Intro to R

Part 3: Visualization

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Agenda

1. Recap of last lecture
   - Using packages: `install.packages()` & `require()`
   - Loading and manipulating data: `readRDS()` and `%>%`
2. Plotting in `R`
   - `ggplot` (`+` instead of `%>%`)

Loading Packages & Data

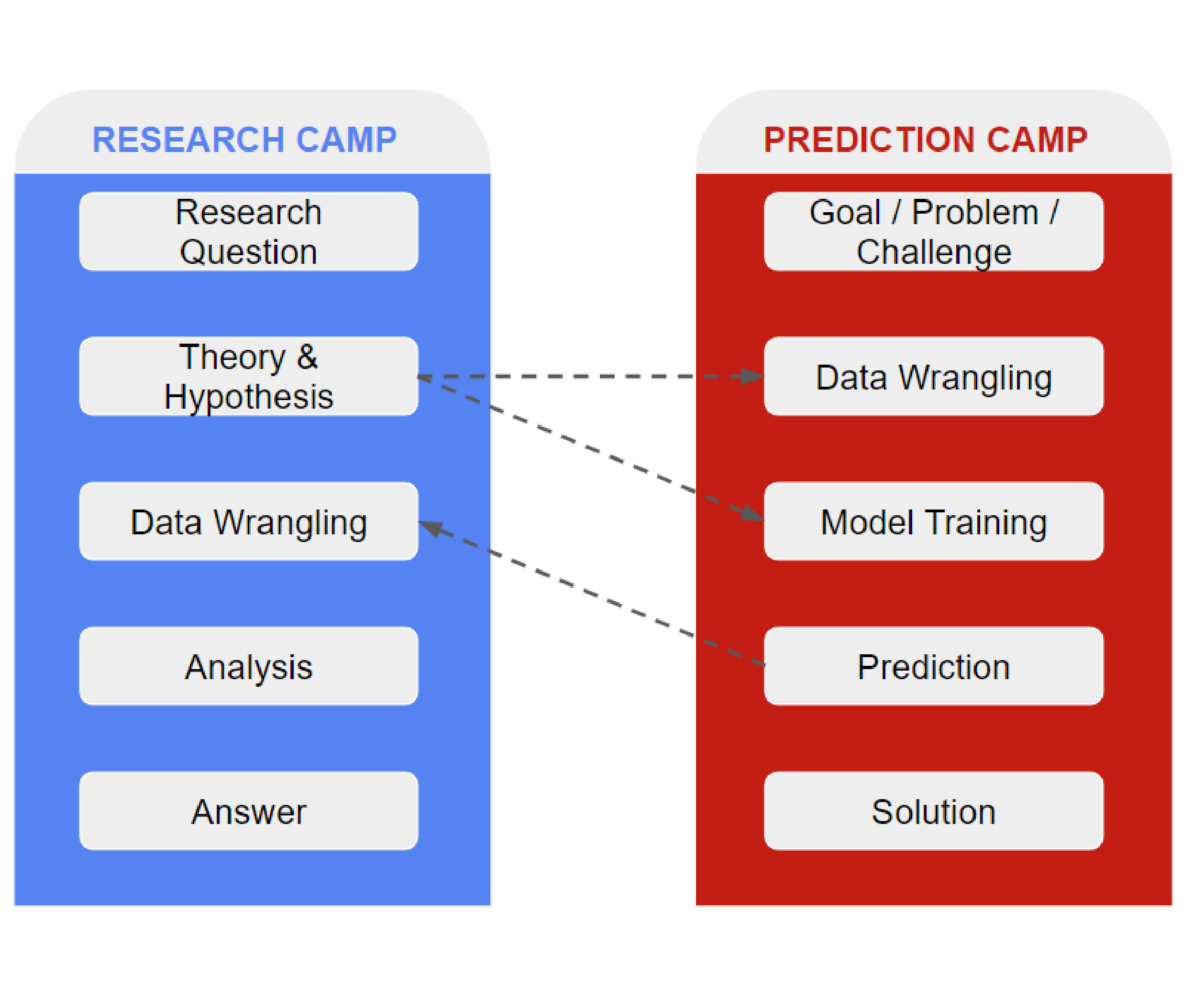
- Create an `.Rmd` file and save to your `code` folder
  - Accept defaults, Save As... (with a good name), then `knit`
- Load the `tidyverse` package

```
require(tidyverse)
```

- Load the data from the course github page directly using `read_rds()`
  - We **create** an "object" to store the data using a left-arrow: `<-`

```
df<-
read_rds("https://github.com/jbisbee1/DS1000_S2024/raw/main/data/sc_deb
```

The Two Camps



RESEARCH CAMP

Research Question

Theory & Hypothesis

Data Wrangling

Analysis

Answer

PREDICTION CAMP

Goal / Problem / Challenge

Data Wrangling

Model Training

Prediction

Solution

The Research Camp

- RQ: How might admissions and SAT scores be **related**?
    - Theory: selective schools have stricter criteria
    - Hypothesis: admissions and SAT scores should be **negatively** related
- How can we test this hypothesis?

Previously: `summarise()`

- We can combine base `R` functions with `tidyverse` functions!
  - Base `R`: `mean()`
  - `tidyverse`: `summarise()` (aka `summarize()`)
- Overall average SAT scores

```
df %>%
  summarise(mean_sat = mean(sat_avg,na.rm=T))
```

```
## # A tibble: 1 × 1
##   mean_sat
##      <dbl>
## 1    1141.
```

Previously: `summarise()`

- Let's unpack this

```
df %>%
  summarise(mean_sat = mean(sat_avg,na.rm=T))
```

- Create new variable `mean_sat` that contains the `mean()` of every school's average SAT score

- `na.rm=T` means we want to ignore missing data. If not?

```
df %>%
  summarise(mean_sat = mean(sat_avg))
```

```
## # A tibble: 1 × 1
##   mean_sat
##      <dbl>
## 1       NA
```

summarise() + filter()

- Recall we want see if more selective schools have higher SAT scores

```
df %>%
  filter(adm_rate < .1) %>%
  summarise(mean_sat_LT10 = mean(sat_avg,na.rm=T))
```

```
## # A tibble: 1 × 1
##   mean_sat_LT10
##           <dbl>
## 1         1510.
```

```
df %>%
  filter(adm_rate > .1 & adm_rate < .2) %>%
  summarise(mean_sat_1020 = mean(sat_avg,na.rm=T))
```

```
## # A tibble: 1 × 1
##   mean_sat_1020
##           <dbl>
## 1         1424.
```

summarise() + group_by()

- One final tidyverse function: group_by()

```
df %>%
  group_by(selective) %>%
  summarise(mean_sat = mean(sat_avg,na.rm=T))
```

```
## # A tibble: 3 × 2
##   selective mean_sat
##       <dbl>    <dbl>
## 1         0    1135.
## 2         1    1510.
## 3        NA      NaN
```

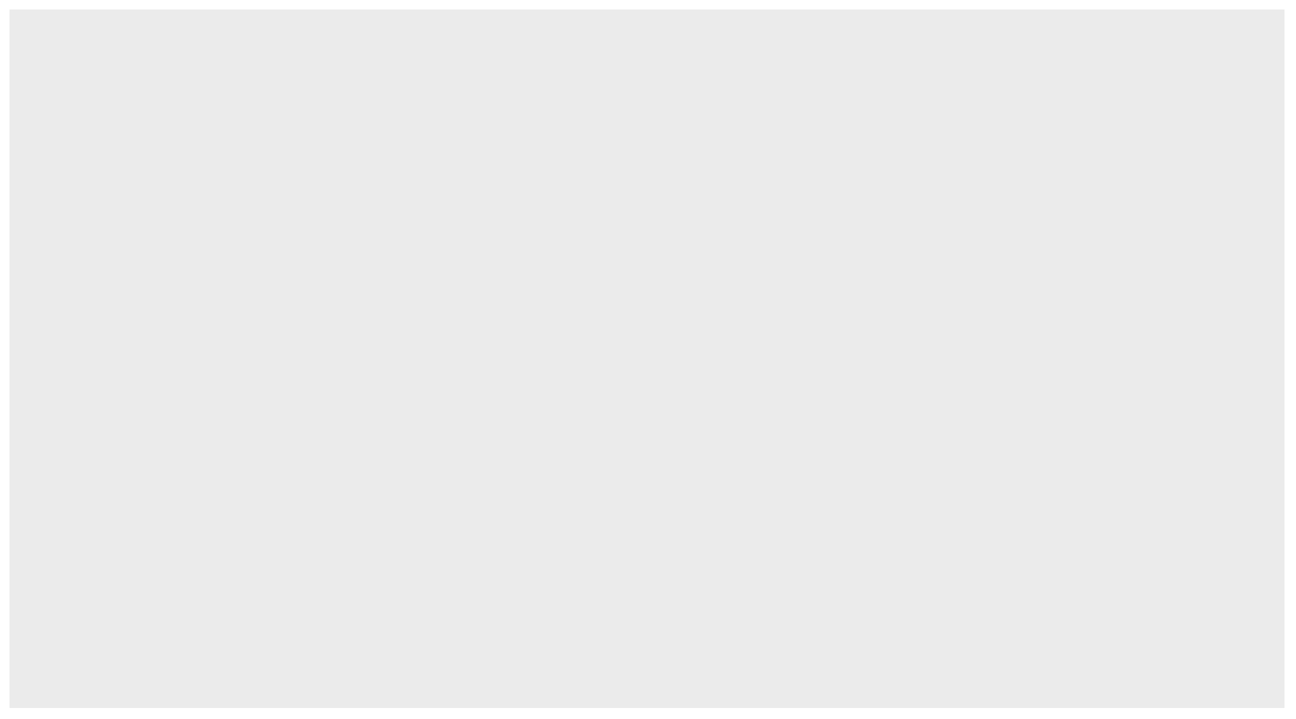
Plotting data

- Let's plot the data instead of writing many of these `summarise()` functions
- Visualization in `R` uses `ggplot()` function
  - Inputs: `aes(x,y,...)` (elipses `...` indicates many more inputs)
  - `x` is the x-axis (horizontal)
  - `y` is the y-axis (vertical)

ggplot()

- Attach `ggplot()` to your data with `%>%`

```
df %>%
  ggplot()
```

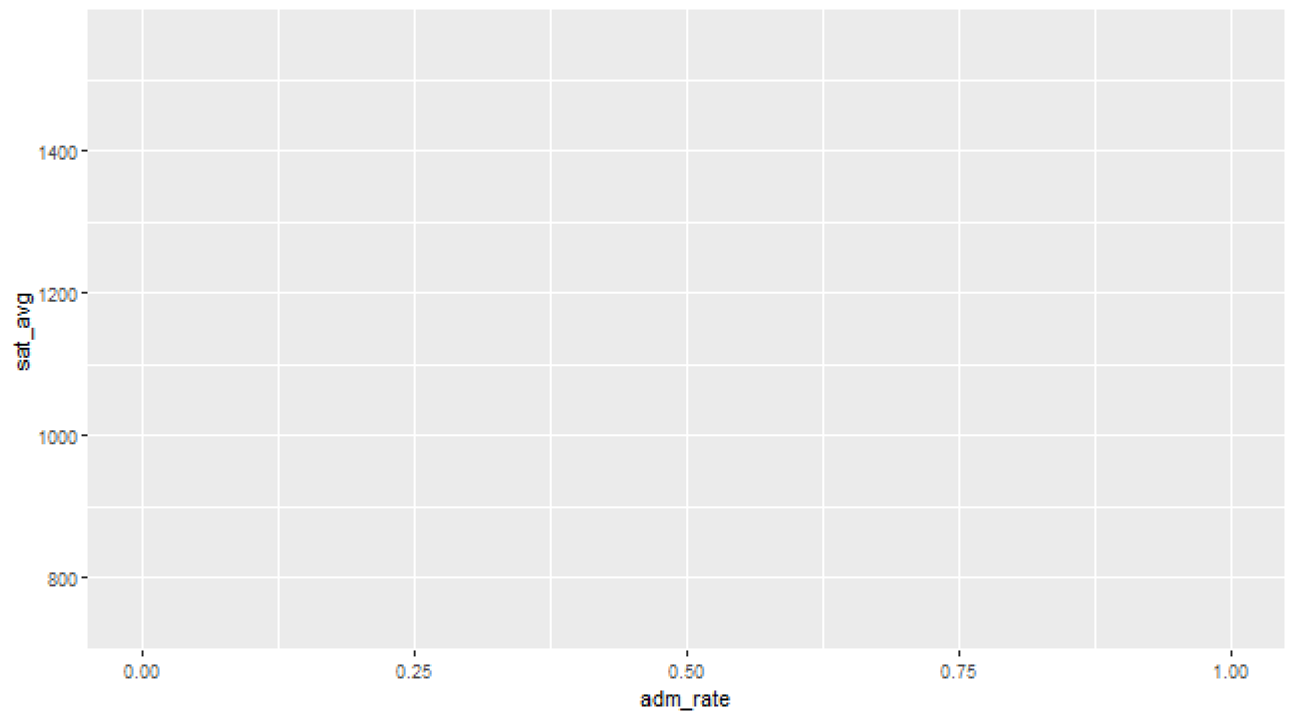


`ggplot()`

- Then tell it what to put in the x-axis and y-axis
- What should go on these axes?
- Theory: Selective schools choose higher scoring students
  - Selective schools **explain** higher scores
  - Selective schools: **independent variable** / **explanatory variable** / **predictor** / X
  - Higher scores: **dependent variable** / **outcome variable** / Y
- Selective schools go on the x-axis, SAT scores go on the y-axis

ggplot()

```
df %>%
  ggplot(aes(x = adm_rate,y = sat_avg))
```



`ggplot()`

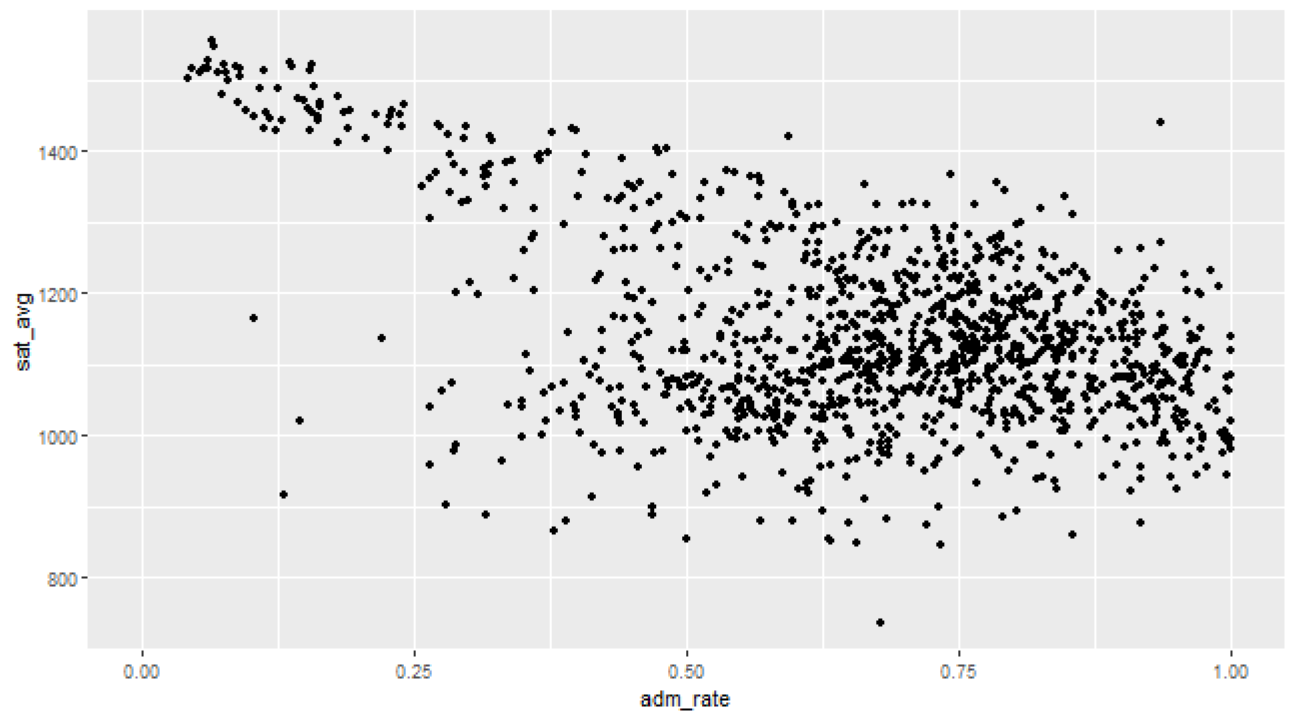
- This gives us an empty plot
- We have the correct variables on the correct axes…
- …but we need to choose how to display them
- There are many different `ggplot()` functions to choose from
    - `geom_point()` creates one point for each x and y coordinate
    - `geom_bar()` creates a barplot
    - `geom_histogram()` creates a histogram
    - `geom_density()` creates a density plot
    - `geom_boxplot()` creates a box-and-whisker plot

`ggplot()`

- We **add** a second `ggplot()` function to the first with a plus sign `+`
  - **NB:** This is JUST LIKE THE PIPE OPERATOR `%>%` in `tidyverse`!
- Since `adm_rate` (the x-axis variable) and `sat_avg` (the y-axis variable) are both numeric ("continuous") measures, we will use `geom_point()`
  - We will come back to **variable types** and how to visualize them later

ggplot()

```
df %>%
  ggplot(aes(x = adm_rate,y = sat_avg)) +
  geom_point()
```



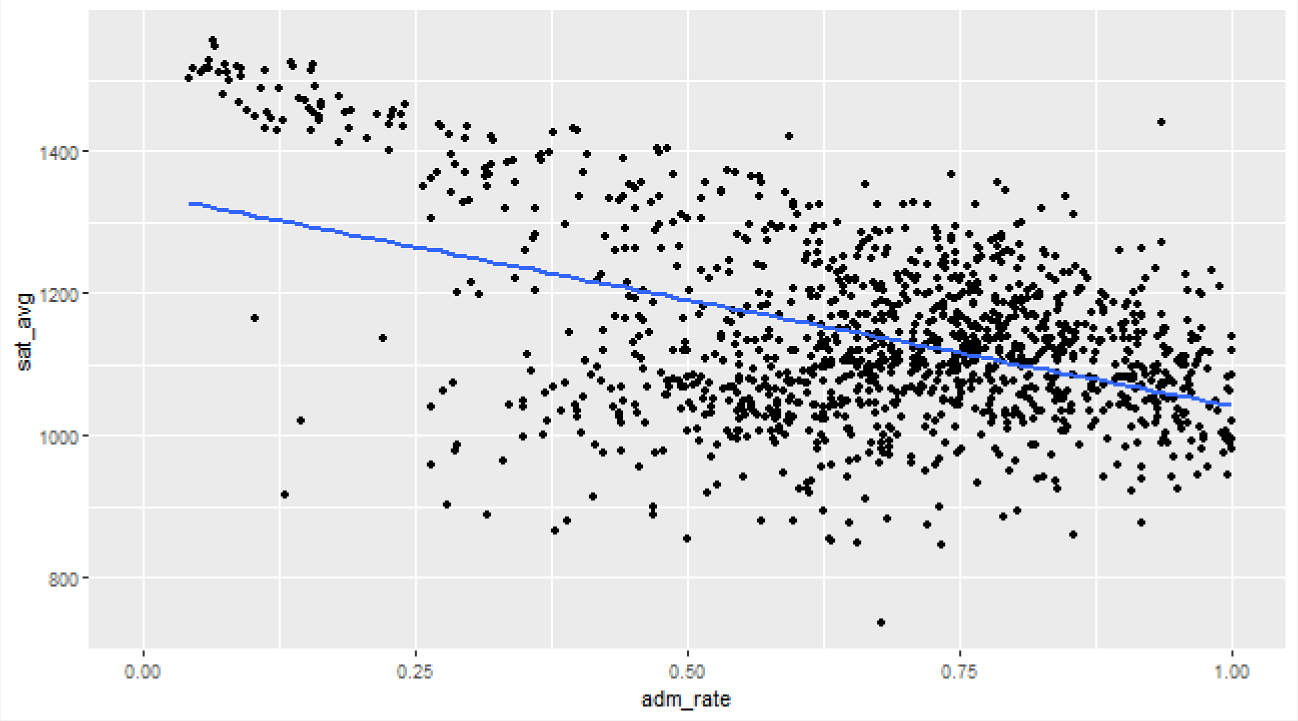
Plotting data

- Let's unpack this
    - `aes(x,y)` sets the basic aesthetics for the plot
    - `geom_point()` tells `ggplot()` how to visualize those aesthetics
    - These two parts are linked with the `+`. Similar to...?
    - ...the `%>%` in `tidyverse`!

Interpreting the plot

- We **hypothesized** that admissions and SAT scores are negatively related
  - Is this supported in the data?
- Let's add a line of best fit with `geom_smooth()`

```r
df %>%
  ggplot(aes(x = adm_rate,y = sat_avg)) +
  geom_point() +
  geom_smooth(method = 'lm',se = F)
```


1400
1200
1000
800
sat_avg
0.00
0.25
0.50
0.75
1.00
adm_rate

The Research Camp

- RQ: How might future earnings and SAT scores be **related**?
    - Theory: SATs measure student ability.
    - Theory: Student ability is valued by the labor market.
    - Theory: Firms pay more for students with higher SAT scores.
    - Hypothesis: Earnings and SAT scores should be **positively** related

Plotting Quiz

- Which variable goes on the x-axis?
    - **SAT scores**
- Which variable goes on the y-axis?
    - **Earnings**
- In our theory, SAT scores **cause** earnings
- Why might this **not** be the case?
    - Spurious 1: SAT scores **and** earnings are caused by student ability
    - Spurious 2: SAT scores **and** earnings are caused by socio-economic privilege

Let's Plot!

```
df %>%
  ggplot(aes(x = sat_avg,y = md_earn_wne_p6)) + # Build axes
  geom_point() +  # Add points
  geom_smooth(method = 'lm',se = F) # Add line of best fit
```

Outliers

- Which schools are furthest from the line?
  - These are **outliers**
  - These schools are the **furthest** from our theory

```
df %>%
  mutate(out = ifelse(md_earn_wne_p6 > 100000,
                          instnm,  # Value if TRUE
                          NA)) %>% # Value if FALSE
  drop_na(out,sat_avg) %>%
  select(instnm,md_earn_wne_p6,sat_avg)
```

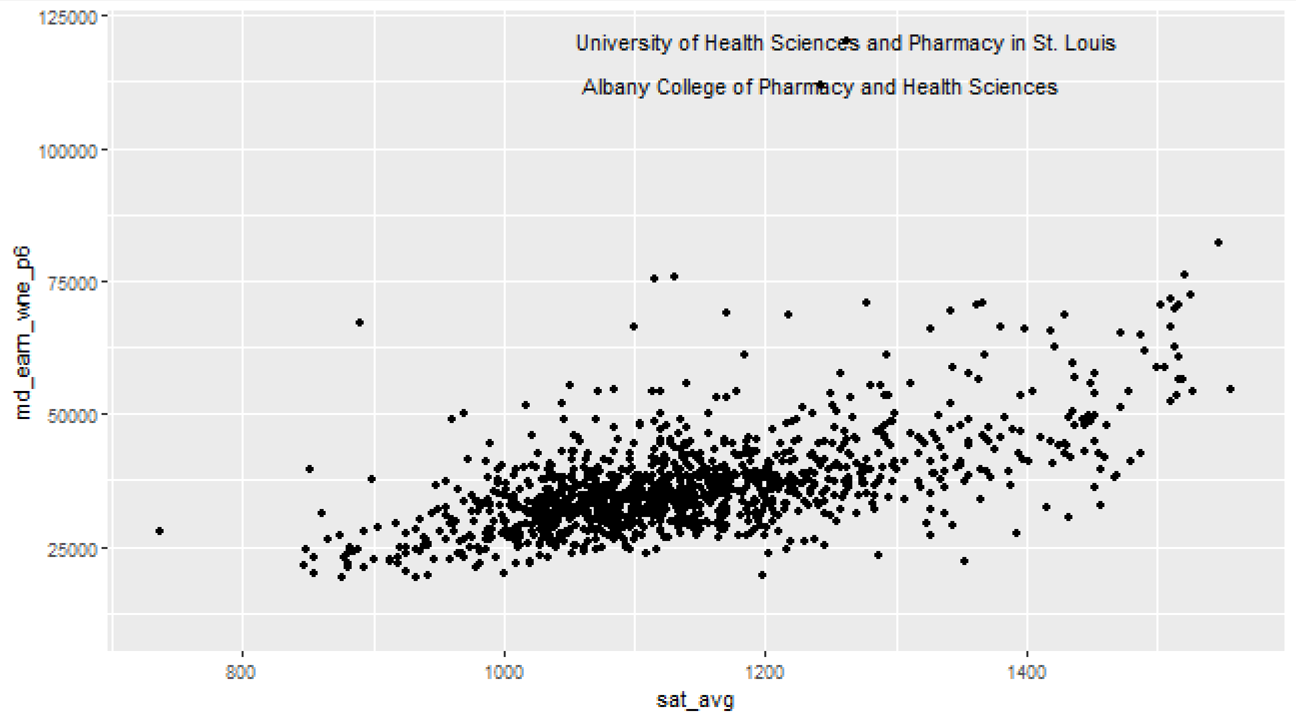
```
## # A tibble: 2 × 3
##   instnm                              md_earn_wne_p6 sat_avg
##   <chr>                                        <int>   <int>
## 1 University of Health Sciences and …         120400    1262
## 2 Albany College of Pharmacy and Hea…         112100    1242
```

Plotting data

- We can add these as labels!

```
df %>%
   mutate(out = ifelse(md_earn_wne_p6 > 100000,
                          instnm,  # Value if TRUE
                          NA)) %>% # Value if FALSE
  ggplot(aes(x = sat_avg,y = md_earn_wne_p6,
             label = out)) +
  geom_point() +
  geom_text()
```

Plotting data

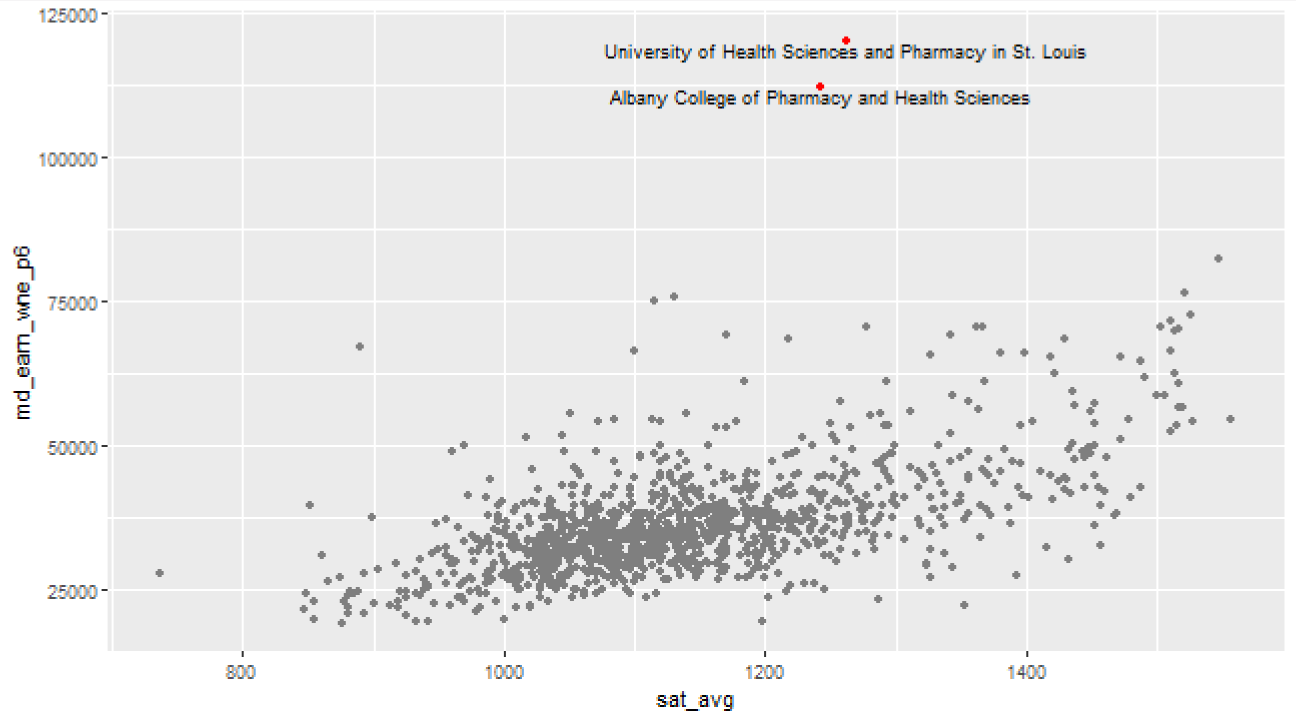


Plotting data

- Let's accentuate the outlier more with color

```
p <- df %>%
   mutate(out = ifelse(md_earn_wne_p6 > 100000,
                          instnm,  # Value if TRUE
                          NA)) %>% # Value if FALSE
  drop_na(sat_avg) %>%
  ggplot(aes(x = sat_avg,y = md_earn_wne_p6,
             label = out,color = out)) +
  geom_point() +
  scale_color_manual(name = "Outlier",values =
c('red','red','black')) +
  geom_text(hjust = .5,vjust = 1,color = 'black',size = 3)
```

Plotting data



Categorical Data

- Thus far, plotting two continuous variables with `geom_point()`
- What if we wanted to see which state has the most selective schools?
- Use `group_by()` and `summarise()`

```
df %>%
  group_by(stabbr) %>%
  summarise(selective_avg = mean(adm_rate,na.rm=T))
```

```
## # A tibble: 51 × 2
##    stabbr selective_avg
##    <chr>          <dbl>
##  1 AK             0.827
##  2 AL             0.654
##  3 AR             0.676
##  4 AZ             0.843
##  5 CA             0.592
##  6 CO             0.768
##  7 CT             0.589
##  8 DC             0.529
##  9 DE             0.627
```

Categorical Data

- Two variables (`stabbr` and `selective_avg`), but one of them is now a `character` type

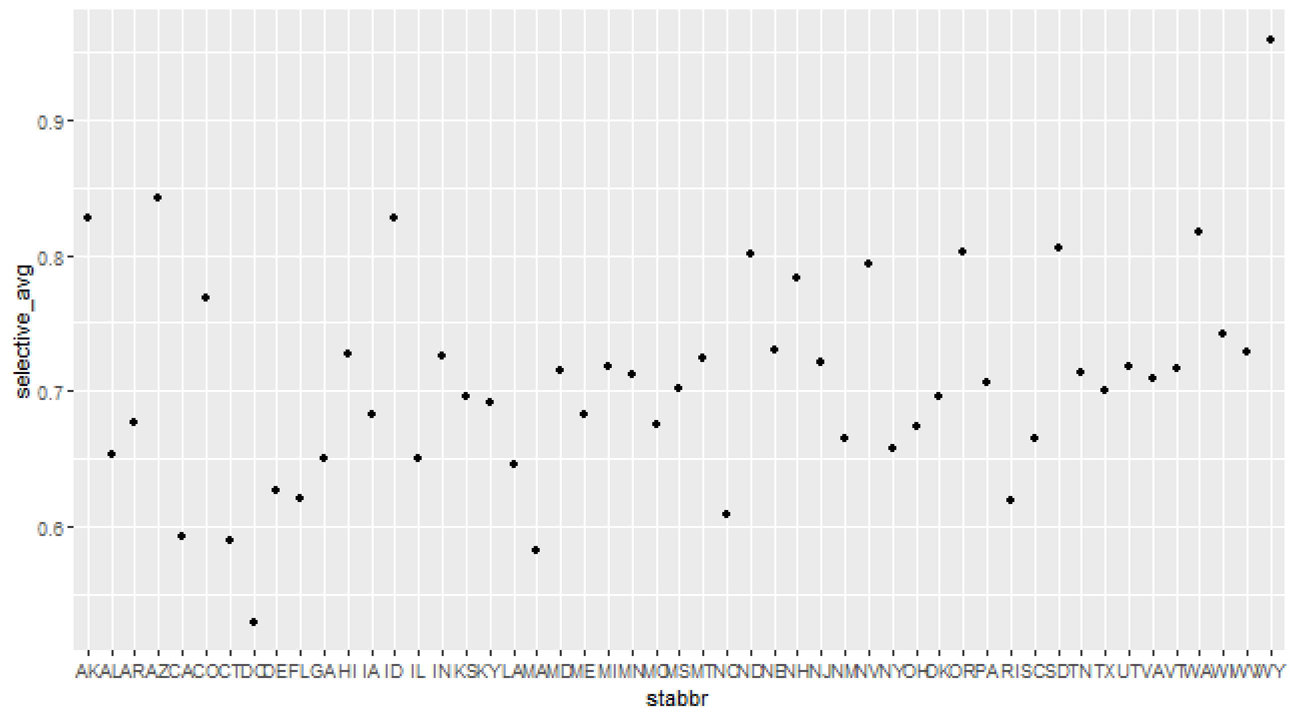
- Can we plot this as a scatterplot?

```
p <- df %>%
  group_by(stabbr) %>%
  summarise(selective_avg = mean(adm_rate,na.rm=T)) %>%
  ggplot(aes(x = stabbr,y = selective_avg)) +
  geom_point()
```

Categorical Data

- Yes...but it isn't very pretty

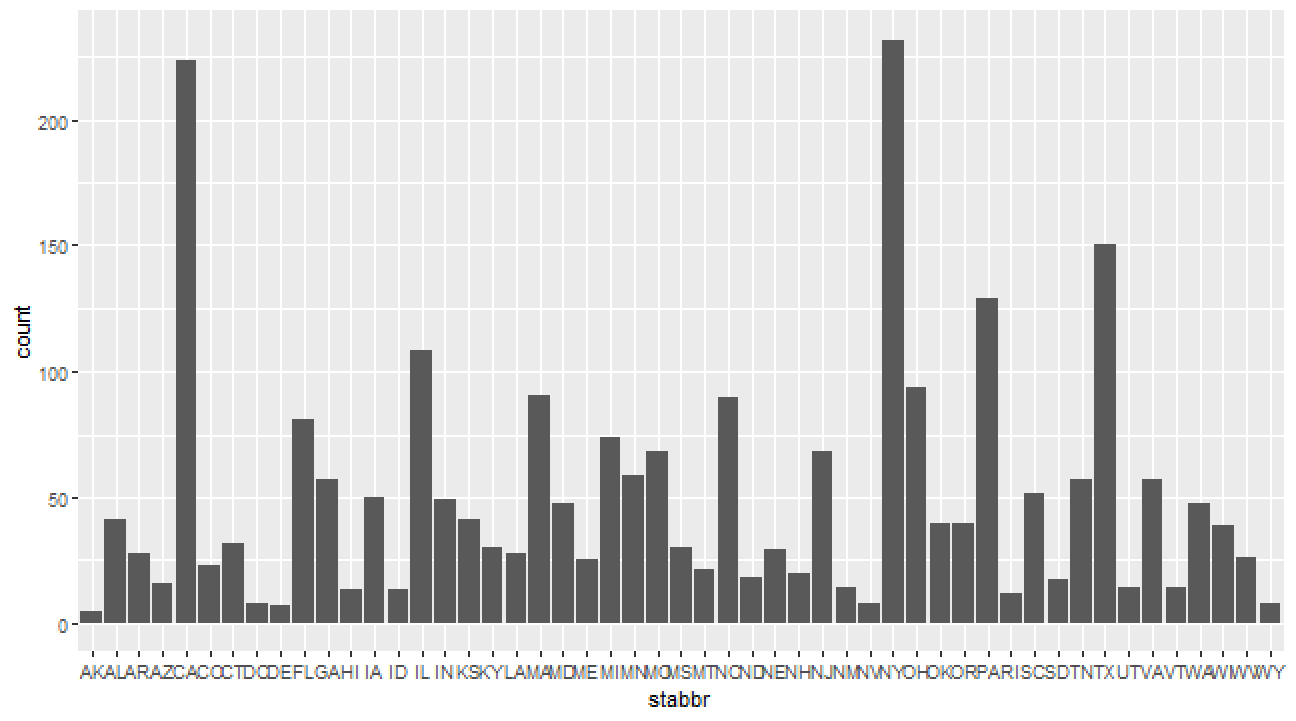
```
p
```



Categorical Data: `geom_bar()`

- NB: `geom_bar()` will automatically count the values on the x-axis

```
df %>%
  ggplot(aes(x = stabbr)) +
  geom_bar()
```



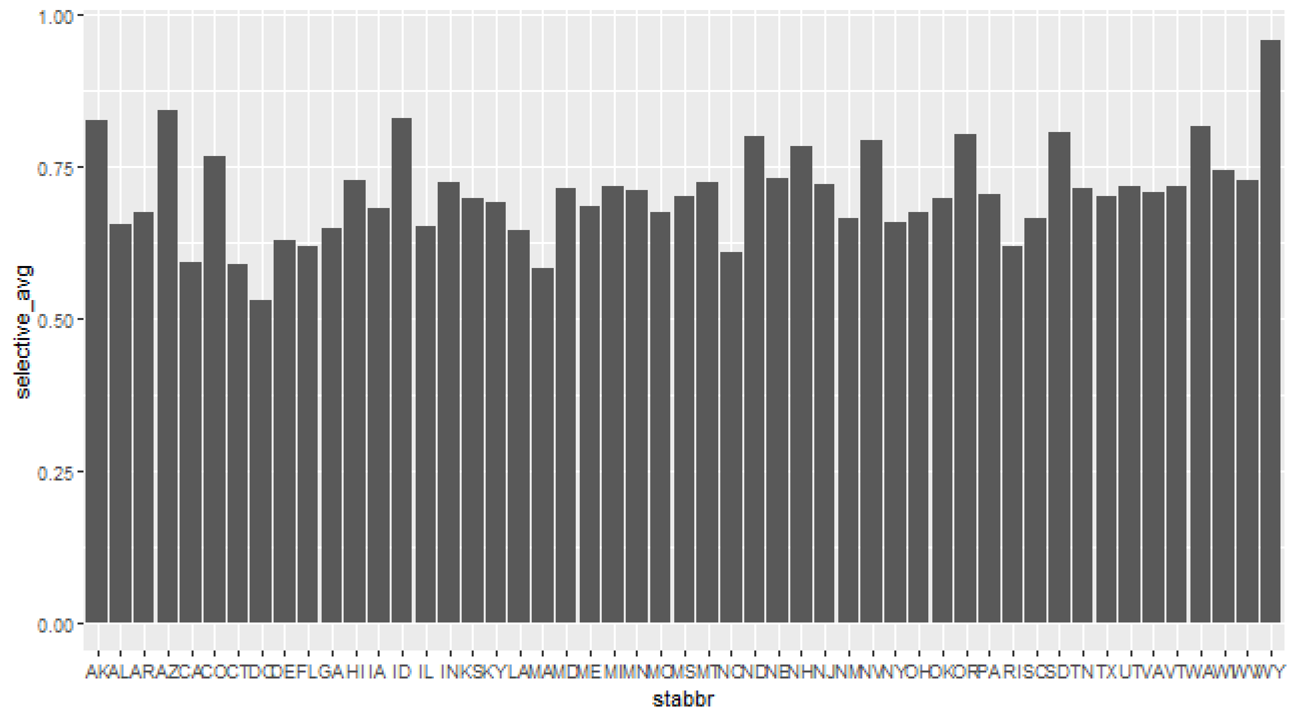
Categorical Data: `geom_bar()`

- This is fine if we just want to know which states have the most schools in our data
- But we want to put the average admissions rate on the y-axis instead
  - Need to **override** `geom_bar()` default behavior

```r
p <- df %>%
  group_by(stabbr) %>%
  summarise(selective_avg = mean(adm_rate,na.rm=T)) %>%
  ggplot(aes(x = stabbr,y = selective_avg)) +
  geom_bar(stat = 'identity')
```

Categorical Data

```
p
```



Categorical Data

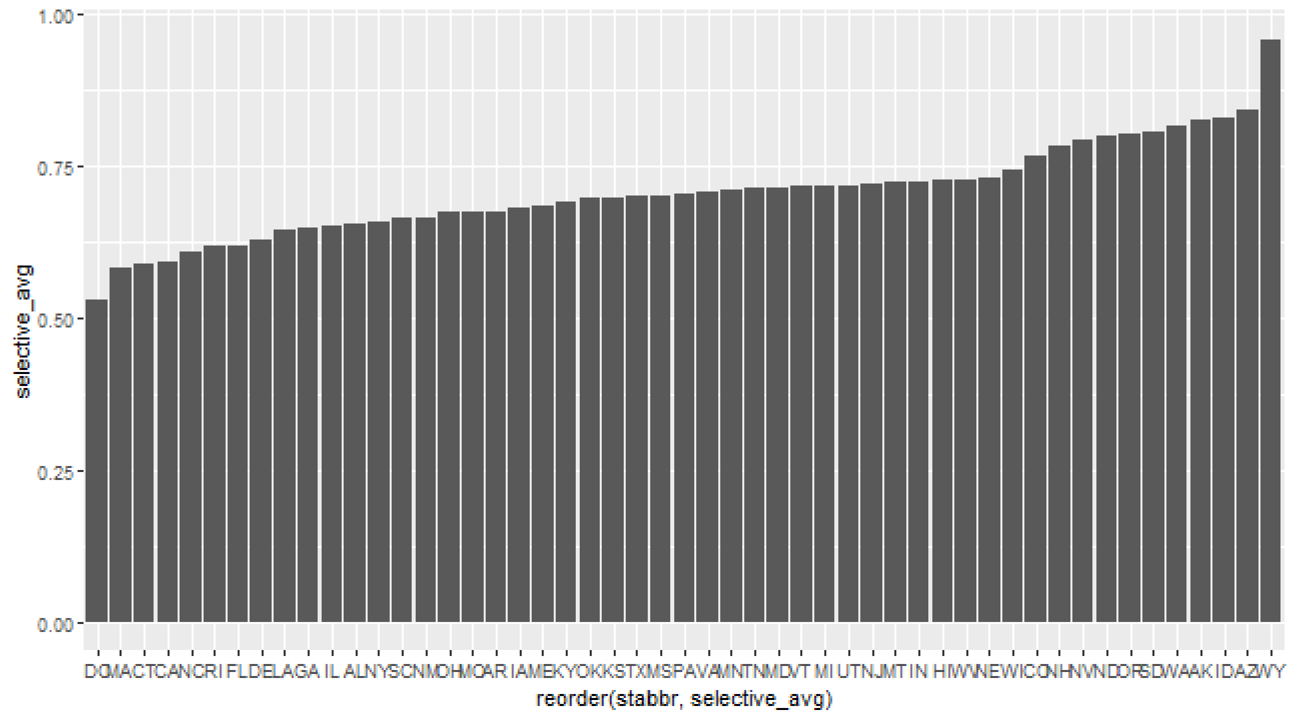
- Getting a little better, but still ugly
- Use `reorder()` to sort the x-axis values by the y-axis

```
p <- df %>%
  group_by(stabbr) %>%
  summarise(selective_avg = mean(adm_rate,na.rm=T)) %>%
  ggplot(aes(x = reorder(stabbr,selective_avg),y = selective_avg)) +
  geom_bar(stat = 'identity')
```

Categorical Data

- Even better!

```
p
```



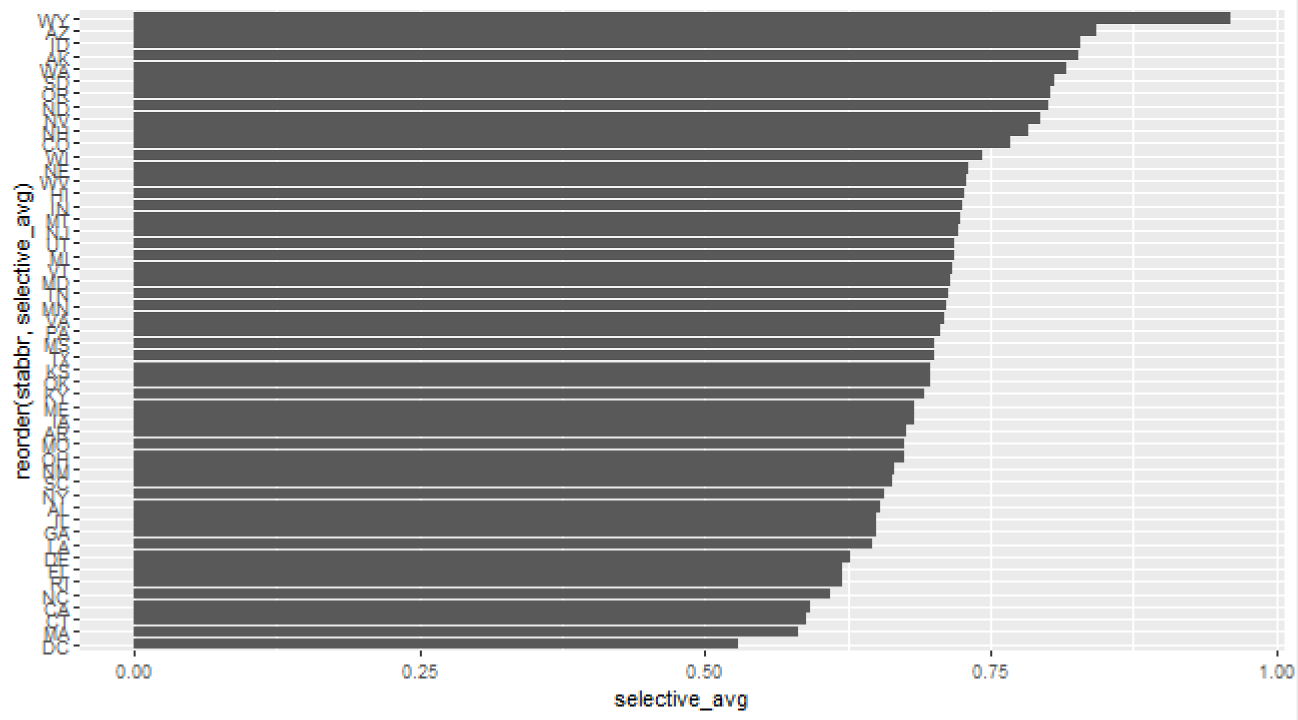
Plot Tweaking

- We could go even further and swap the x and y-axes (although this isn't always a good idea!)

```r
p <- df %>%
  group_by(stabbr) %>%
  summarise(selective_avg = mean(adm_rate,na.rm=T)) %>%
  ggplot(aes(y = reorder(stabbr,selective_avg),x = selective_avg)) +
  geom_bar(stat = 'identity')
```

Plot Tweaking

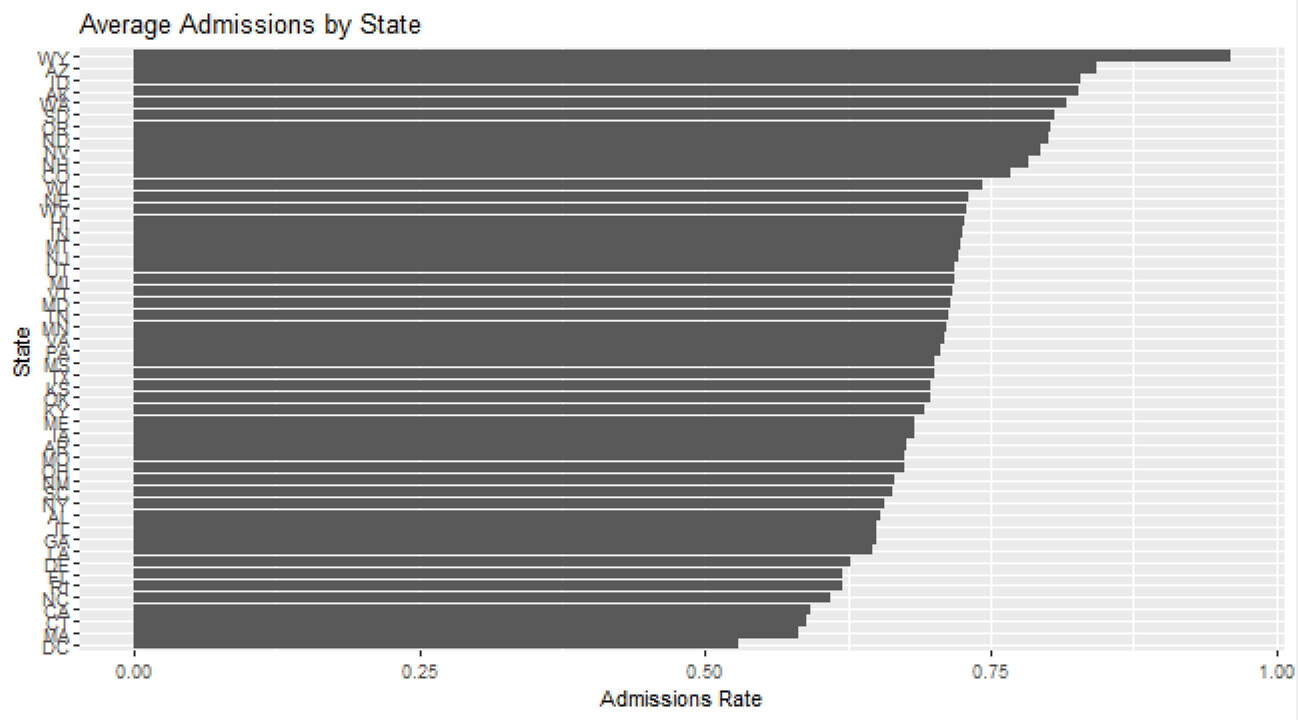
```
p
```



- Still ugly though! We want to tweak the labels with `labs()`

Plot Tweaking

```
p +
  labs(title = "Average Admissions by State",
       x = "Admissions Rate",
       y = "State")
```



Conclusion

- What to take away
  1. Which variables go on which axes
  2. How to put these on a `ggplot()` figure
  3. How to create a visualization of these variables
- This wraps up the crash course in `R`
  - **REMEMBER**: This class is *inherently* challenging because of `R`
  - The course is graded leniently to reflect the inherent difficulty of the material

Quiz & Homework

- Go to Brightspace and take the **3rd** quiz
  - The password to take the quiz is ####
- **Homework:**
  1. Work through ds1000_hw_4.Rmd
  2. Complete Problem Set 2 by Friday