul Latif Jameel Poverty Action Lab (J-PAL) study into the effectiveness of a digital vocabulary learning program, the Big Word Club (BWC) (Kalil, Mayer, and Oreopoulos 2020). In our analysis of this program, we'll utilize weakly informative priors with a baseline understanding that the average student saw 0 change in their vocabulary scores throughout the program. We'll balance these priors by the big_word_club data in the bayesrules package. For each student participant, big_word_club includes a school_id and the percentage change in vocabulary scores over the course of the study period (score_pct_change). We keep only the students that participated in the BWC program (treat == 1), and thus eliminate the control group.

```
data("big_word_club")
big_word_club <- big_word_club %>%
  filter(treat == 1) %>%
  select(school_id, score_pct_change) %>%
  na.omit()
```

- (a) How many schools participated in the Big Word Club?
- (b) What's the range in the number of student participants per school?
- (c) On average, at which school did students exhibit the greatest improvement in vocabulary? The least?

- (d) Construct and discuss a plot which illustrates the variability in score_pct_change within and between schools.

2 BR Exercise 16.7 (Big words: setting up the model)

In the next exercises you will explore a hierarchical one-way ANOVA model (16.12) of Y_{ij} , the percentage change in vocabulary scores, for student i in school j .

- (a) Why is a hierarchical model, vs a complete or no pooled model, appropriate in our analysis of the BWC program?
- (b) Compare and contrast the meanings of model parameters μ and μ_j in the context of this vocabulary study.
- (c) Compare and contrast the meanings of model parameters σ_y and σ_μ in the context of this vocabulary study.

3 BR 16.8

Exercise 16.8 (Big words: simulating the model)

- (a) Simulate the hierarchical posterior model of parameters $(\mu_j, \mu, \sigma_y, \sigma_\mu)$ using 4 chains, each of length 10000.
- (b) Construct and discuss Markov chain trace, density, and autocorrelation plots.
- (c) Construct and discuss a pp_check() of the chain output.

4 BR 16.11

Suppose we continue the vocabulary study at each of Schools 6 and 17 (which participated in the current study) and Bayes Prep, a school which is new to the study. In this exercise you'll make predictions about $Y_{new,j}$, the vocabulary performance of a student that's new to the study from each of these three schools j .

- (a) *Without* using the `posterior_predict()` shortcut function, simulate posterior predictive models of $Y_{new,j}$ for School 6 and Bayes Prep. Display the first 6 posterior predictions for both schools.
- (b) Using your simulations from part (a), construct, interpret, and compare the 80% posterior predictive intervals of $Y_{new,j}$ for School 6 and Bayes Prep.
- (c) Using `posterior_predict()` this time, simulate posterior predictive models of $Y_{new,j}$ for each of School 6, School 17, and Bayes Prep. Illustrate your simulation results using `mcmc_areas()` and discuss your findings.
- (d) Finally, construct, plot, and discuss the 80% posterior prediction intervals for all schools in the original study.