STA 235 - Causal Inference: K-nearest neighbors

Spring 2021

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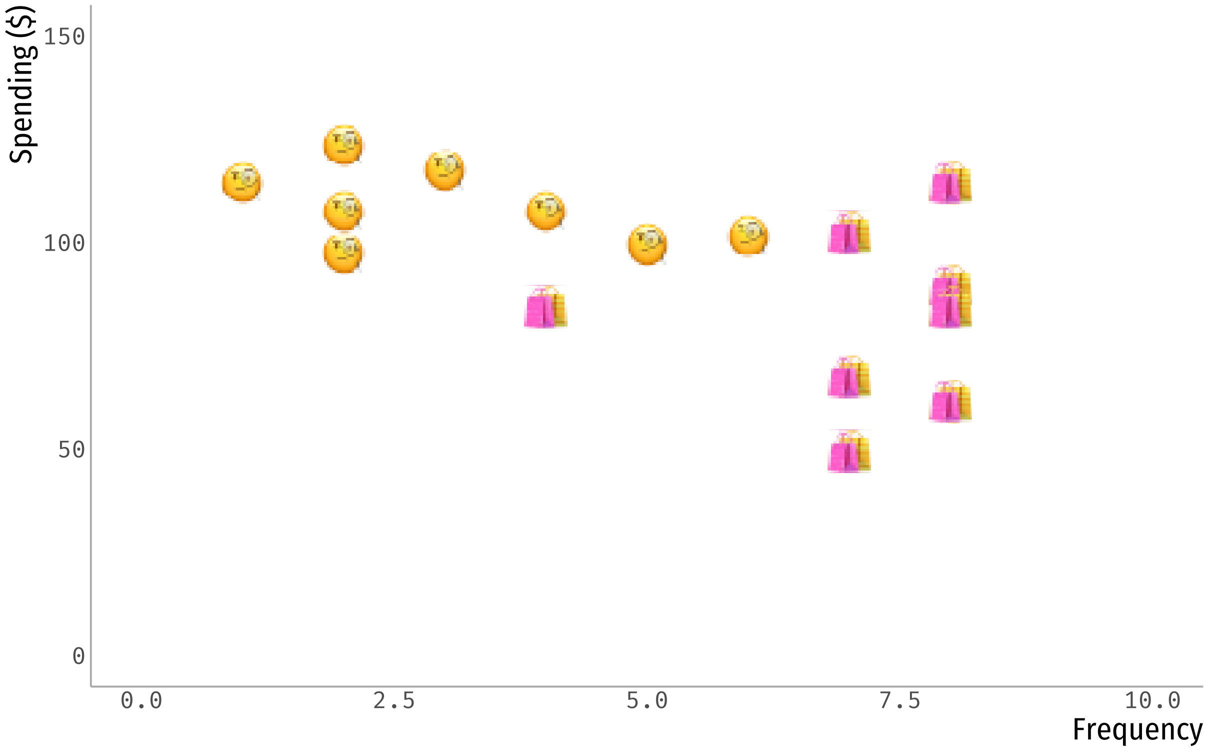
Prediction tasks

- We have seen the main issue with **bias vs variance trade-off**
- Beyond regression, **what methods can we use for prediction?**

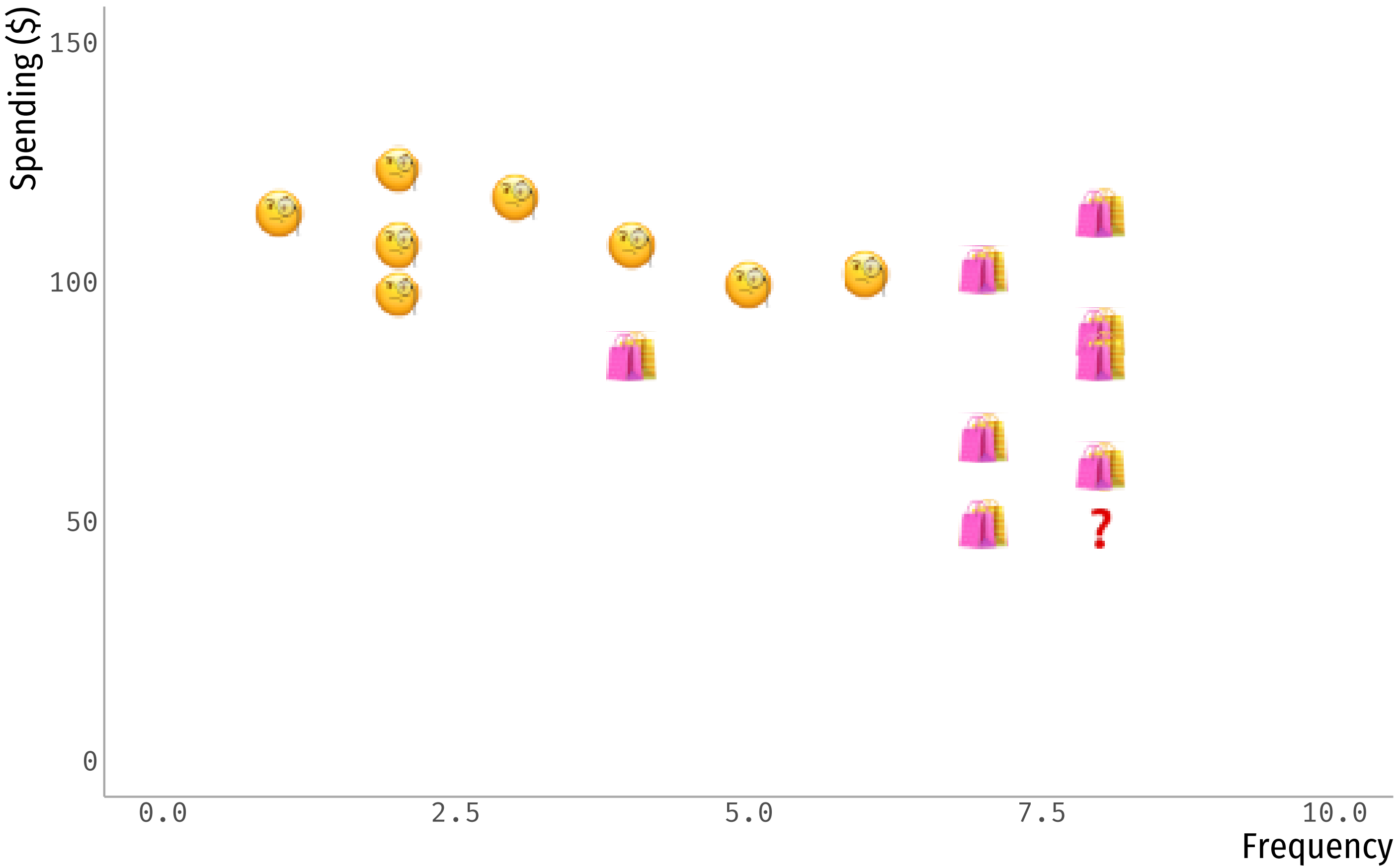
K-nearest neighbor

KNN as a classification problem

- Again: Window shoppers vs high rollers



How would you classify this unit?



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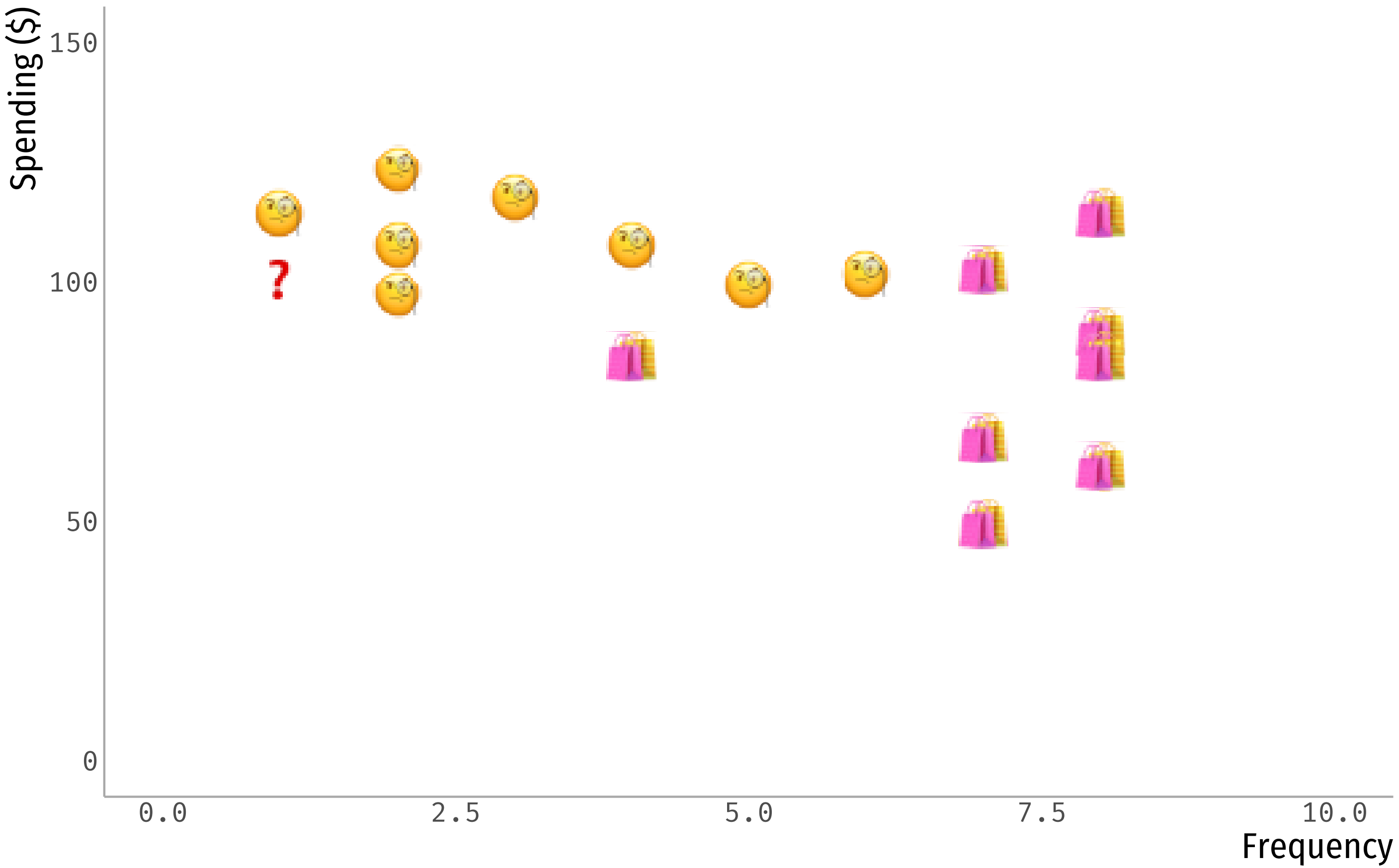
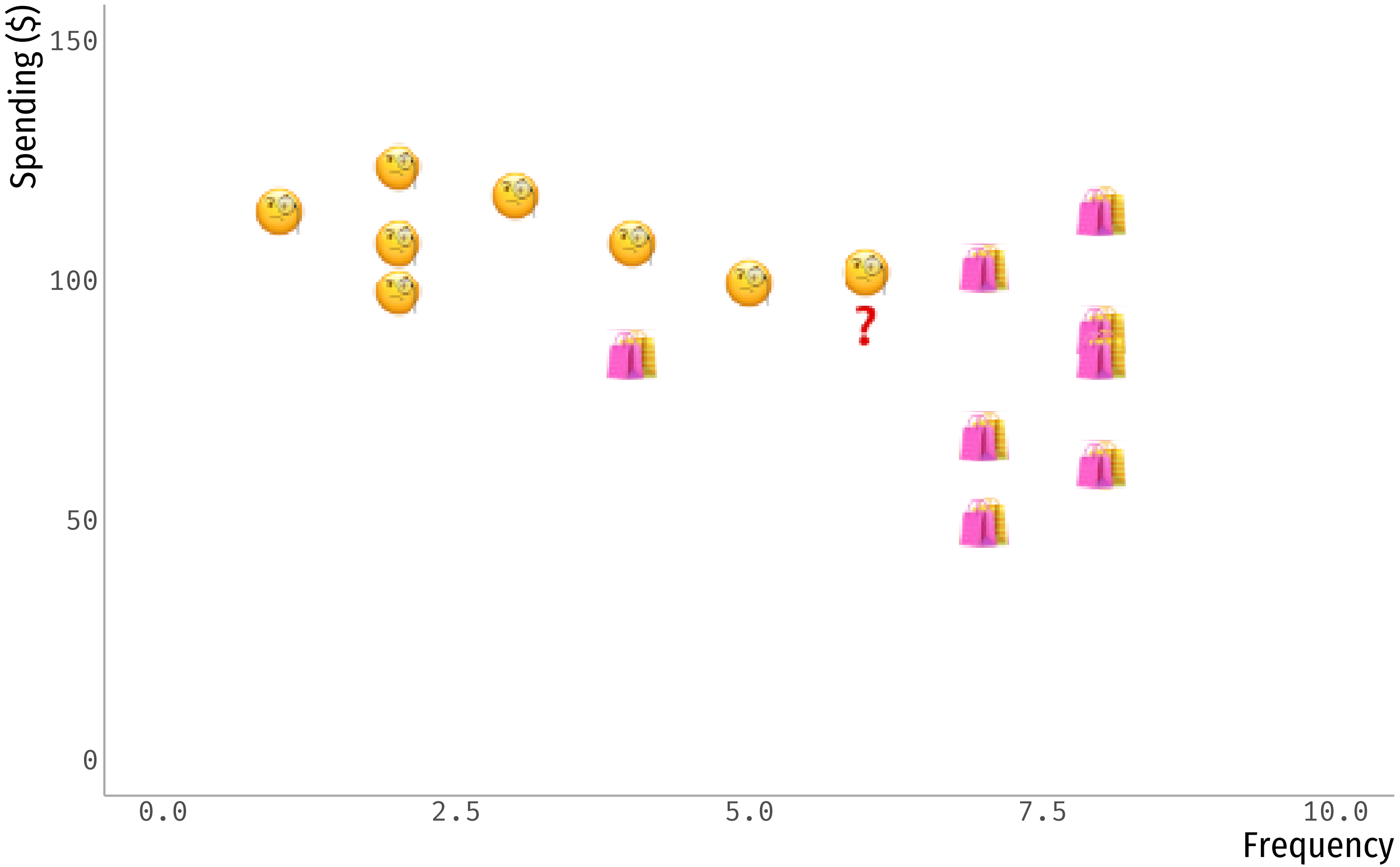


But what about this one?



K-nearest neighbor classifier

- One of the **simplest classifications methods**

1) Choose a **distance measure** (e.g. eucledian).

2) Choose a **number of neighbors**, K (*Note: Choose an odd number!*).

3) **Calculate the distance** between data and other points.

4) Calculate the **rate for each class** according to K: $Pr(Y = j|X = x_0) = \frac{1}{K} \sum_{i \in N_0} \mathrm{I}(y_i = j)$.

5) **Assign the majority class**.

KNN with $K = 1$

Classifier: High-roller

KNN with $K = 3$

Classifier: High-roller

KNN with $K = 9$

Classifier: Window-shopper

Poll time!

A lower number of neighbors K yields...

KNN Classifier in R?

```r
library(caret)

d <- read.csv("https://raw.githubusercontent.com/maibennett/sta235/main/exampleSite/content/Classes/

head(d)
```

```
##   freq female spend type
## 1   10      1    59   WS
## 2    7      1    71   WS
## 3    6      1    79   WS
## 4    3      0    97   HR
## 5    9      1    52   WS
## 6   10      1    56   WS
```

KNN Classifier in R?

```r
library(caret)

d <- read.csv("https://raw.githubusercontent.co

set.seed(100)

n <- nrow(d)

train.row <- sample(1:n, 0.8*n)

test.data <- d[-train.row,]
train.data <- d[train.row,]

knn <- train(
  type ~., data = train.data,
  method = "knn",
  trControl = trainControl("cv", number = 10),
  preProcess = c("center","scale"),
  tuneLength = 15
  )
```

- Again, we'll be using the `caret` package.

KNN Classifier in R?

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- Create a **training** and **testing** dataset.

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- Again, we'll be using the `caret` package.
- Create a **training** and **testing** dataset.
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- We also **pre-process** the data. Why?

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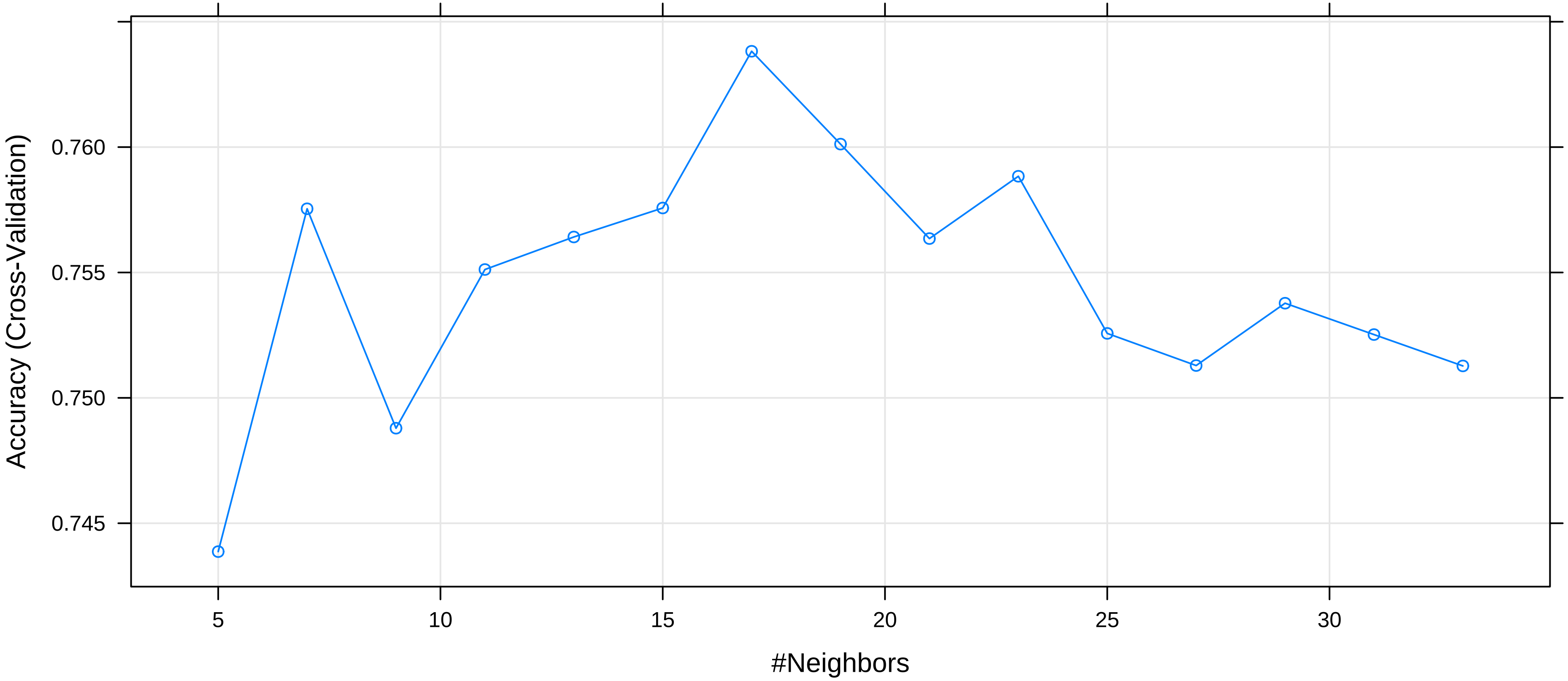
  method = "knn",
  trControl = trainControl("cv", number = 10),
  preProcess = c("center","scale"),
  tuneLength = 15
  )
```

- Again, we'll be using the `caret` package.
- Create a **training** and **testing** dataset.
- Use the method `knn` on a factor variable (i.e. classification)
- We also **pre-process** the data. Why?
- `tuneLength` is the level of granularity for searching K.

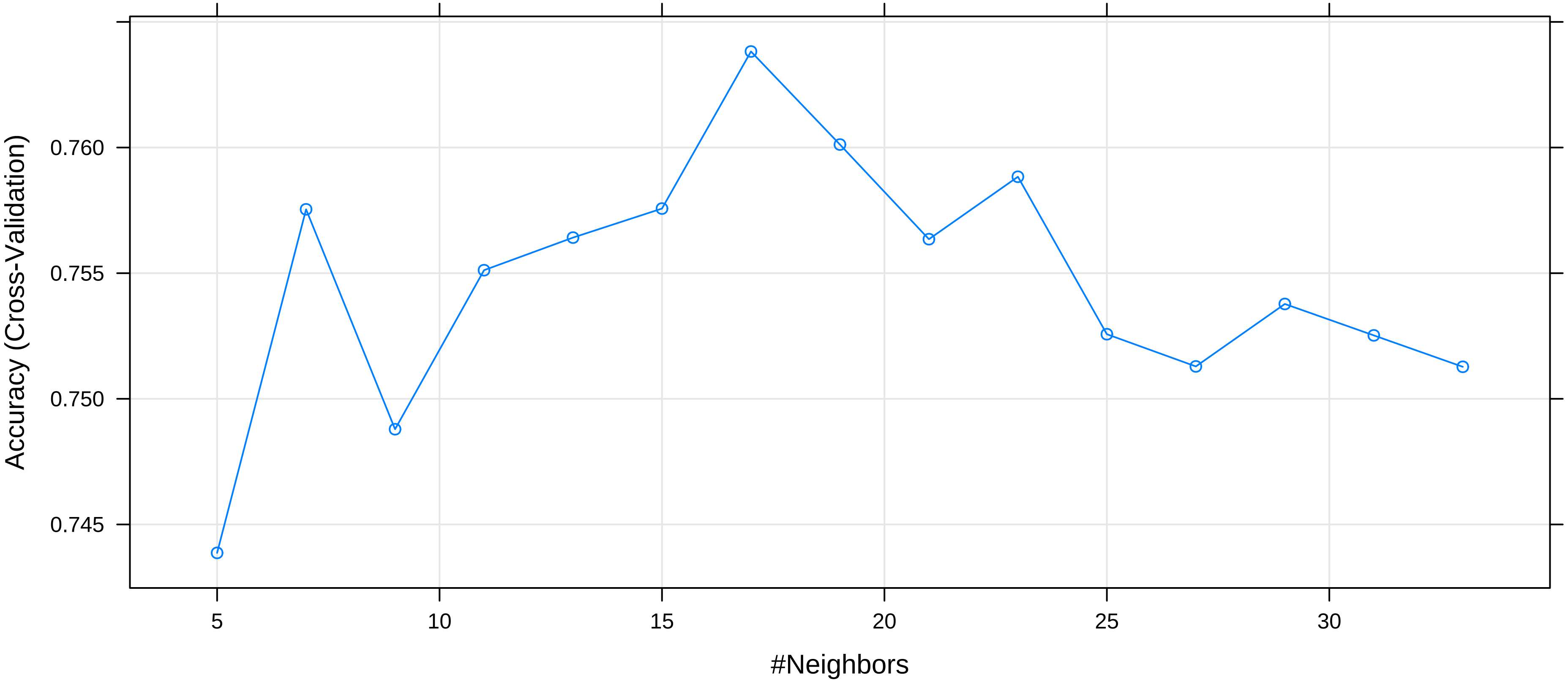
How many neighbors?

We can see the optimal K using `bestTune` parameter.



Poll time

Which K would you choose?



How accurate is this?

- For **classification** problems, we care about *false positive* and *false negative*.
- Say 1: window-shoppers and 2: high-rollers.

```
pred.type <- knn %>% predict(test.data)

table(pred.type, test.data$type)
```

```
##
## pred.type HR WS
##        HR 72 28
##        WS 17 83
```

Poll time

In a table like this, where would you like to see most of the observations?

```r
pred.type <- knn %>% predict(test.data)

table(pred.type, test.data$type)
```

```
##
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##        HR 73 28
##        WS 16 83
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pred.type <- knn %>% predict(test.data)

table(pred.type, test.data$type)
```

```
##
## pred.type HR WS
##        HR 73 29
##        WS 16 82
```

```
mean(pred.type == test.data$type)
```

```
## [1] 0.775
```

KNN for regression

- We can also use KNN for **continuous outcomes**
- **Similar** to the KNN classifier, but now we will take the *average of the K-neighbors* for prediction:

$$\hat{f}\left(x_0\right) = \frac{1}{K} \sum_{i \in N_0} y_i$$

KNN Regression in R?

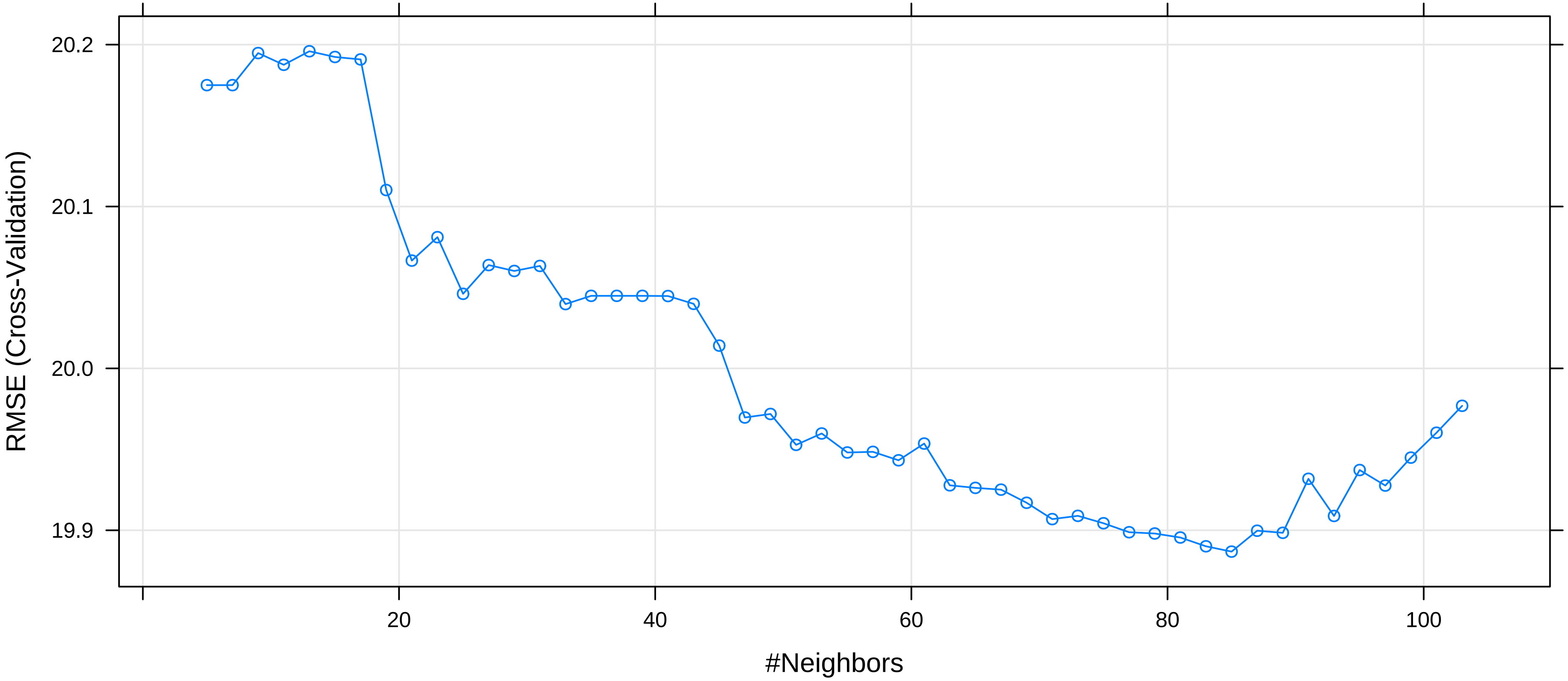
```
library(caret)

d <- read.csv("https://raw.githubusercontent.co

set.seed(100)

n <- nrow(d)

train.row <- sample(1:n, 0.8*n)

test.data <- d[-train.row,]
train.data <- d[train.row,]

knnr <- train(
  spend ~. - type, data = train.data,
  method = "knn",
  trControl = trainControl("cv", number = 10),
  preProcess = c("center","scale"),
  tuneLength = 50
  )
```

Same as before!

... but with a continuous variable

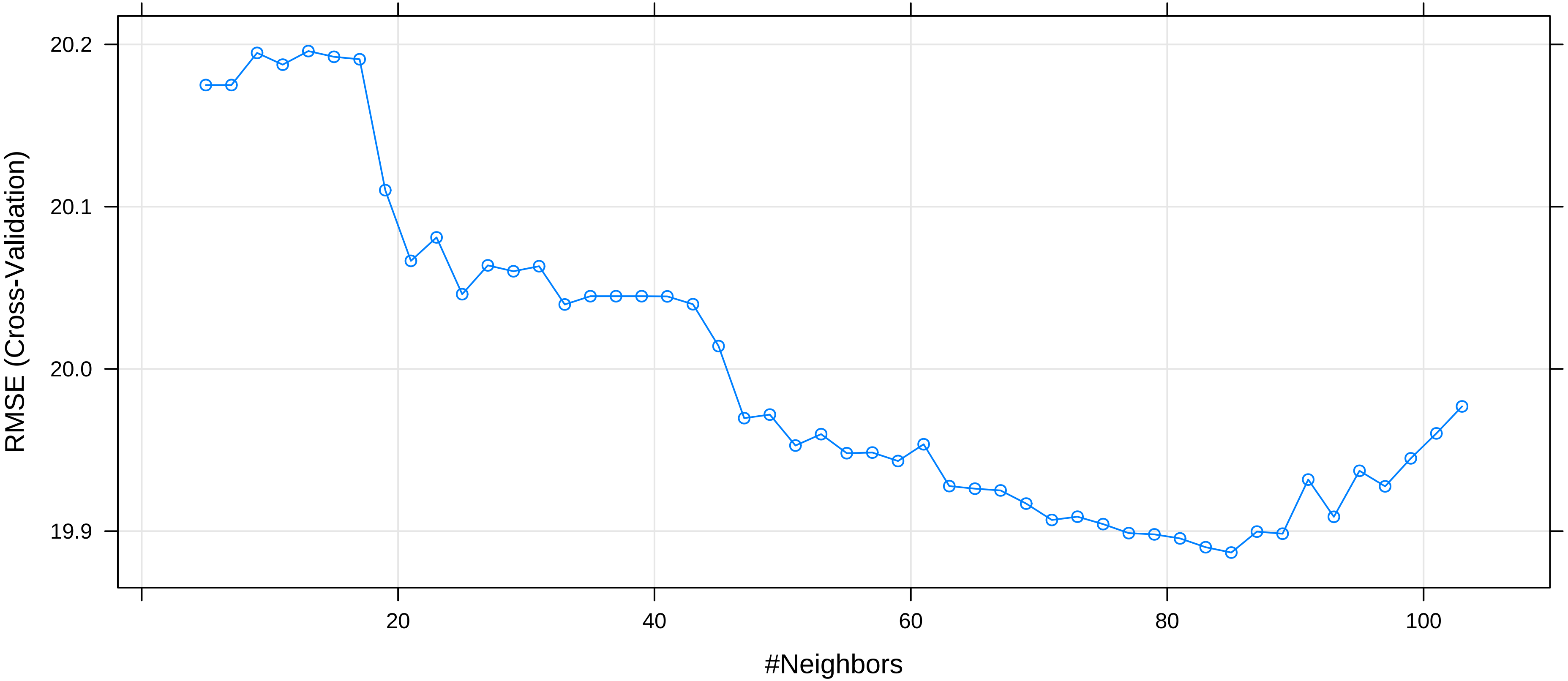
Choose optimal K

We get the optimal K the same way, using `knnr$bestTune`



Poll time

Which K would you choose?



Takeaway points

- KNN is a simple, nonparametric way to do prediction for both **categorical** and **continuous** outcomes.
- Be sure to **check your accuracy/error metric** depending on your outcome.
- **Pre-processing** can play an important role!

Plot your data and results

Next class

- Other **prediction methods**:

Decision trees!

References

- James, G. et al. (2013). "Introduction to Statistical Learning with Applications in R". *Springer. Chapter 2, Chapter 3.*
- STDHA. (2018). "KNN: K-Nearest Neighbors Essentials"