Lesson 6, Part 2: Linear Mixed Effects Models

This Lesson's Goals

Learn about other methods for LMEMs

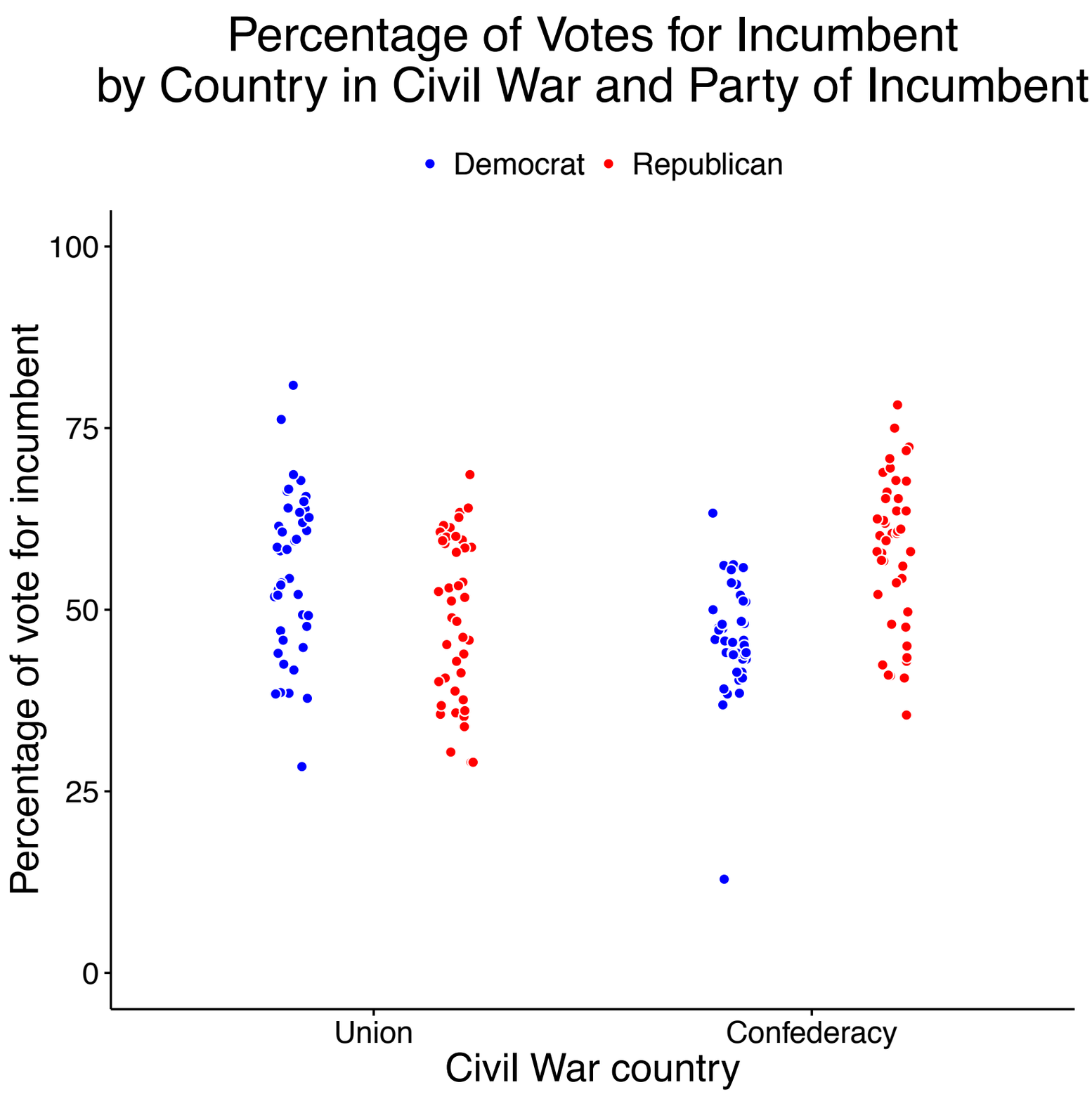
Update our LMEMs in R

Summarise results in an R Markdown document

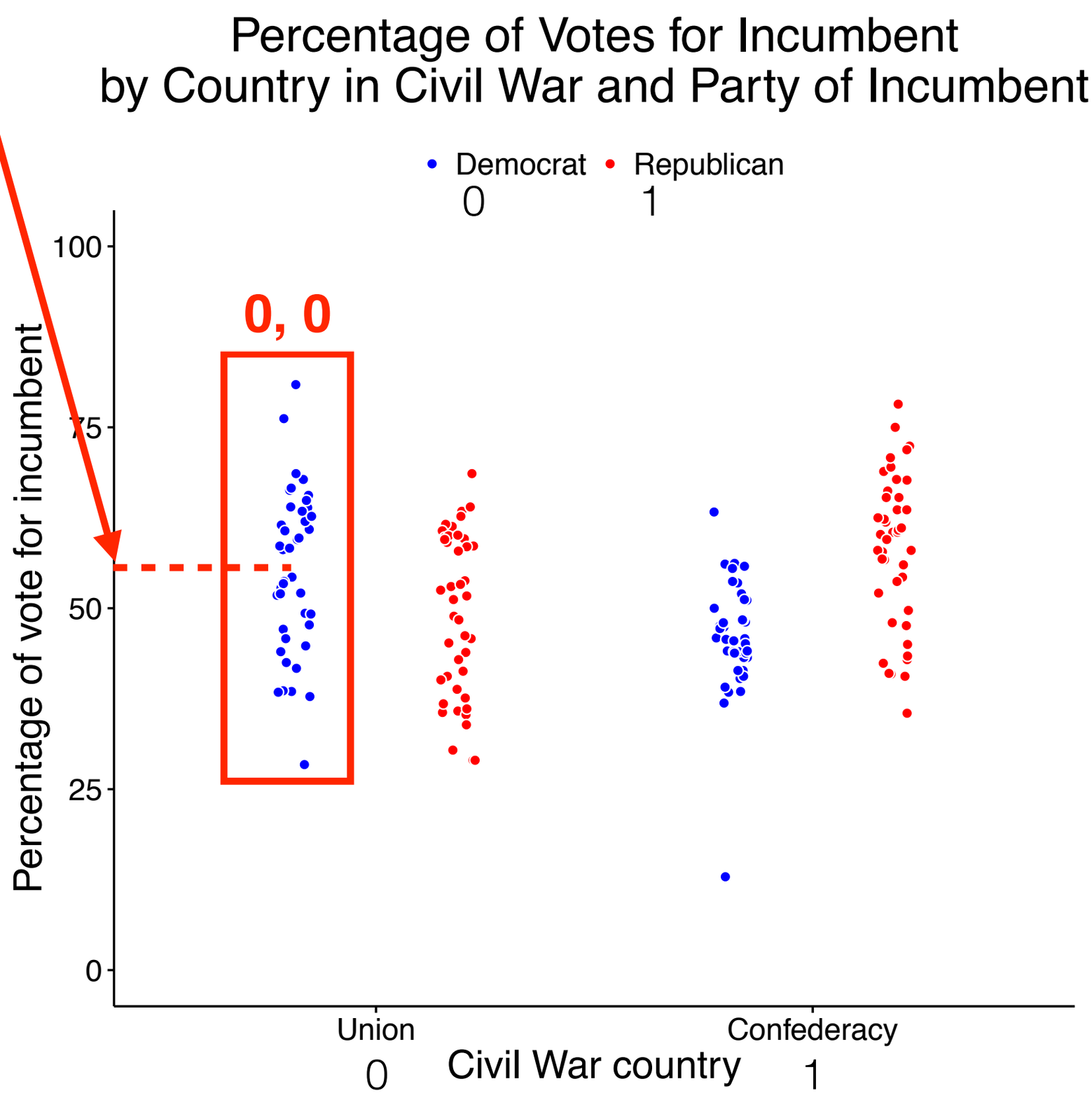
But, in the ANOVA we got rid of our baseline issue, can I do that with an LMEM?

Math (Part 1)

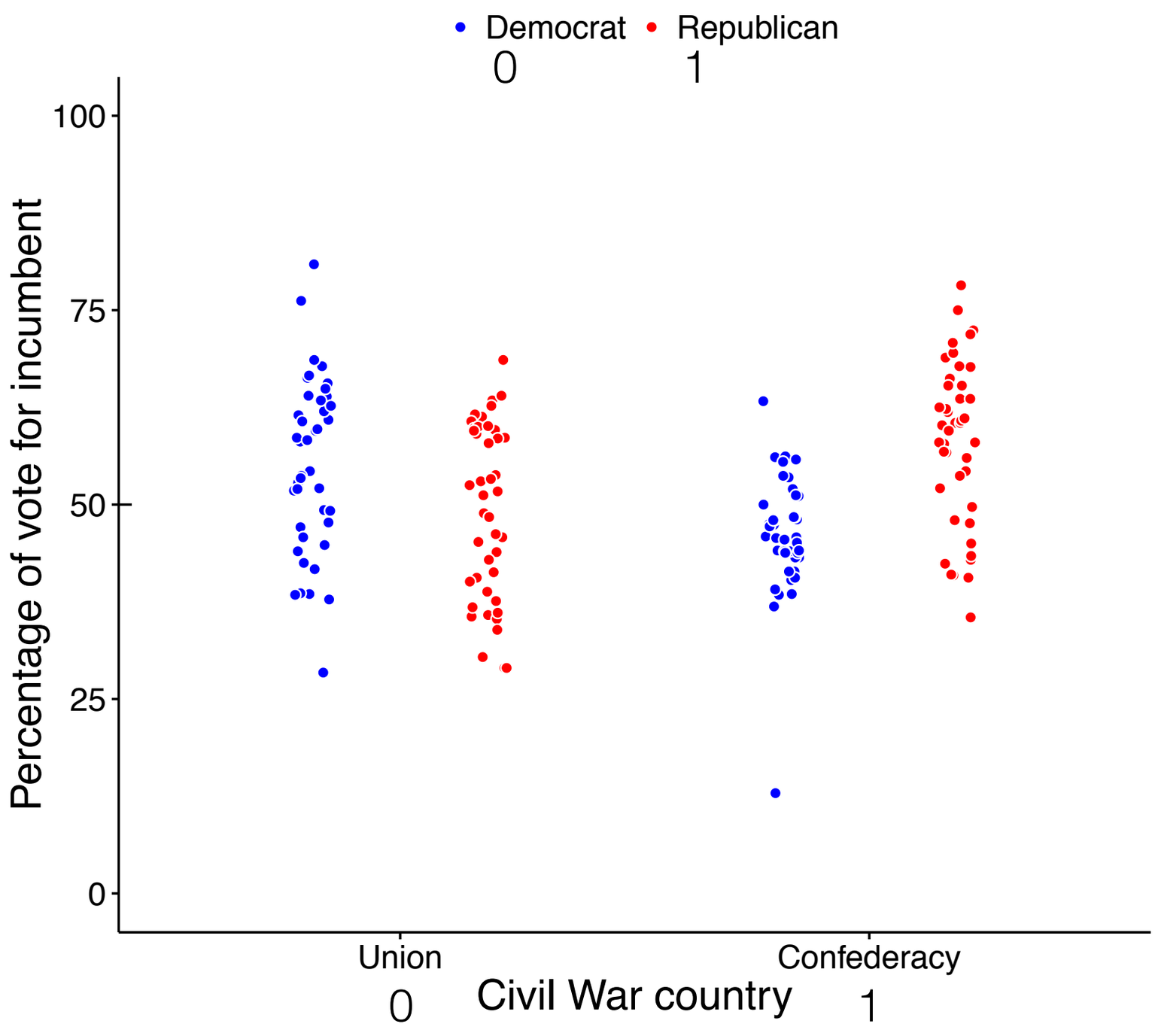
$$y_i = a + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{1i} x_{2i} + e_i$$



$$y_i = a + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{1i} x_{2i} + e_i$$

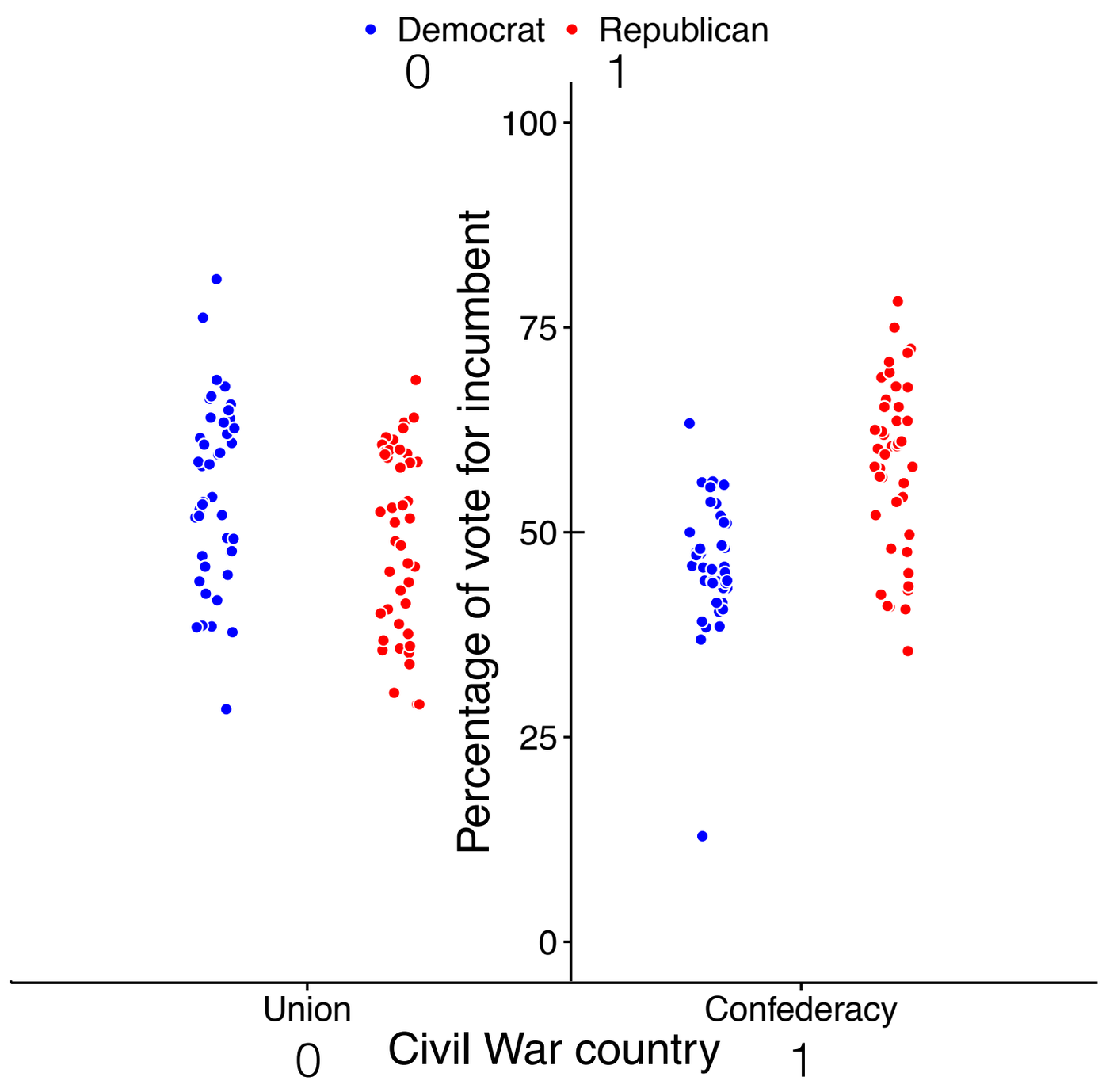


$$y_i = a + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{1i} x_{2i} + e_i$$

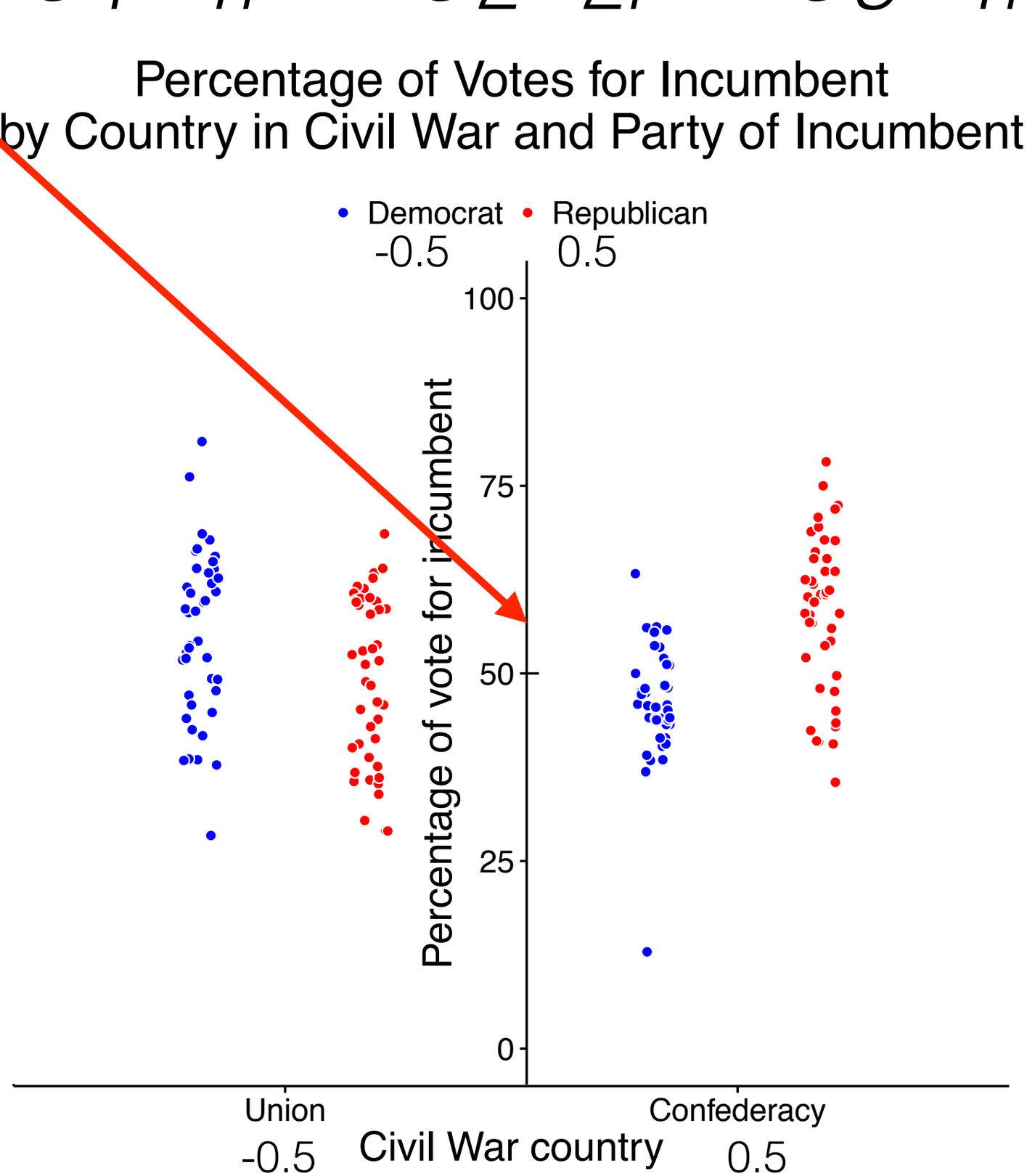


$$y_i = a + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{1i} x_{2i} + e_i$$

Percentage of Votes for Incumbent
by Country in Civil War and Party of Incumbent

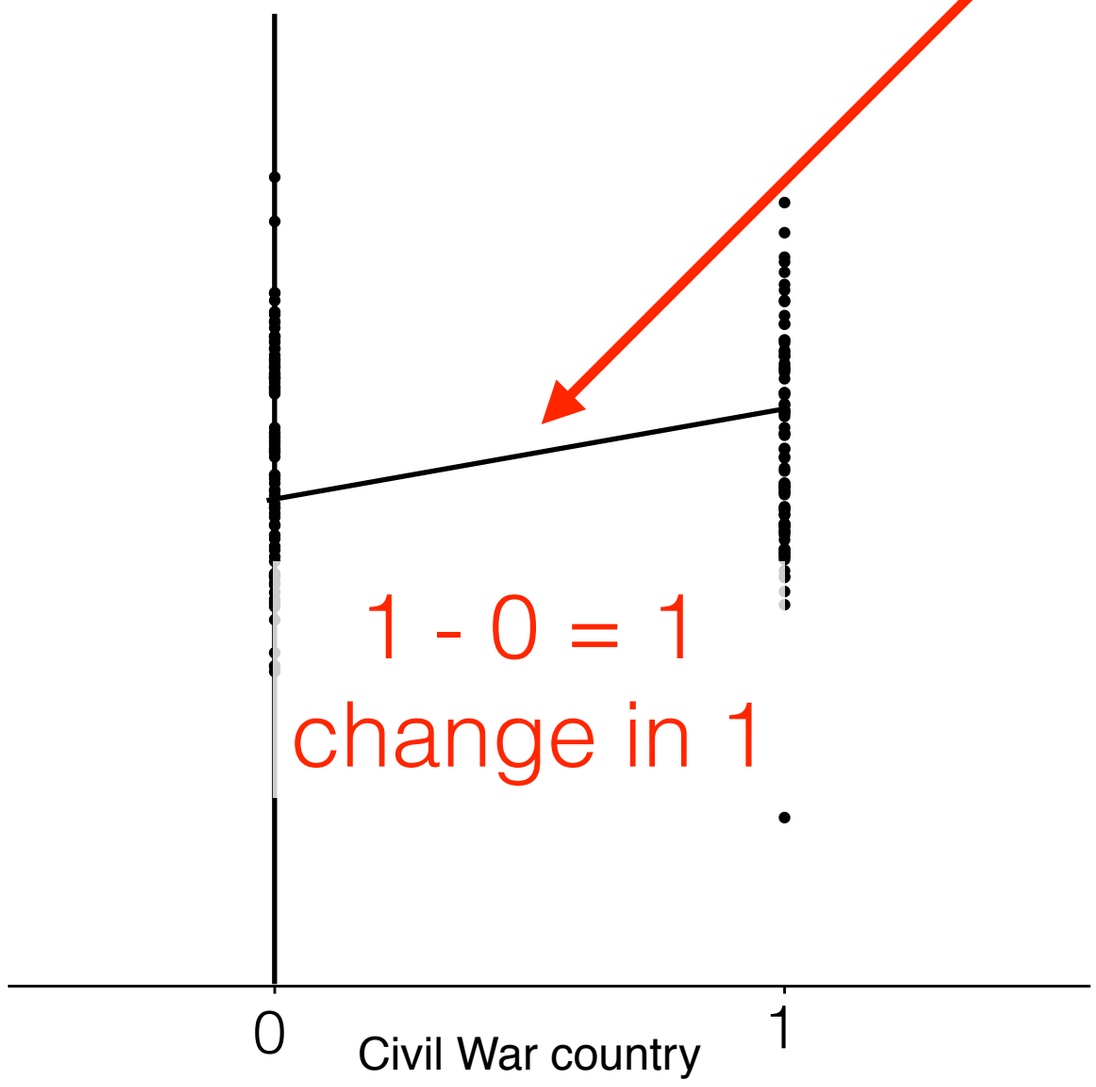


$$y_i = a + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{1i} x_{2i} + e_i$$

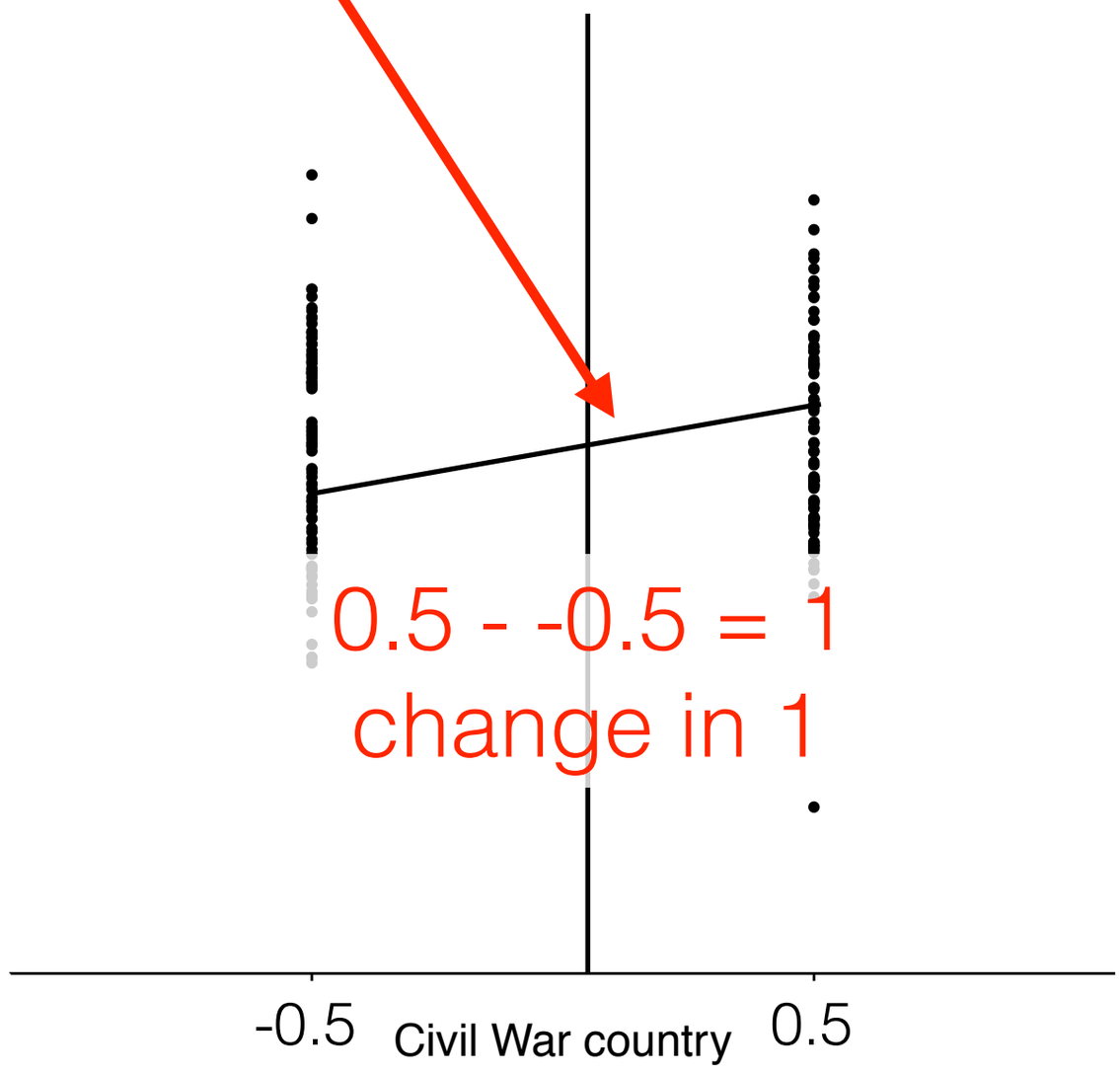


$$y_i = a + bx_i$$

dummy coding

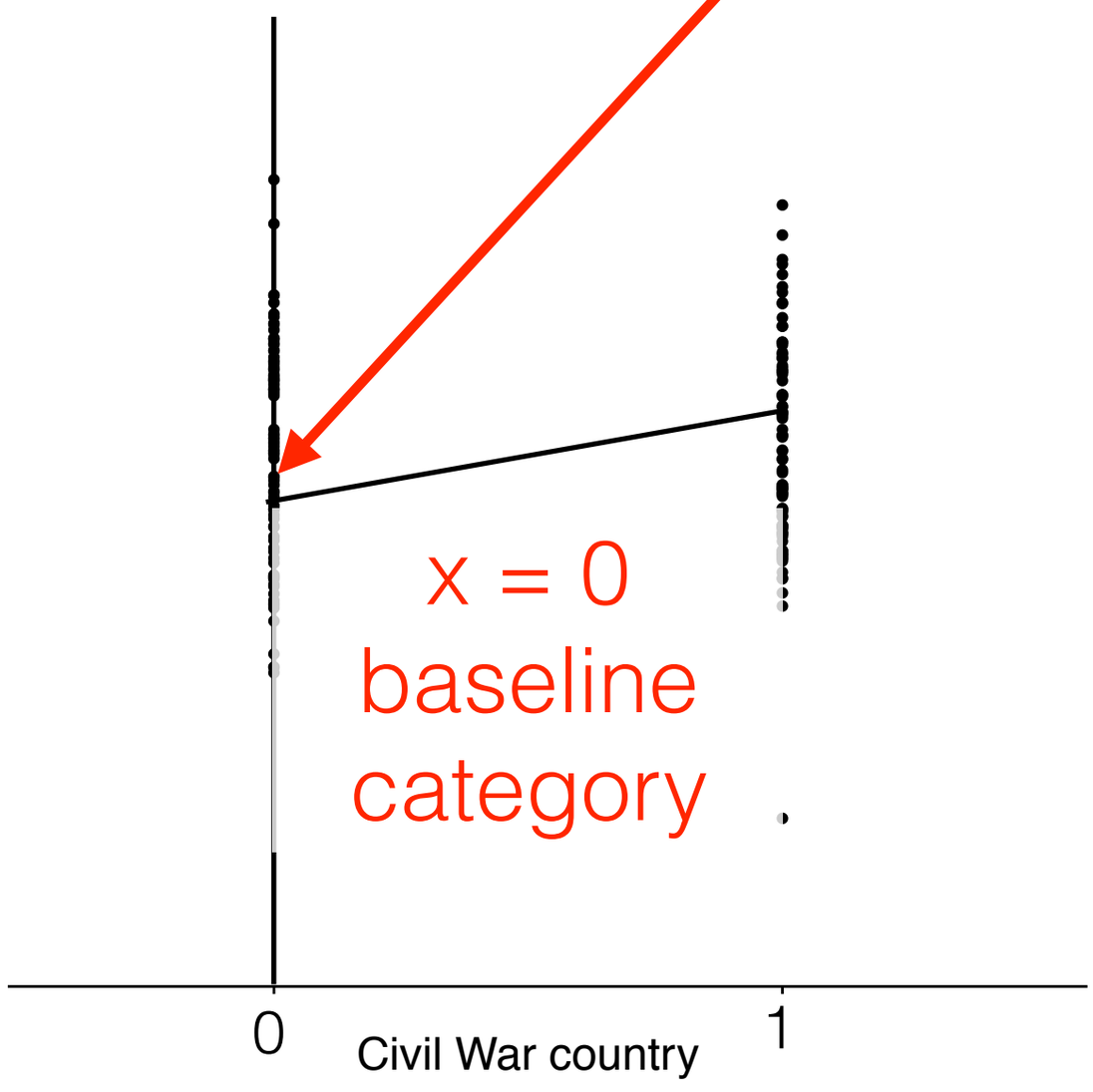


contrast coding

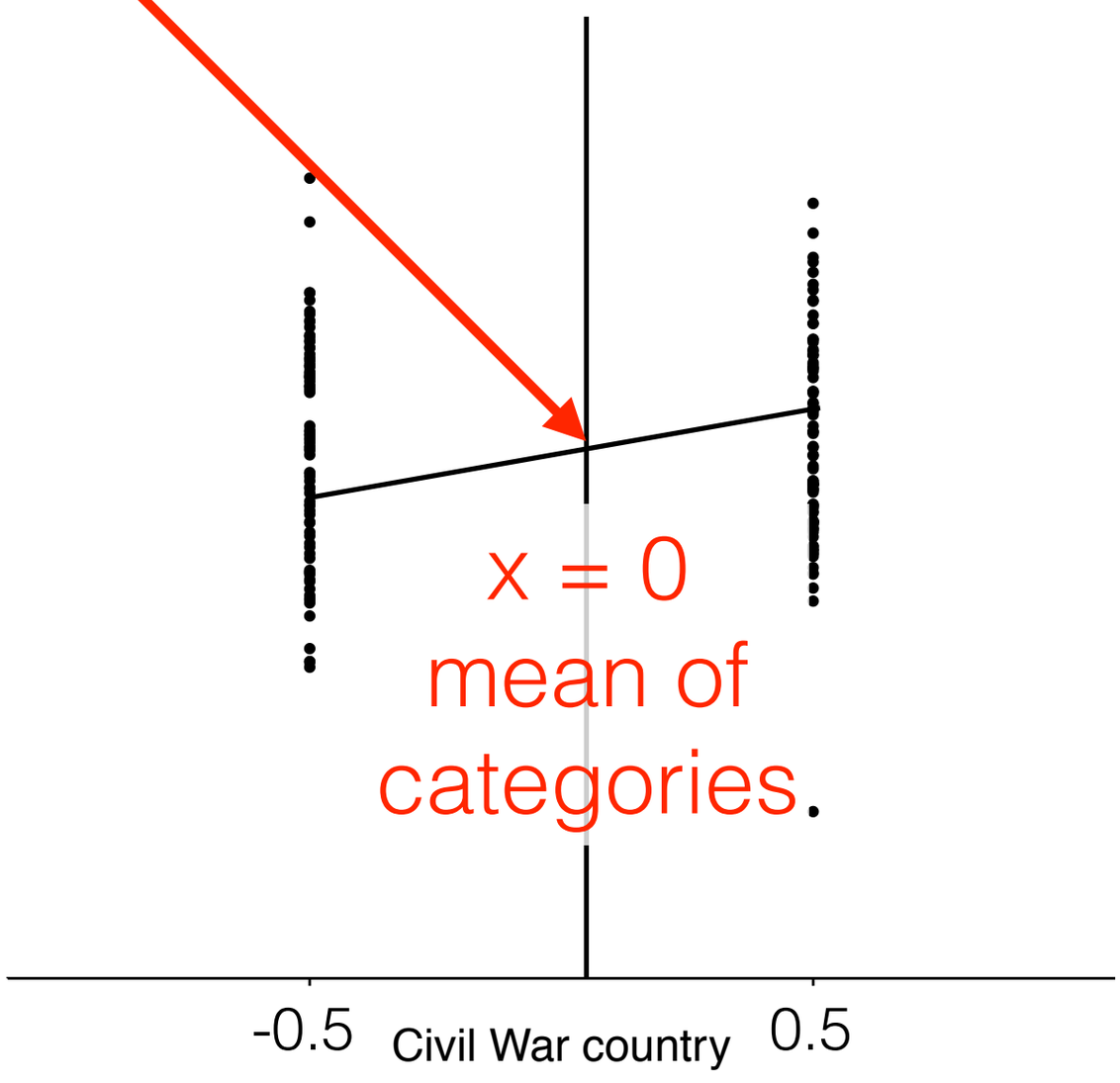


$$y_i = a + bx_i$$

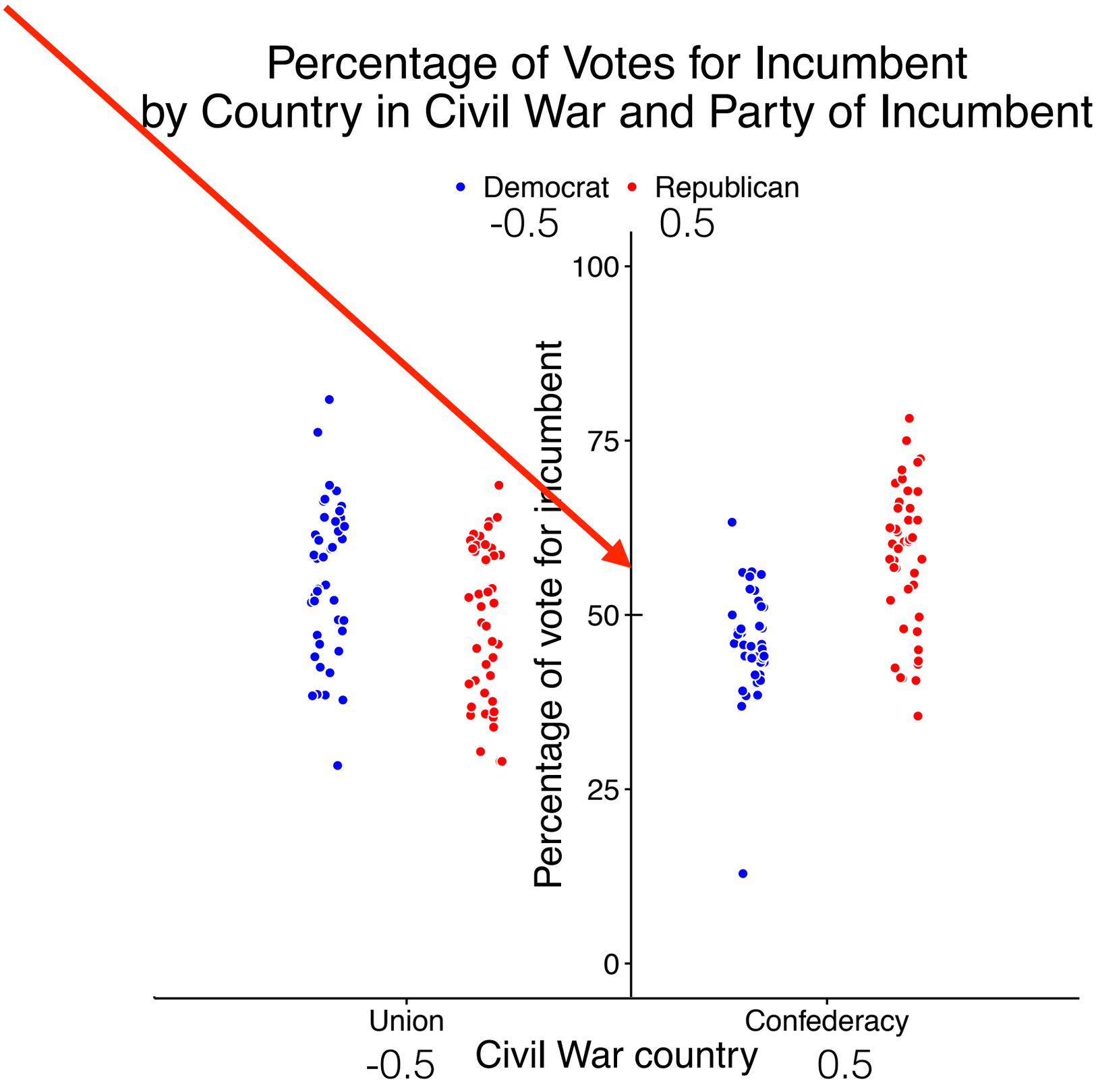
dummy coding



contrast coding



$$y_i = a + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{1i} x_{2i} + e_i$$



R Code (Part 1)

lme4

$$y_i = a + a_s + a_y + (b_{s1}+b_1)x_{1i} + (b_{y1}+b_2)x_{2i} + b_3x_{1i}x_{2i} + e_i$$

```
lmer(perc_votes_incumbent ~
incumbent_party_contrast * civil_war_contrast
  + (1+incumbent_party_contrast|state)
    + (1+civil_war_contrast|year))
```

```
Fixed effects:
                                                Estimate Std. Error t value
(Intercept)                                     52.04864    3.11346  16.717
incumbent_party_contrast                         2.92546    6.37541   0.459
civil_war_contrast                               0.04273    2.77575   0.015
incumbent_party_contrast:civil_war_contrast     18.39637    6.18901   2.972
```

LMEM with dummy coding

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	55.164	5.591	9.866
incumbent_partyRepublican	-6.273	8.012	-0.783
civil_warConfederacy	-9.155	4.183	-2.189
incumbent_partyRepublican:civil_warConfederacy	18.396	6.189	2.972

LMEM with contrast coding

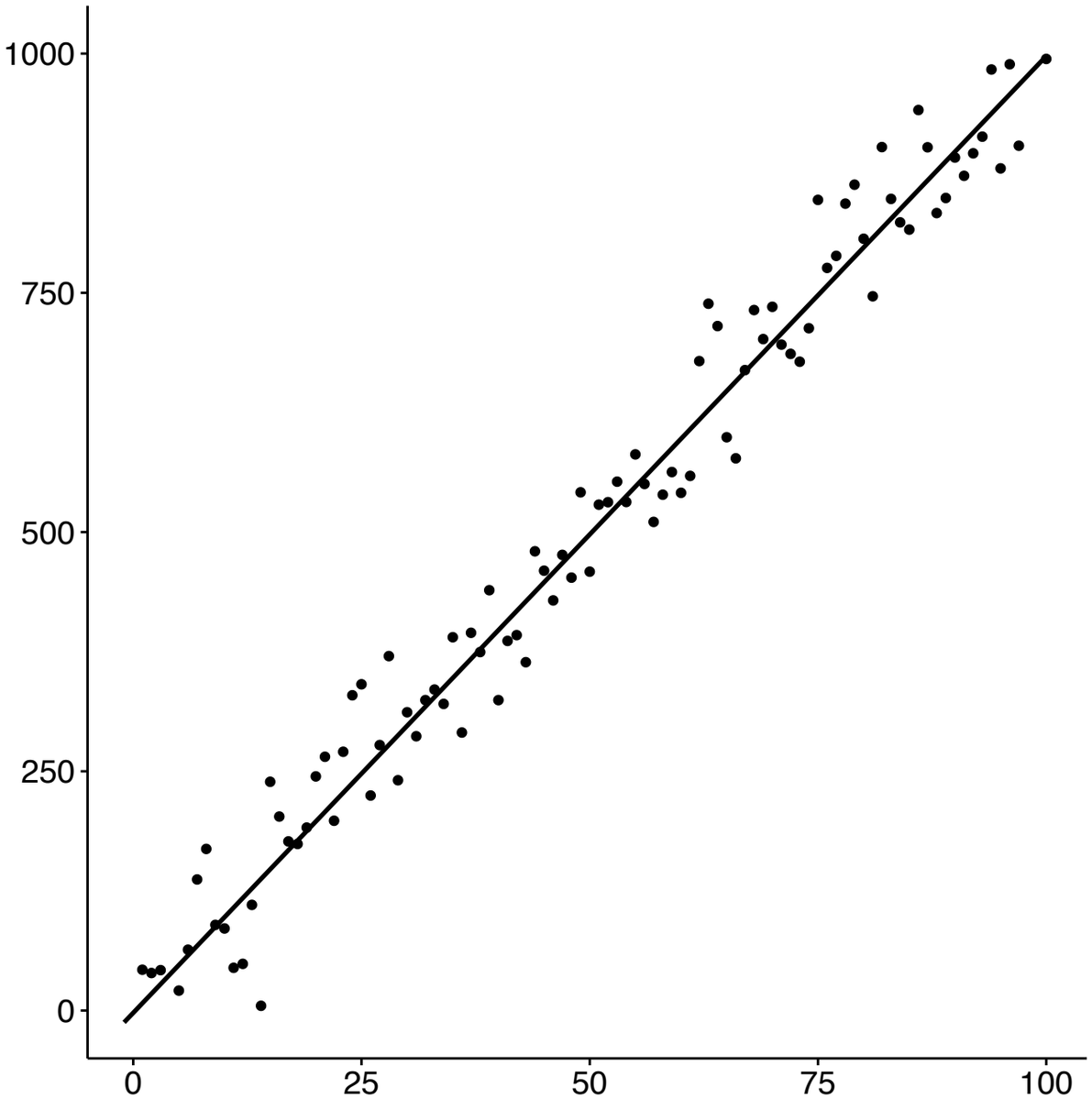
Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	52.04864	3.11346	16.717
incumbent_party_contrast	2.92546	6.37541	0.459
civil_war_contrast	0.04273	2.77575	0.015
incumbent_party_contrast:civil_war_contrast	18.39637	6.18901	2.972

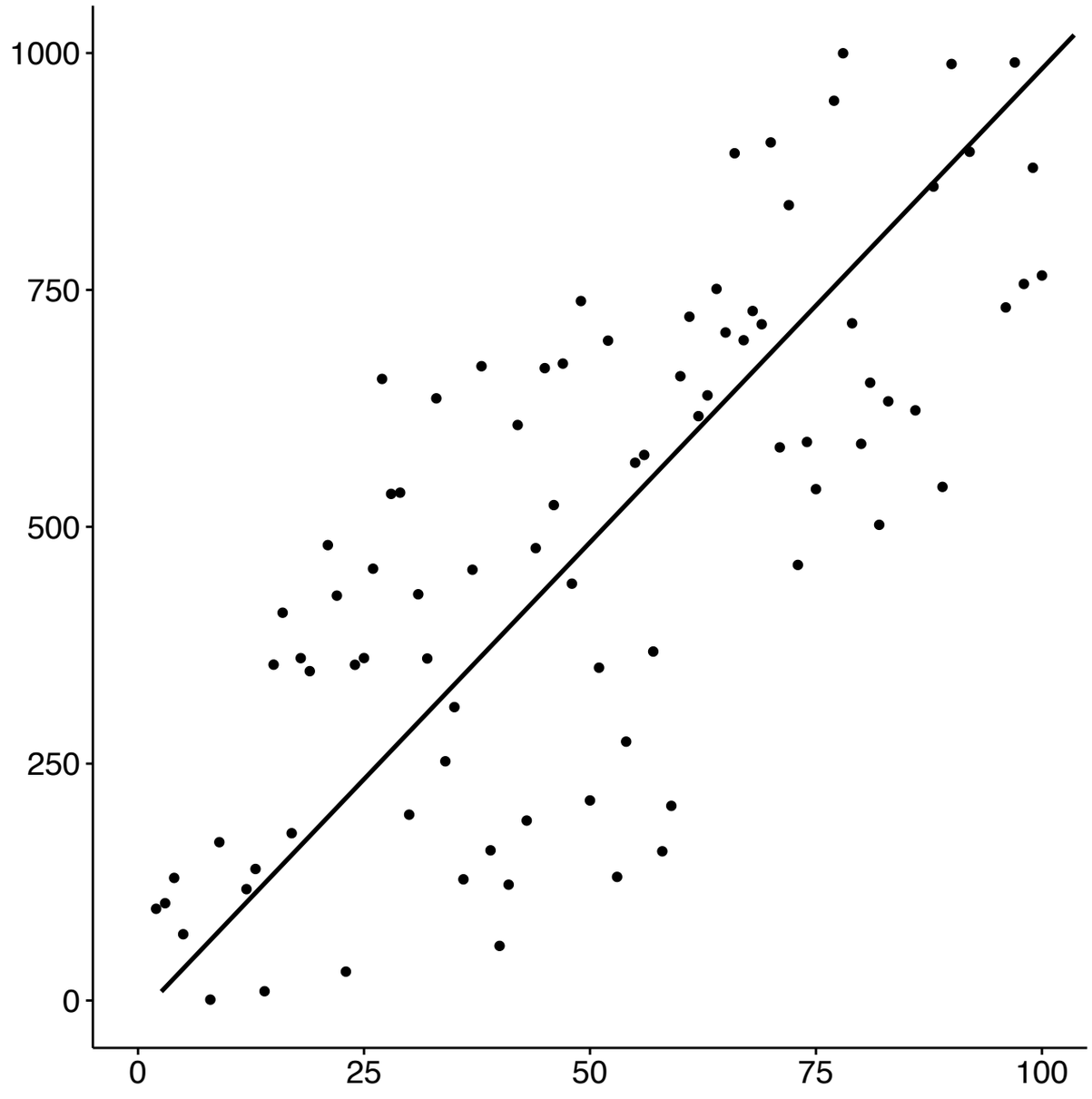
How do I get p-values out of this?

Math (Part 2)

very good fit



not as good fit



R Code (Part 2)

$$y_i = a + a_s + a_y + (b_{s1}+b_1)x_{1i} + (b_{y1}+b_2)x_{2i} + b_3x_{1i}x_{2i} + e_i$$

```
lmer(perc_votes_incumbent ~
incumbent_party_contrast * civil_war_contrast
    + (1+incumbent_party_contrast|state)
  + (1+civil_war_contrast|year), REML = F)
```

$$y_i = a + a_s + a_y + (b_{s1}+b_1)x_{1i} + (b_{y1}+b_2)x_{2i} + b_3x_{1i}x_{2i} - b_1x_{1i} + e_i$$

```
lmer(perc_votes_incumbent ~
incumbent_party_contrast * civil_war_contrast
          - incumbent_party_contrast
    + (1+incumbent_party_contrast|state)
  + (1+civil_war_contrast|year), REML = F)
```

$$y_i = a + a_s + a_y + (b_{s1}+b_1)x_{1i} + (b_{y1}+b_2)x_{2i} + b_3x_{1i}x_{2i} + e_i$$

$$y_i = a + a_s + a_y + (b_{s1}+b_1)x_{1i} + (b_{y1}+b_2)x_{2i} + b_3x_{1i}x_{2i} - b_1x_{1i} + e_i$$

```
anova(m1, m2_party)
```

```
           Df    AIC    BIC  logLik deviance  Chisq Chi Df Pr(>Chisq)
m2_party 10 1153.5 1185.1 -566.74   1133.5
m1       11 1155.2 1190.0 -566.61   1133.2 0.2706      1     0.6029
```

smaller AIC means better fit

not significant at $p < 0.05$

LMEM summary

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	52.04934	2.70659	19.231
incumbent_party_contrast	2.92405	5.57867	0.524
civil_war_contrast	0.04413	2.43834	0.018
incumbent_party_contrast:civil_war_contrast	18.39355	5.57298	3.300

model comparison for incumbent party

	Df	AIC	BIC	logLik	deviance	Chisq	Chi Df	Pr(>Chisq)
m2_party	10	1153.5	1185.1	-566.74	1133.5			
m1	11	1155.2	1190.0	-566.61	1133.2	0.2706	1	0.6029

model comparison for civil war

	Df	AIC	BIC	logLik	deviance	Chisq	Chi Df	Pr(>Chisq)
m3_country	10	1153.2	1184.9	-566.61	1133.2			
m1	11	1155.2	1190.0	-566.61	1133.2	3e-04	1	0.9856

model comparison for incumbent party x civil war

	Df	AIC	BIC	logLik	deviance	Chisq	Chi Df	Pr(>Chisq)
m4_partyxcountry	10	1160.8	1192.4	-570.39	1140.8			
m1	11	1155.2	1190.0	-566.61	1133.2	7.567	1	0.005945

Lab

Data set: Stroop Task

Congruency: Are responses to incongruent trials less accurate and slower than to congruent trials?

Experiment half: Are responses more accurate and faster in the second half of the experiment then the first half of the experiment?

Congruency x Experiment half: Is there an interaction between these variables?

accuracy (logistic)

logit p_i = accuracy
x1 = congruency
x2 = experiment half
r1 = participant
r2 = item

reaction times (linear)

y_i = reaction times
x1 = congruency
x2 = experiment half
r1 = participant
r2 = item

source: real students!

dplyr

```
data_accuracy_stats = data_accuracy_clean
```

dplyr

```
data_accuracy_stats = data_accuracy_clean %>%
          mutate(congruency_contrast =

                                        )
```

make new variable

dplyr

```
data_accuracy_stats = data_accuracy_clean %>%
          mutate(congruency_contrast =
                   ifelse(
                                    ))
```

make new variable

make condition statement

dplyr

```
data_accuracy_stats = data_accuracy_clean %>%
          mutate(congruency_contrast =
                   ifelse(congruency
                                    ))
```

make new variable

make condition statement

call original variable

dplyr

```
data_accuracy_stats = data_accuracy_clean %>%
          mutate(congruency_contrast =
                   ifelse(congruency == “con"
                                        ))
```

make new variable

make condition statement

call original variable

reference level

dplyr

```
data_accuracy_stats = data_accuracy_clean %>%
          mutate(congruency_contrast =
                   ifelse(congruency == “con",
                          -0.5     ))
```

make new variable

make condition statement

call original variable

reference level

new value of con

dplyr

```
data_accuracy_stats = data_accuracy_clean %>%
          mutate(congruency_contrast =
                   ifelse(congruency == “con",
                          -0.5, 0.5))
```

make new variable

make condition statement

call original variable

reference level

new value of con

new value of incon