Preliminary Analysis

Bias in PERSUADE

```
library(sjPlot)
library(lme4)
library(car) # level names in contrasts
library(stargazer) # LaTeX tables
library(emmeans)
library(performance) # ICC
library(tidyverse)

df <- read.csv("../data/persuade_corpus.csv",
               na.strings = c("", " ", "NA")) %>%
  select(-c(full_text, X, assignment, source_text)) %>%
  mutate_if(is.character, as.factor) %>%

  # drop American Indian/Alaskan Native group because there are < 200 samples
  filter(race_ethnicity != "American Indian/Alaskan Native") %>%

  # remove unused levels (American Indian)
  droplevels() %>%

  # simplify level and variable names
  mutate(
    race=fct_recode(race_ethnicity,
                    asian="Asian/Pacific Islander",
                    black="Black/African American",
                    hisp="Hispanic/Latino",
                    other="Two or more races/Other",
                    white="White")
    ) %>%

  # collapse NaNs into negative level of binary factors
```

```
  mutate(
    is_ell=fct_collapse(addNA(ell), Yes = "Yes", No = c("No", NA)),
    is_disadvantaged=fct_collapse(addNA(economically_disadvantaged),
                                  Yes = "Economically disadvantaged",
                                  No = c("Not economically disadvantaged", NA)),
    has_disability=fct_collapse(addNA(student_disability_status),
                                  Yes = "Identified as having disability",
                                  No = c("Not identified as having disability", NA))
    ) %>%

  # set the first level, which will be used as "reference"
  mutate(
    is_disadvantaged=fct_relevel(is_disadvantaged, "No"),
    has_disability=fct_relevel(has_disability, "No"),
  )

# configure contrasts for race and source
options(decorate.contr.Sum = c("", ""))
contrasts(df$race) = contr.Sum(levels(df$race))
contrasts(df$source) = contr.Sum(levels(df$source))

summary(df)
```

```
       essay_id     holistic_score_1 holistic_score_2
5.04604E+12:    2   Min.   :1.000    Min.   :1.0
5.88194E+12:    2   1st Qu.:2.000    1st Qu.:2.0
2021000039 :    1   Median :3.000    Median :3.0
2021000047 :    1   Mean   :3.272    Mean   :3.3
2021000071 :    1   3rd Qu.:4.000    3rd Qu.:4.0
2021000080 :    1   Max.   :6.000    Max.   :6.0
(Other)    :25847
holistic_score_adjudicated             source
Min.   :1.000              Florida        :3987
1st Qu.:2.000              Georgia Virtual:1165
Median :3.000              Indiana        :8799
Mean   :3.317              NCES           :4798
3rd Qu.:4.000              Virginia       :7106
Max.   :6.000

                         prompt_name                task       gender
Distance learning              : 2153   Independent   :13069   F:13067
```

```
Facial action coding system     : 2150   Text dependent:12786   M:12788
Does the electoral college work?: 2035
Car-free cities                 : 1952
Driverless cars                 : 1868
Exploring Venus                 : 1849
(Other)                         :13848
    grade          ell                        race_ethnicity
Min.   : 6.000   No  :22318   Asian/Pacific Islander : 1743
1st Qu.: 8.000   Yes : 2242   Black/African American : 4959
Median : 9.000   NA's: 1295   Hispanic/Latino        : 6560
Mean   : 9.174                Two or more races/Other: 1022
3rd Qu.:10.000                White                  :11571
Max.   :12.000

                economically_disadvantaged
Economically disadvantaged    : 9565
Not economically disadvantaged:11074
NA's                          : 5216



                     student_disability_status    race       is_ell
Identified as having disability    : 3325       asian: 1743   No :23613
Not identified as having disability:21365       black: 4959   Yes: 2242
NA's                               : 1165       hisp : 6560
                                                other: 1022
                                                white:11571


is_disadvantaged has_disability
No :16290        No :22530
Yes: 9565        Yes: 3325
```

```r
eval_model <- function(mod) {
  print(performance(mod))
```

```
  # print(tab_model(mod,
  #                 p.adjust="HB",
  #                 show.aic=TRUE,
  #                 show.re.var=TRUE,
  #                 # show.reflvl=TRUE,
  #                 prefix.labels="varname"
  #                 ))
}
```

```
mod.null <-lmer(holistic_score_adjudicated ~ 1 + (1|prompt_name), data=df)
eval_model(mod.null)
```

```
# Indices of model performance

AIC       |      AICc |       BIC | R2 (cond.) | R2 (marg.) |   ICC |  RMSE | Sigma
-------------------------------------------------------------------------------------
73488.393 | 73488.394 | 73512.874 |      0.270 |      0.000 | 0.270 | 1.000 | 1.000
```

Simple model with just race

```
mod.race <-lmer(holistic_score_adjudicated
                ~ race
                + (race|prompt_name),
                data=df
                )
```

```
boundary (singular) fit: see help('isSingular')
```

```
eval_model(mod.race)
```

```
Random effect variances not available. Returned R2 does not account for random effects.
# Indices of model performance

AIC       |      AICc |       BIC | R2 (cond.) | R2 (marg.) |  RMSE | Sigma
-----------------------------------------------------------------------------
72069.770 | 72069.805 | 72241.135 |            |      0.044 | 0.970 | 0.971
```

All fixed effects

```
mod.all_fixed_effects <- lmer(holistic_score_adjudicated
                              ~ race
                              + grade
                              + is_disadvantaged
                              + is_ell
                              + has_disability
                              # + source # slightly improves model fit, but is not of inte
                              + gender
                              + (1|prompt_name),
                              data=df
                              )
eval_model(mod.all_fixed_effects)
```

```
# Indices of model performance

AIC       |      AICc |       BIC | R2 (cond.) | R2 (marg.) |   ICC |  RMSE | Sigma
-------------------------------------------------------------------------------------
69367.123 | 69367.135 | 69465.046 |      0.387 |      0.121 | 0.303 | 0.922 | 0.922
```

Search for interactions

We drop grade because it was not significant, but we test for an interaction between grade and ell. We might expect interactions: race*ses, race*ell, and race*disability.

```
mod.interactions <- lmer(holistic_score_adjudicated
                         ~ race
                         + is_disadvantaged
                         + is_ell
                         + has_disability
                         + gender
                         # + race*is_disadvantaged # increases AIC
                         + race*is_ell
                         # + race*has_disability # increases AIC
                         # + race*source # increases AIC
                         # + race*gender # increases AIC
                         # + race*grade # increases AIC
                         + is_disadvantaged*has_disability
```

```
                          + is_disadvantaged*is_ell
                          + has_disability*is_ell
                          # + gender*has_disability # increases AIC
                          # + gender*is_disadvantaged # increases AIC
                          # + gender*is_ell # small decrease (-1) to AIC
                          + (1|prompt_name),
                          data=df
                          )
eval_model(mod.interactions)
```

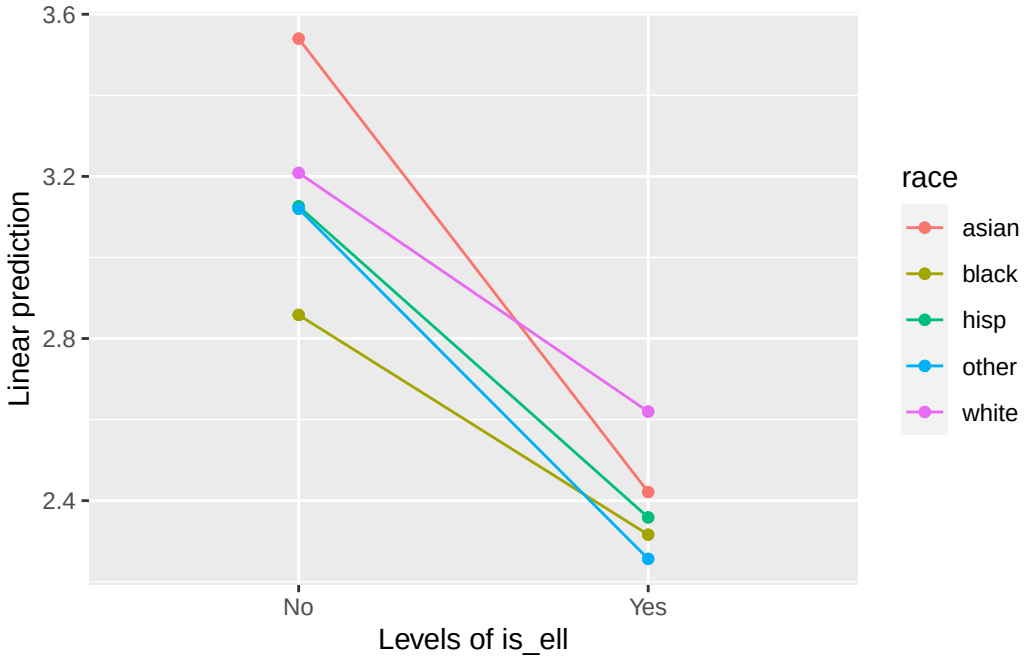
```
# Indices of model performance

AIC       |      AICc |       BIC | R2 (cond.) | R2 (marg.) |   ICC |  RMSE | Sigma
-------------------------------------------------------------------------------------
69272.702 | 69272.729 | 69419.587 |      0.394 |      0.125 | 0.308 | 0.920 | 0.920
```

Search for random slopes

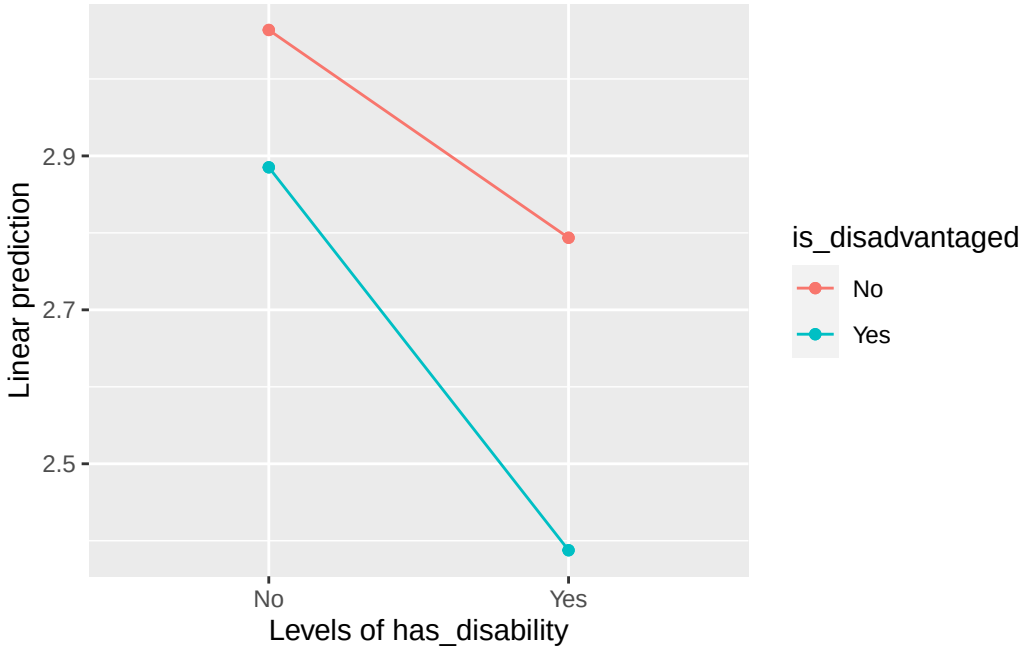
There are no good random slopes.

```
mod.final <- mod.interactions
```

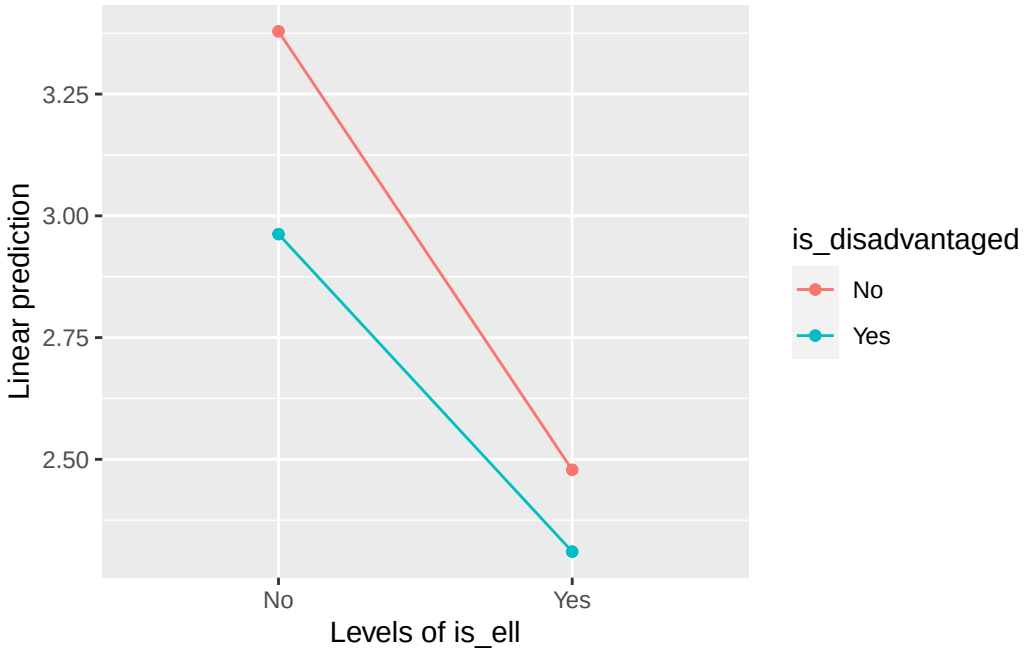
```
emmip(mod.final, race~is_ell, mode = "asymp")
```



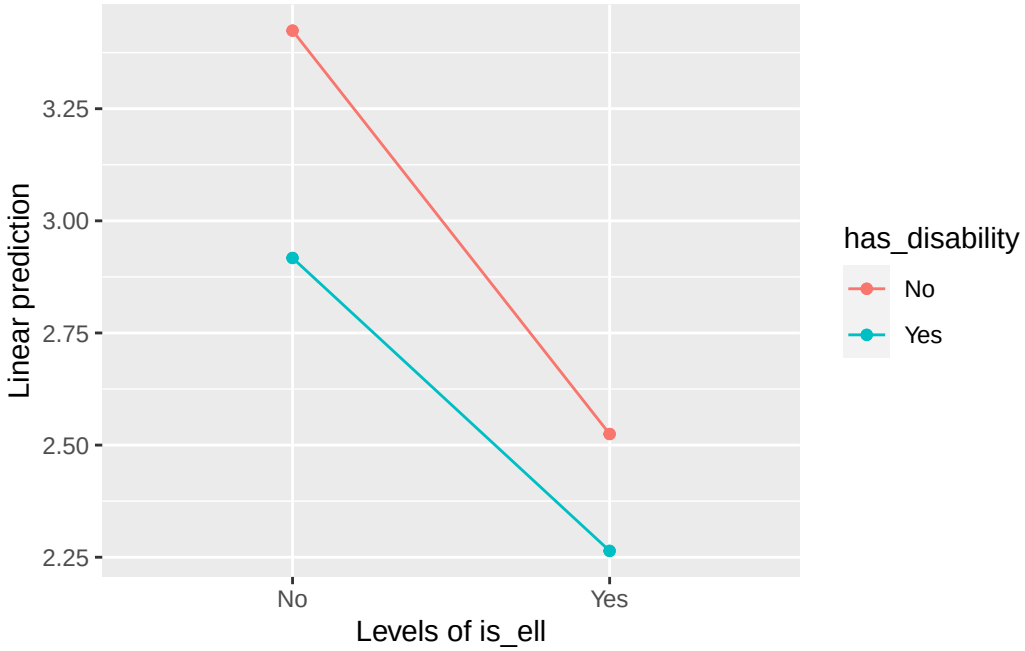

```
emmip(mod.final, is_disadvantaged~has_disability, mode = "asymp")
```



```
emmip(mod.final, is_disadvantaged~is_ell, mode = "asymp")
```




```
emmip(mod.final, has_disability~is_ell, mode = "asymp")
```




```
coefs <- summary(mod.final)$coefficients
cat(rownames(coefs), sep="\", \"")
```

```
(Intercept)", "race[asian]", "race[black]", "race[hisp]", "race[other]", "is_disadvantagedYes
```

```
labels <- c("(Intercept)", "Asian/Pacific Islander", "Black/African American", "Hispanic/L
```

```
tab_model(mod.final,
          title = "Essay Scores Regressed on Demographic Variables",
          dv.labels = "Holistic Score",
          pred.labels = labels,
          emph.p = TRUE,
          p.adjust = "BH",
          # show.reflvl=TRUE,
          show.re.var=TRUE,
          file="../results/RQ1.html"
          )
```

```
Length of `pred.labels` does not equal number of predictors, no labelling applied.
```

Essay Scores Regressed on Demographic Variables

Holistic Score

Predictors

Estimates

CI

p

(Intercept)

3.70

3.39 – 4.01

<0.001

race[asian]

0.37

0.33 – 0.41

<0.001

race[black]

-0.31

-0.34 – -0.29

<0.001

race[hisp]

-0.04

-0.07 – -0.02

0.001

race[other]

-0.05

-0.10 – -0.00

0.041

is_disadvantagedYes

-0.30

-0.33 – -0.27

<0.001

is_ellYes

-1.02

-1.16 – -0.89

<0.001

has_disabilityYes

-0.39

-0.44 – -0.35

<0.001

genderM

-0.25

-0.27 – -0.22

<0.001

race[asian]:is_ellYes

-0.34

-0.49 – -0.19

<0.001

race[black]:is_ellYes

0.23

0.07 – 0.39

0.005

race[hisp]:is_ellYes

0.01

-0.12 – 0.14

0.893

race[other]:is_ellYes

-0.09

-0.53 – 0.35

0.743

is_disadvantagedYes:has_disabilityYes

-0.23

-0.30 – -0.16

<0.001

is_disadvantagedYes:is_ellYes

0.25

0.16 – 0.34

<0.001

is_ellYes:has_disabilityYes

0.25

0.13 – 0.36

<0.001

Random Effects

τ_{00}

0.85

$\tau_{00\ prompt\_name}$

0.38

ICC

0.31

N_{prompt_name}

15

Observations

25855

Marginal R^2 / Conditional R^2

0.125 / 0.394