Quiz 3

Data Science for Studying Language & the Mind

Estimated time: 30 minutes

You may need more time if programming is completely new to you, or less if you have some experience already.

Instructions

- The quiz is closed book/note/computer/phone
- If you need to use the restroom, leave your exam and phone with the TA
- You have 60 minutes to complete the quiz. If you finish early, you may turn in your quiz and leave early

Name: ____
PennKey: ______________________________________

Lab section TA: __________________________________

Score by topic area

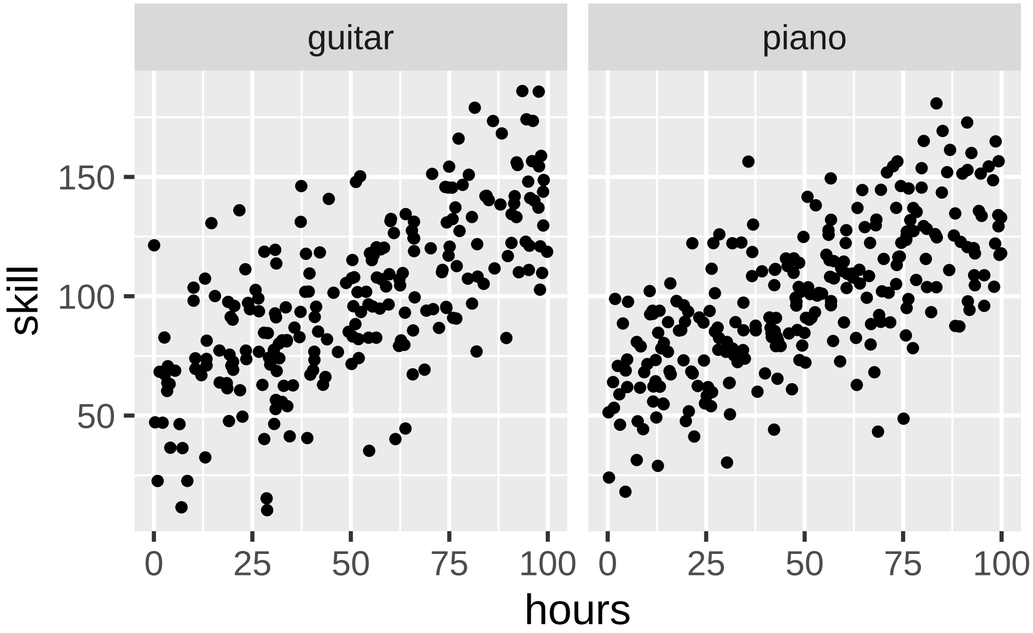
Model Fitting	
Model Fitting in R	
Model Accuracy	
Model Accuracy in R	
Total	

The data

Suppose we want to study the effect hours practicing an instrument has on your ultimate skill level with the instrument. We study 500 participants who are learning to play either piano or guitar. Below we explore these data in a few ways.

```
glimpse(data)
```

```
Rows: 500
Columns: 4
$ hours              <dbl> 11.3703411, 62.2299405, 60.9274733, 62.3379442, 86.~
$ instrument_recoded <dbl> 1, 0, 0, 0, 0, 1, 0, 1, 1, 1, 1, 0, 1, 1, 0, 0, 0, ~
$ skill              <dbl> 93.91577, 79.16551, 126.48513, 107.13986, 173.43843~
$ instrument         <chr> "piano", "guitar", "guitar", "guitar", "guitar", "p~
```



```
data %>%
    group_by(instrument) %>%
    summarise(
        n = n(),
        mean_skill = mean(skill), sd_skill = sd(skill),
        mean_hours = mean(hours), sd_hours = sd(hours))
```

```
# A tibble: 2 x 6
  instrument     n mean_skill sd_skill mean_hours sd_hours
  <chr>      <int>      <dbl>    <dbl>      <dbl>    <dbl>
1 guitar       233       99.2     34.8       51.0     28.4
2 piano        267       99.1     30.9       50.1     28.3
```

1 Model Fitting

Suppose we fit a model represented by the following equation, where x_1 is the number of hours spent pracicing, x_2 is the instrument, and y is the skill acheived:

$y = b_0 + b_1 x_1 + b_2 x_2$

(a) Which of the following would work to estimate the free parameters of this model? Choose one.

□ only gradient descent
□ only ordinary least squares
□ both gradient descent and ordinary least squares

(b) True or false, ordinary least squares finds the best fitting free paramters by solving a system of linear equations.

□ True
□ False

(c) True or false, when performing gradient descent on a **nonlinear** model, we might arrive at a local minimum and miss the global one.

□ True
□ False

(d) True or False, given the model above, gradient descent and ordinary least squares would both converge on approximately the same parameter estimates.

□ True
□ False

2 Model Fitting in R

Questions in section 2 refer to the code below.

```
# fit model with lm
model
```

```
Call:
lm(formula = skill ~ hours + instrument_recoded, data = data)

Coefficients:
       (Intercept)               hours  instrument_recoded
           58.9493              0.7885              0.6834
```

```
#fit model with optimg
optimg(data = data, par = c(1,1,1), fn=SSE, method = "STGD")
```

```
$par
[1] 58.9488377  0.7884514  0.6900582

$value
[1] 286497.6

$counts
[1] 26

$convergence
[1] 0
```

(a) What parameters did the gradient descent algorithm try first?

(b) Which of the following could be the model specification in R? Choose all the apply.

- □ `skill ~ hours + instrument_recoded`
- □ `skill ~ hours * instrument_recoded`
- □ `skill ~ 1 + hours + instrument_recoded`

□ `y ~ x`
□ `y ~ 1 + x`

(c) Given the equation given below, what are the best fitting free parameter for b_1 and b_2?

$y = b_0 + b_1 x_1 + b_2 x_2$ where x_1 is the number of hours spent practicing, x_2 is the instrument, and y is the skill acheived.

\answerbox

(d) Which of the following could be the value of the sum of squared errors when the parameters b_0, b_1, and b_2 are set to 0?

□ exactly 286497.6
□ a value higher than 286497.6
□ a value lower than 286497.6
□ approximately 26
□ approximately 0

3 Model Accuracy

Questions in section 3 refer to the following code below.

```r
summary(model)
```

```

Call:
lm(formula = skill ~ hours + instrument_recoded, data = data)

Residuals:
    Min      1Q  Median      3Q     Max 
-71.284 -15.388  -0.196  16.230  68.624 

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)    
(Intercept)        58.94933    2.49405  23.636   <2e-16 ***
hours               0.78845    0.03795  20.778   <2e-16 ***
instrument_recoded  0.68342    2.15273   0.317    0.751    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 24.01 on 497 degrees of freedom
```

```
Multiple R-squared:  0.4649,    Adjusted R-squared:  0.4627
F-statistic: 215.9 on 2 and 497 DF,  p-value: < 2.2e-16
```

(a) What is the R^2 for this model?

(b) Which of the following is true about this R^2 value?

□ tends to overestimate R^2 on the population
□ tends to underestimate R^2 on the population
□ tends to overestimate R^2 on the sample
□ tends to underestimate R^2 on the sample

(c) Explain why an overfit model would perfrom well on the sample, but poorly on predicting new values.

(d) True or false, we can use cross-valiation **or** bootstrapping to estimate R^2 on the population?

□ True
□ False

4 Model Accuracy in R

Quesitons in section 4 refer to the following code:

```
# we divide the data
set.seed(2)
splits <- vfold_cv(data, v = 20)

# model secification
model_spec <-
  linear_reg() %>%
  set_engine(engine = "lm")

# add a workflow
```

```r
our_workflow <-
  workflow() %>%
  add_model(model_spec) %>%
  add_formula(skill ~ hours + instrument_recoded)

# fit models
fitted_models <-
  fit_resamples(
    object = our_workflow,
    resamples = splits
    )

fitted_models %>%
    collect_metrics()
```

```
# A tibble: 2 x 6
  .metric .estimator   mean     n std_err .config
  <chr>   <chr>       <dbl> <int>   <dbl> <chr>
1 rmse    standard   23.8      20  0.762  Preprocessor1_Model1
2 rsq     standard    0.468    20  0.0267 Preprocessor1_Model1
```

(a) In the outupt above, what is our estimate for R^2 on the population?

(b) In the code above, what method did we use to estimate R^2 on the population? Choose one.

□ k-fold cross-valiation
□ leave one out cross-valiation
□ boostrapping
□ workflow()

(c) In the code above, how many models did we fit when calling `fit_resamples()`?

□ 2
□ 20
□ 10
□ 100

(d) True or false, if we estimated the R^2 for the population with another approach, the value would be exactly the same.

□ True
□ False