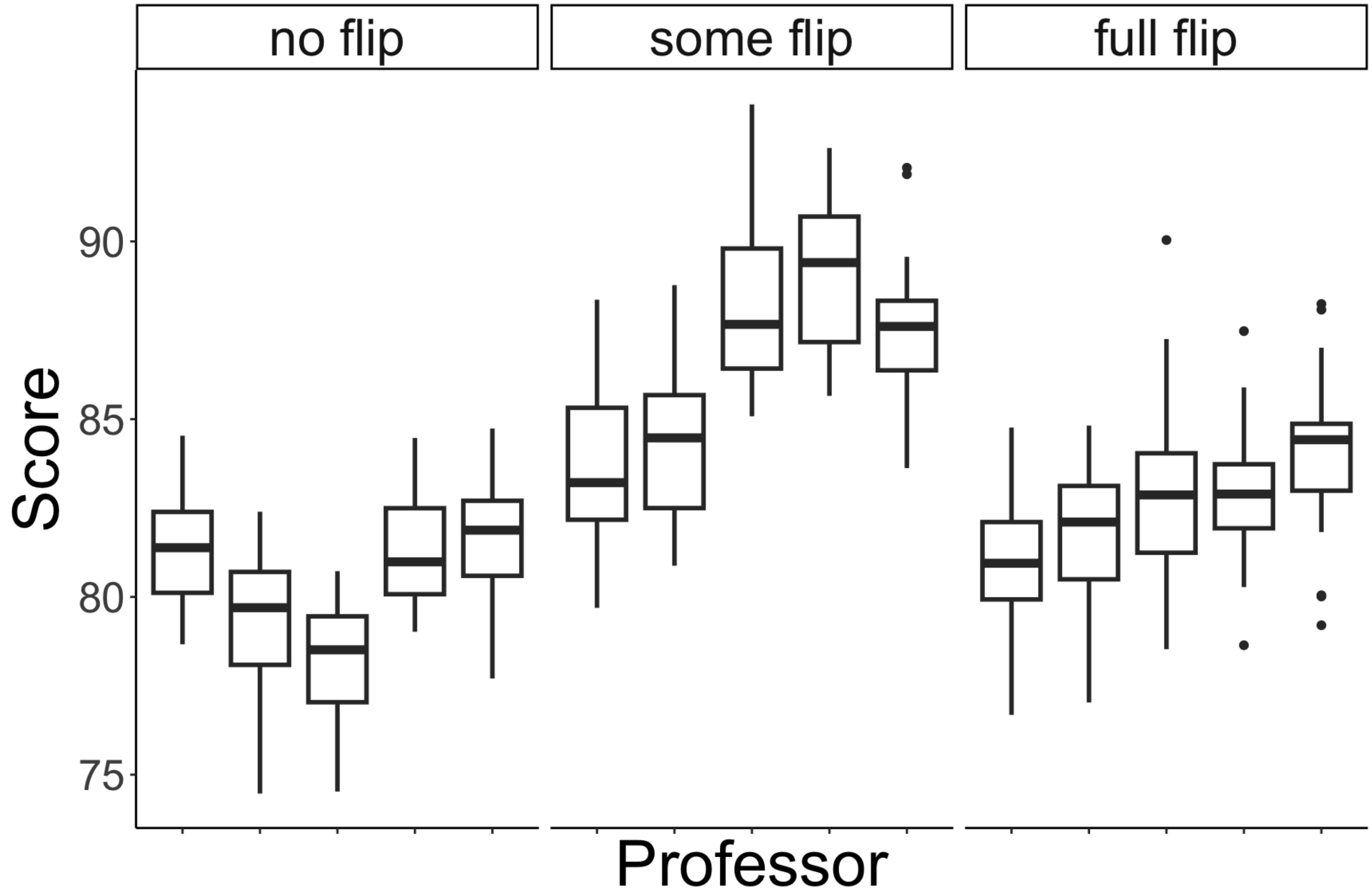
Lecture 31

Data: flipped classrooms?

Data set has 375 rows (one per student), and the following variables:

- `professor`: which professor taught the class (1 – 15)
- `style`: which teaching style the professor used (no flip, some flip, fully flipped)
- `score`: the student's score on the final exam

Visualizing the data



Mixed effects model

Linear mixed effects model: Let Score_{ij} be the score of student j in class i

$$\mathrm{Score}_{ij} = \beta_0 + \beta_1 \mathrm{SomeFlipped}_i + \beta_2 \mathrm{FullyFlipped}_i + u_i + \varepsilon_{ij}$$

$$\varepsilon_{ij} \overset{iid}{\sim} N(0, \sigma_\varepsilon^2) \qquad u_i \overset{iid}{\sim} N(0, \sigma_u^2)$$

Fitting mixed effects models

```
library(lme4)
m1 <- lmer(score ~ style + (1|professor),
           data = teaching)
summary(m1)
```

Fitting mixed effects models

```r
library(lme4)
```

```r
m1 <- lmer(score ~ style + (1|professor),
           data = teaching)
summary(m1)
```

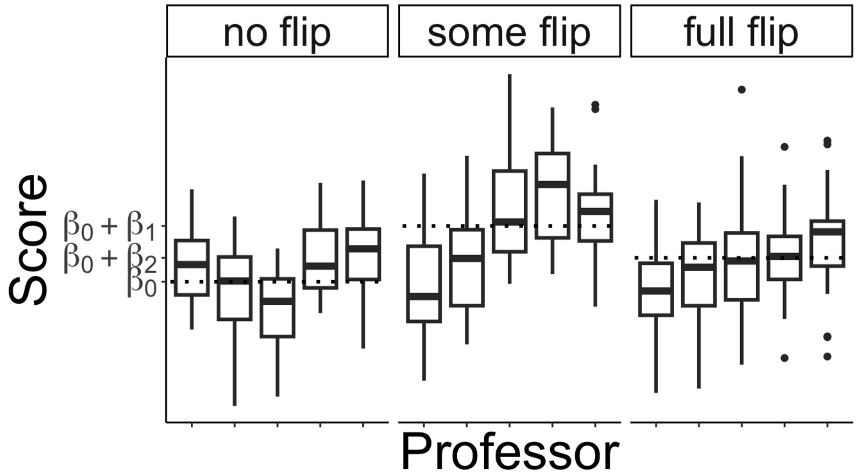
```
...
Random effects:
 Groups    Name        Variance Std.Dev.
 professor (Intercept) 21.365   4.622
 Residual               4.252   2.062
...
```

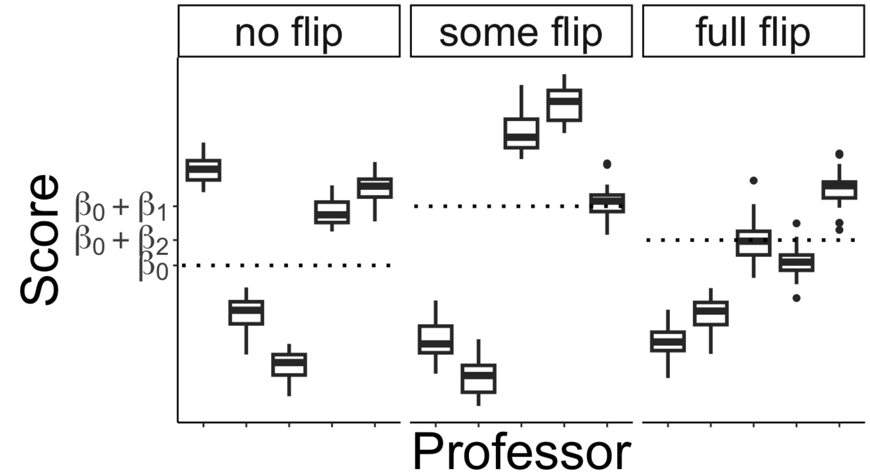
Fitting mixed effects models

```r
m1 <- lmer(score ~ style + (1|professor),
           data = teaching)
summary(m1)
```

```
...
Fixed effects:
               Estimate Std. Error t value
(Intercept)      77.657      2.075  37.419
stylesome flip   11.073      2.935   3.773
stylefull flip    2.805      2.935   0.956
...
```

Intra-class correlation





σ_ε^2 is large relative to σ_u^2

σ_ε^2 is small relative to σ_u^2

Intra-class correlation:

$$\varrho_{\text{group}} = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_\varepsilon^2} = \frac{\text{between group variance}}{\text{total variance}}$$

Intra-class correlation

$$\varepsilon_{ij} \overset{\text{iid}}{\sim} N(0, \sigma_\varepsilon^2) \qquad u_i \overset{\text{iid}}{\sim} N(0, \sigma_u^2)$$

- $\widehat{\beta}_0 = 77.66, \qquad \widehat{\beta}_1 = 11.07, \qquad \widehat{\beta}_2 = 2.81$
- $\widehat{\sigma}_\varepsilon^2 = 4.25, \qquad \widehat{\sigma}_u^2 = 21.37$

$$\widehat{\rho}_{\text{group}} = \frac{21.37}{21.37 + 4.25} = 0.83$$

So 83% of the variation in student's scores can be explained by differences in average scores from class to class (after accounting for teaching style). That's huge!

Class activity

https://sta712-f23.github.io/class_activities/ca_lecture_32.html