Stat 120

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Contents

About

This is a *sample* book written in **Markdown** to guide STAT 120 students interactively explore various class activities and projects in R.

Chapter 1

Class Activity 1

1.1 Your Turn 1

---

a. Run the following chunk. Comment on the output.

```
example_data = data.frame(ID = c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10),
                          Greeting = c(rep("Hello", 5), rep("Goodbye",5)),
                          Male = rep(c(TRUE, FALSE), 5),
                          Age = runif(n=10, 20, 60))
```

Click for answer

```
example_data
```

```
   ID Greeting  Male      Age
1   1    Hello  TRUE 48.06314
2   2    Hello FALSE 33.63869
3   3    Hello  TRUE 47.64219
4   4    Hello FALSE 27.86439
5   5    Hello  TRUE 41.19441
6   6  Goodbye FALSE 40.71712
7   7  Goodbye  TRUE 56.48527
8   8  Goodbye FALSE 36.85101
9   9  Goodbye  TRUE 40.62793
10 10  Goodbye FALSE 49.46967
```

Answer: We see a data frame with four columns, where the first column is an `identifier` for the cases. We have information on the greeting types, whether male or not, and age on these cases in the remaining columns.

b. What is the dimension of the dataset called 'example_data'?

Click for answer

```
dim(example_data)
[1] 10  4
nrow(example_data)
[1] 10
ncol(example_data)
[1] 4
```

Answer: There are 10 rows and 4 columns.

1.2 Your Turn 2

a. Read the dataset `EducationLiteracy` from the Lock5 second edition book.

Click for answer

```
# read in the data
education_lock5 <- read.csv("https://www.lock5stat.com/datasets2e/EducationLiteracy.csv
```

b. Print the header (i.e. first 6 cases by default) of the dataset in part a.

Click for answer

```
head(education_lock5)
```

```
              Country EducationExpenditure Literacy
1         Afghanistan                   3.1     31.7
2             Albania                   3.2     96.8
3             Algeria                   4.3       NA
4             Andorra                   3.2       NA
5              Angola                   3.5     70.6
6 Antigua and Barbuda                   2.6     99.0
```

c. What is the dimension of the dataset in a?

Click for answer

```
dim(education_lock5)
```

```
[1] 188   3
```

Answer: There are 188 rows and 3 columns.

d. What type of variables are `Country`, `EducationExpenditure`, and `Literacy`?

Click for answer

Answer: `Country` is a categorical variable. `EducationExpenditure` and `Literacy` are both quantitative variables.

e. If we would like to use education expenditure to predict the literacy rate of each countries, which variable is the explanatory variable and which one is the response?

Click for answer

Answer: The education expenditure is the explanatory variable, and the literacy rate is the response.

1.3 Quiz

1. Cases are a set of individual units where the measurements are taken.

A. TRUE

B. FALSE

Click for answer

TRUE

2. The characteristic that is recorded for each case is called a

A. ledger

B. caseholder

C. placeholder

D. variable

Click for answer

variable

3. Variables can be either categorical or quantitative.

A. TRUE

B. FALSE

Click for answer

TRUE

Chapter 2

Class Activity 2

2.1 Your Turn 1

This exercise is about finding the average word length in Lincoln's Gettysburg's address.

2.2 Your Turn 2

2.2.1 Summary of article on It depends on how you ask!

Click for answer

Answer:

This study aimed to measure the effects of psychological biases on estimates of compliance with public health guidance regarding COVID-19. Results showed that compliance estimates were reduced when questions were framed negatively and anonymity was increased. Effect sizes were large, with compliance estimates diminishing by up to 17% points and 10% points, respectively. These findings suggest that standard tracking surveys pose questions in ways that lead to higher compliance estimates than alternative approaches.

2.3 Your Turn 3

2.3.1 Gettysburg random sample

Let's take a simple random sample (SRS) of Gettysburg words. The "population" is contained in the spreadsheet `GettysburgPopulationCounts.csv`. Carefully load this data into R:

```
pop <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/Gettysberg
head(pop)
```

```
  position size  word
1        1    4  Four
2        2    5 score
3        3    3   and
4        4    5 seven
5        5    5 years
6        6    3  ago,
```

The `position` variable enumerates the list of words in the population (address).

(a). Sample

Run the following command to obtain a SRS of 10 words from the 268 that are in the population:

```
samp <- sample(1:268, size=10)
samp
```

```
 [1] 261 247  46 114 267 189 215 266 126 254
```

This tells you the position (row number) of your sampled words. What are your sampled positions? Why are your sampled positions different from other folks in class?

(b). Get words and lengths

We will *subset* the data set `pop` to obtain only the sampled rows listed in `samp`. We do this using **square bracket notation** 'dataset[row number, column number/name]. Run the following command to find your sampled words and sizes:

```
pop[samp,]
```

```
    position size      word
261      261    3       the
```

```
247      247    3       new
46        46    6    nation
114      114    2        we
267      267    3       the
189      189    6    rather
215      215    3       for
266      266    4      from
126      126    9 struggled
254      254    2        of
```

c. Compute your sample mean

The word lengths in part (b) are the data for your sample. You can compute your sample mean using a calculator, or using R. Let's try R (you will find it faster!). First save the quantitative variable `size` in a new variable called `mysize`:

```
mysize <- pop[samp, "size"]
mysize
```

```
 [1] 3 3 6 2 3 6 3 4 9 2
```

Then find the mean of these values:

```
mean(mysize)
```

```
[1] 4.1
```

How does this sample mean (from a truly random sample) compare to your sample mean from the non-random sample?

Click for answer

Answer: The true mean is 4.29. Your two means will likely vary. Since the many non-random samples generally overestimated the population mean length, it is possible (but not guaranteed) that *your* one non-random sample gave a mean length that is greater than the random sample's mean length.

2.3.2 Driving with a Pet on your Lap

Over 30,000 people participated in an online poll on `cnn.com` conducted in April 2012 asking: "Have you ever driven with a pet on your lap"? We see that 34% of the participants answered yes and 66% answered no.

a. Can you conclude that a random sample was used from the description given? Explain.

Click for answer

Answer: No you can't make this conclusion from the info given. In fact, an online poll at a website like `cnn.com` is almost always reporting results from a non-random sample. The people who respond are individuals who visit `cnn.com`, then see the online poll and decide to respond.

b. Explain why it is not appropriate to generalize these results to all drivers, or even to all drivers who visit cnn.com.

Click for answer

Answer: This is a volunteer sample, and volunteer samples are often biased and can't be generalized to *all drivers* (the population). It is likely that people who have driven with a pet on their lap are more likely to respond to the poll.

c. How might we select a sample of people that would give us results that we can generalize to a broader population?

Click for answer

Answer: A random sample of individuals from all U.S. drivers would need to be selected and given the poll question. (There are many ways to do this, the most common being a variation of random digit dialing where phone numbers are randomly selected from known area codes.)

d. Is the variable measured in this study quantitative or categorical?

Click for answer

Answer: Categorical (yes or no answer to the question).

2.4 Quiz

1. A group of researchers investigated the effect of media usage (whether or not subjects watch television or use the Internet) in the bedroom on "Tiredness" during the day (measured on a 50 point scale). The explanatory and response variables are

A. Explanatory is media usage in the bedroom and response is "tiredness"

B. Explanatory is "tiredness" and response is media usage in the bedroom

Click for answer

The correct answer is A.

2. An October 2016 Gallup poll estimates that 60% of US adults support legalizing the use of marijuana. Their results were based on a "random sample of 1,017 adults, aged 18 and older, living in all 50 U.S. states and the District of Columbia". The population for this study is

A. all adults (18 and older) living in the U.S. (including D.C)

B. the 1,017 adults (18 and older) living in the U.S. (including D.C) who were sampled

C. the 1,017 adults (18 and older) living in the U.S. (including D.C) who were sampled and support legalizing marijuana

D. all adults (18 and older) living in the U.S. (including D.C) who support legalizing marijuana

Click for answer

The correct answer is A.

3. An October 2016 Gallup poll estimates that 60% of US adults support legalizing the use of marijuana. Their results were based on a "random sample of 1,017 adults, aged 18 and older, living in all 50 U.S. states and the District of Columbia". Which statement below regarding bias is true?

A. The results are biased because Gallup only contacted a small fraction of people in the population.

B. The results may be biased because people may not have answered a survey question about marijuana truthfully

Click for answer

The correct answer is B.

Chapter 3

Class Activity 3

3.1 Case Study 1

Consider the following case study:

"Swimming with dolphins can certainly be fun, but is it also therapeutic for patients suffering from clinical depression? To investigate this possibility, researchers recruited 30 subjects aged 18-65 with a clinical diagnosis of mild to moderate depression. Subjects were required to discontinue use of any antidepressant drugs or psychotherapy four weeks prior to the experiment, and throughout the experiment. These 30 subjects went to an island off the coast of Honduras, where they were randomly assigned to one of two treatment groups. Both groups engaged in the same amount of swimming and snorkeling each day, but one group (the animal care program) did so in the presence of bottlenose dolphins and the other group (outdoor nature program) did not. At the end of two weeks, each subjects' level of depression was evaluated, as it had been at the beginning of the study, and it was determined whether they showed substantial improvement (reducing their level of depression) by the end of the study (Antonioli and Reveley, 2005)."

Observed data:

The researchers found that 10 of 15 subjects in the dolphin therapy group showed substantial improvement, compared to 3 of 15 subjects in the control group.

(a). Identify the observational units in this study.

Click for answer

Answer: The observational units in this study are the 30 subjects.

(b). Classify each variable as categorical or quantitative.

Click for answer

Answer: The variables in this study can be classified as follows: Categorical: Treatment Group (Dolphin and Control) Quantitative: Age, Level of Depression (Beginning and End of Study)

(c). Which variable would you regard as explanatory and which as response?

Click for answer

Answer: The explanatory variable would be the Treatment Group and the response variable would be the Level of Depression.

(d). Is this an observational study or an experiment? Justify your answer.

Click for answer

Answer: This is an experiment because the researchers randomly assigned the subjects to the two treatment groups, and then observed the effect of the treatment (presence of dolphins) on the response variable (level of depression).

(e). Construct a two-way table based on the results of the experiment.

Click for answer

Two-way table:

Treatment	Improved	Not Improved	Total
Dolphin Group	10	5	15
Control Group	3	12	15
Total	13	17	30

3.2 Case Study 2

Consider the following case study:

"Researchers want to find out how a new diet affects weight gain among underweight subjects. This experiment only has two treatment conditions, the new diet and the standard diet. For this study, the researchers recruited 200 subjects which will be grouped into 100 pairs based on shared characteristics such as age, gender, weight, height, lifestyle, and so on. A 20-year-old female within the weight range of 90-110 pounds and the height range of 60-63 inches will be paired with another 20-year-old female that falls into the same weight and height categories. Once all 100 pairs are made, a subject from each pair will be randomly assigned into the treatment group (will be administered the new diet for 2 months) while the other subject from the pair will be assigned to the control group (will be assigned to follow the standard diet for two months).

At the end of the time time period of 2 months, researchers will measure the total weight gain for each subject."

Observed data:

The researchers found that 60 of 100 subjects in the new diet group showed substantial improvement, compared to 43 of 100 subjects in the standard diet group.

(a). Identify the observational units in this study.

Click for answer

Answer: The observational units in this study are the 200 subjects.

(b). Classify each variable as categorical or quantitative.

Click for answer

Answer: The variables are: age (quantitative), gender (categorical), weight (quantitative), height (quantitative), lifestyle (categorical), and total weight gain (quantitative).

(c). Which variable would you regard as explanatory and which as response?

Click for answer

Answer: The explanatory variable is the type of diet (new or standard) and the response variable is the total weight gain.

(d). Is this an observational study or an experiment? Justify your answer.

Click for answer

Answer: This is an experiment because the researchers are manipulating the explanatory variables (type of diet) to observe the effects on the response variables (total weight gain).

(e). If it is an experiment, is it randomized comparative experiment or a matched pairs experiment?

Click for answer

Answer: This is a matched pairs experiment because each subject is paired with another subject who has similar characteristics and one subject from each pair is randomly assigned to the treatment group and the other to the control group.

(f). Construct a two-way table based on the results of the experiment.

Click for answer

Two-way table:

Outcome	New Diet	Standard Diet	Total
Improvement	60	43	103

Outcome	New Diet	Standard Diet	Total
No Improvement	40	57	97
Total	100	100	200

3.3 Quiz

1. A third variable that is associated with both the explanatory variable and the response variable is called a confounding variable.

A. TRUE

B. FALSE

Click for answer

TRUE

2. The different levels of an explanatory variable are known as

A. treatments

B. local groups

C. response

D. cases

Click for answer

treatments

3. Causality can always be inferred from observational studies.

A. TRUE

B. FALSE

Click for answer

FALSE

Chapter 4

Class Activity 4

4.1 Your Turn 1

4.1.1 Flowers v. Mississippi

The data set `APM_DougEvensCases.csv` contains data from 1517 potential black and white jurors for 66 cases that Doug Evans was primary prosecutor for between 1992 and 2017. These jurors were available for Doug Evans to strike using his "peremptory strikes" during the jury selection phase.

(a). Inspect data

Read in the data

```
jurors <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/APM_DougEvansCase
```

```
# dimension of dataset
dim(jurors)
```

```
[1] 1517    6
```

Look at the first **three rows** of the data set

```
jurors[c(1,2,3), ]
```

```
  trial__id  race        struck_state defendant_race
1         4 Black Not struck by State          White
2         4 Black     Struck by State          White
3         4 White Not struck by State          White
```

```
       same_race                     struck_by
1 different race Juror chosen to serve on jury
2 different race           Struck by the state
3      same race Juror chosen to serve on jury
```

To get the data from one variable, we use the command `dataset$variable`. For example, `jurors$struck_state` gives us the data values from the `struck_state` variable, which tells us if a juror was struck by the state from the jury pool. Here we can see the first 10 entries in this variable:

```
jurors$struck_state[1:10]
```

```
 [1] "Not struck by State" "Struck by State"
 [3] "Not struck by State" "Not struck by State"
 [5] "Struck by State"     "Not struck by State"
 [7] "Struck by State"     "Not struck by State"
 [9] "Not struck by State" "Not struck by State"
```

(b). Table of counts and proportions

The `summary` command used with a data frame gives summaries of each variable

```
summary(jurors)
```

```
  trial__id         race           struck_state
 Min.   :  4.0   Length:1517        Length:1517
 1st Qu.: 52.0   Class :character   Class :character
 Median : 82.0   Mode  :character   Mode  :character
 Mean   :112.6
 3rd Qu.:170.0
 Max.   :301.0
 defendant_race      same_race          struck_by
 Length:1517        Length:1517        Length:1517
 Class :character   Class :character   Class :character
 Mode  :character   Mode  :character   Mode  :character
```

The `table` command gives the distribution of counts for a single categorical variable. To obtain the count table for `struck_state` you need to

```
counts <- table(jurors$struck_state)
counts
```

```
Not struck by State     Struck by State
               1084                 433
```

We can add the `prop.table` command to turn these counts into proportions:

```
prop.table(counts)
```

```
Not struck by State     Struck by State
          0.7145682           0.2854318
```

- What proportion of eligible jurors were struck by the state from the jury pool?

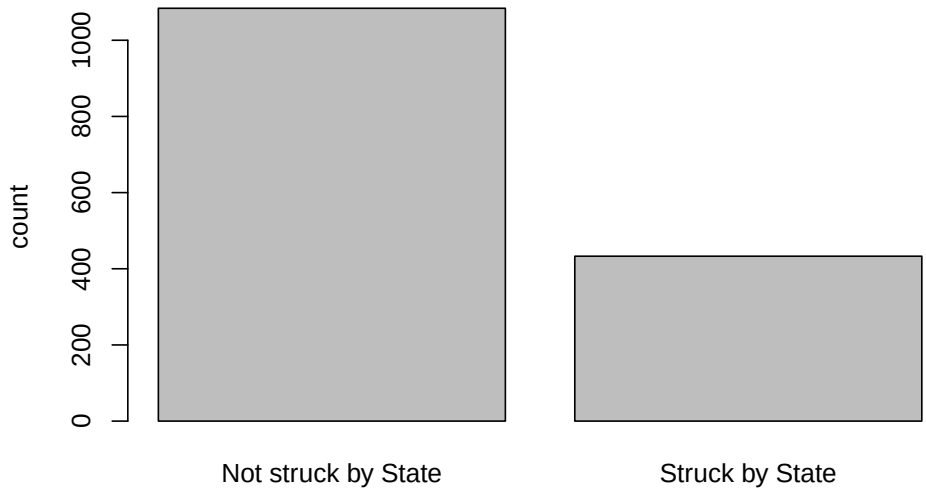
Click for answer

Answer: about 28.5% of eligible jurors were struck by the state.

(c). Bar graph for one variable

You can create a simple bar graph for one categorical variable with the `barplot` command. Here we visualize the distribution of struck status for all eligible jurors:

```
barplot(counts, ylab = "count")
```



(d). Two-way tables

First 10 entries of `race` and `struck_state` variable is

```
jurors[(1:10),(2:3)]
```

```
    race        struck_state
1  Black Not struck by State
2  Black     Struck by State
3  White Not struck by State
4  White Not struck by State
5  Black     Struck by State
6  White Not struck by State
7  Black     Struck by State
8  White Not struck by State
9  White Not struck by State
10 White Not struck by State
```

The `table` command also gives two-way tables when two variables are included. Here is the two-way table for juror race and state struck status:

```
mytable <- table(jurors$race, jurors$struck_state)
mytable
```

```
       Not struck by State Struck by State
  Black                 225             310
  White                 859             123
```

- How many jurors were white and were not struck by the state?

Click for answer

answer: 859

(e). Conditional proportions: state strike status by juror race

The `prop.table` command gives conditional proportions for a two-way table. We plug our two-way table into `prop.table` with a `margin=1` to get proportions grouped by the **row** variable:

```
prop.table(mytable, margin = 1)
```

```
       Not struck by State Struck by State
  Black           0.4205607       0.5794393
  White           0.8747454       0.1252546
```

Of all eligible black jurors, about 57.9% were struck by the state.

- What proportion of eligible white jurors were struck by the state?
  Click for answer
  answer: about 12.5%
- Is there evidence of an association between juror race and state strikes?
  Click for answer
  answer: Yes, there is an association because the rate of state strikes varies greatly by juror race with about 60% of black jurors were struck compared to only 13% of white jurors

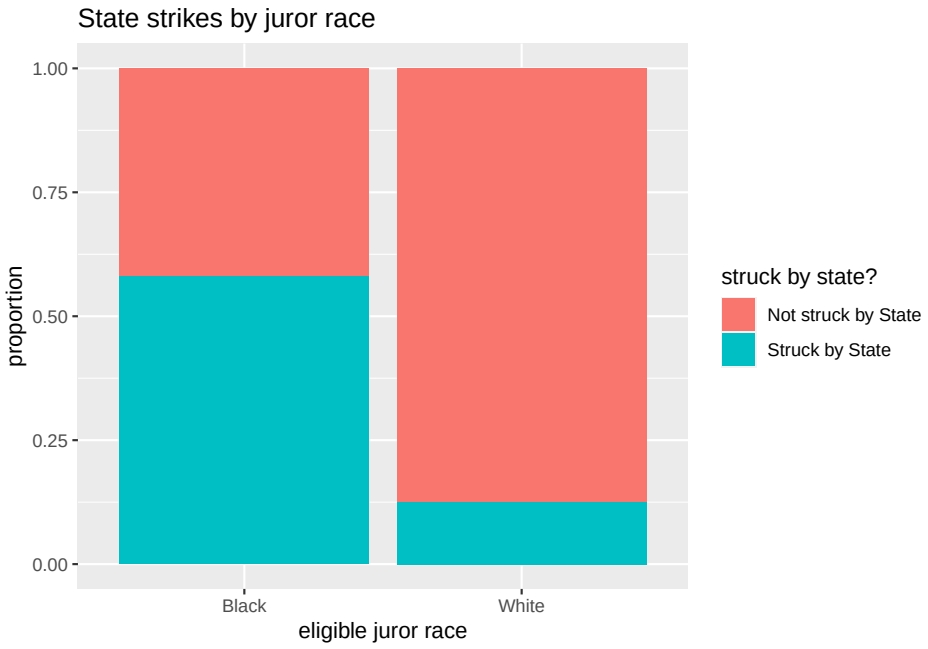
(f). Stacked bar graph for two variables

We can visualize the conditional distribution from part (e) with a stacked bar graph created using the `ggplot2` graphing package. First, load this package's functions with the `library` command:

```
library(ggplot2)
```

Now we can use the `geom_bar` command in this package. Here we get the conditional distribution of `struck_state` given `race`:

```
ggplot(jurors, aes(x = race, fill = struck_state)) +
  geom_bar(position = "fill") +
  labs(title = "State strikes by juror race", y = "proportion",
       x = "eligible juror race", fill = "struck by state?")
```



The basic syntax for this function is to let `ggplot` know your data set name (`jurors`), then specify the grouping or conditional variable on the x-axis (`race`) in the `aes` (aesthetic) argument. The `fill` variable is the response variable (`struck_state`). We add (`+`) the `geom_bar` geometry to get a bar graph with the `fill` position specified. Adding an informative label and title complete the graph.

(g). Conditional distribution of race grouped by strike status

We can "flip" our response and grouping variables easily (if we think it makes sense to do so). Here we specify the `margin=2` to get proportions grouped by the **column** variable:

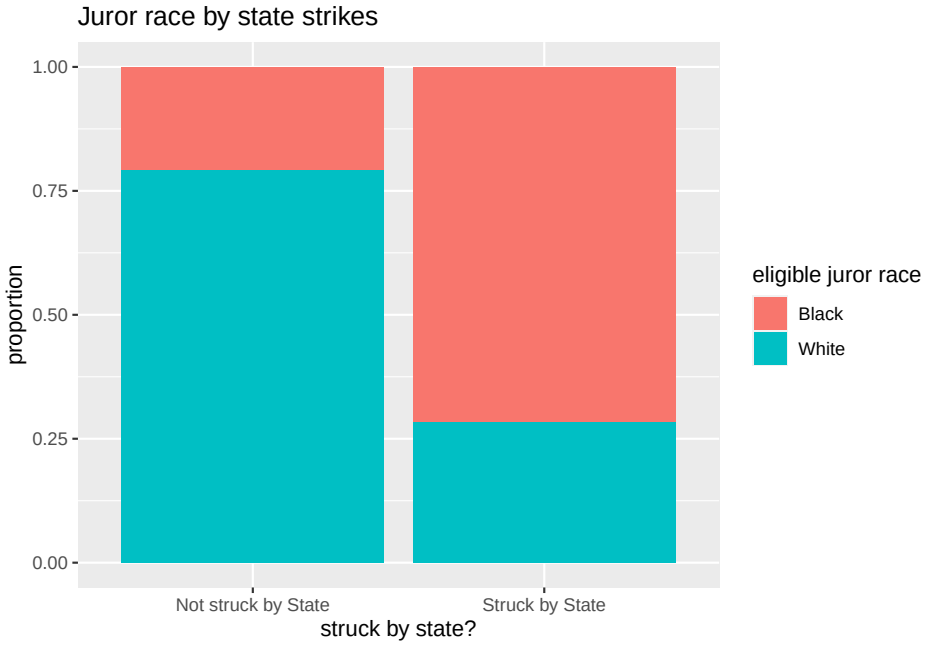
```
prop.table(mytable, margin = 2)
```

```
       Not struck by State Struck by State
  Black           0.2075646       0.7159353
  White           0.7924354       0.2840647
```

Notice that the proportions add to one **down** each column. Of all eligible jurors struck by the state, about 71.6% were black.

The stacked bar graph for this distribution is

```
ggplot(jurors, aes(x = struck_state, fill = race)) +
  geom_bar(position = "fill") +
  labs(title = "Juror race by state strikes", y = "proportion",
       fill = "eligible juror race", x = "struck by state?")
```



- What proportion of eligible jurors who were not struck by the state were black? were white?

Click for answer

Answer: Of all jurors not struck by the state, about 20.8% were black

---

4.2 Your Turn 2

4.2.1 Graduate programs acceptance and sex

How are grad school program acceptance rates associated with sex? We will look at a classic data set from Berkeley grad school applications from 1973 (*Science*, 1975). The data cases are applicants to four graduate programs at Berkeley during 1973. The variable `result` tells us if the applicant was accepted to the graduate program, `sex` tells us the sex of the applicant (male or female), and `program` tells us program type (programs 1,2,3 or 4).

```
grad <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/BerkeleyGrad.csv")
```

```
# dimension of the dataset
dim(grad)
```

```
[1] 3014    3
```

```
# first 6 rows
head(grad)
```

```
   program  sex result
1 program1 male accept
2 program1 male accept
3 program1 male accept
4 program1 male accept
5 program1 male accept
6 program1 male accept
```

(a). Table of counts and proportions

```
prop.table(table(grad$result))
```

```
   accept    reject
0.4260119 0.5739881
```

- What proportion of applicants were accepted?

Click for answer

Answer: About 43% (1284/3014) of applicants were accepted.

(b). Two-way tables

The `table` command also gives two-way tables when two variables are included. Here is the two-way table for result and sex:

```
table(grad$sex, grad$result)
```

```
        accept reject
  female    262    587
  male     1022   1143
```

- How many applicants involved females who were accepted?

Click for answer

Answer: : 262 applicants involved females who were accepted.

(c). Conditional proportions: acceptance given sex

The `prop.table` command gives conditional proportions for a two-way table. First let's save the two-way table in an object named `mytable`:

```
mytable <- table(grad$sex, grad$result)
```

Then use `prop.table` to get the distribution of result conditioned (grouped) on applicant's sex:

```
prop.table(mytable, 1)
```

```
           accept    reject
female 0.3085984 0.6914016
male   0.4720554 0.5279446
```

The value of `1` in this command tell's R that you want *row* proportions (the denominator of the proportion is each row total).

- What proportion of female were accepted?

Click for answer

Answer: about 31% (262/(262+587))

- What proportion of males were accepted?

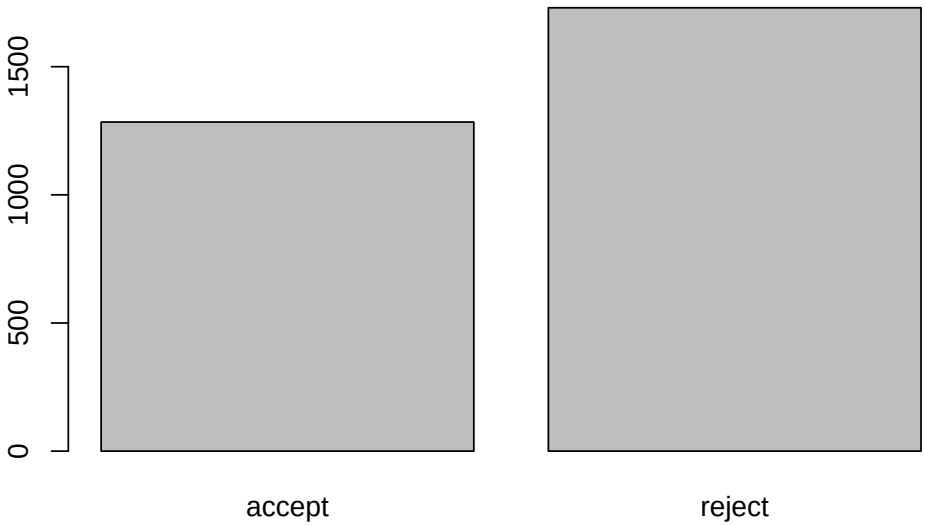
Click for answer

Answer: about 47% (1022/(1022+1143))

(d). Bar graph for one variable

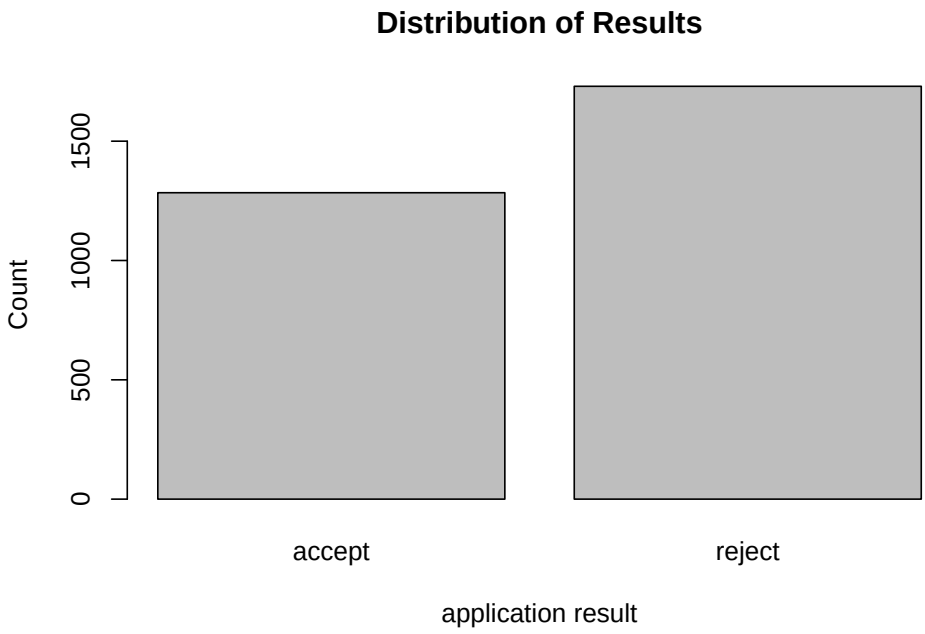
You can create a simple bar graph for one categorical variable with the `barplot` command. Here we visualize the distribution of result:

```
barplot(table(grad$result))
```



We can add in a title and x and y axis labels too:

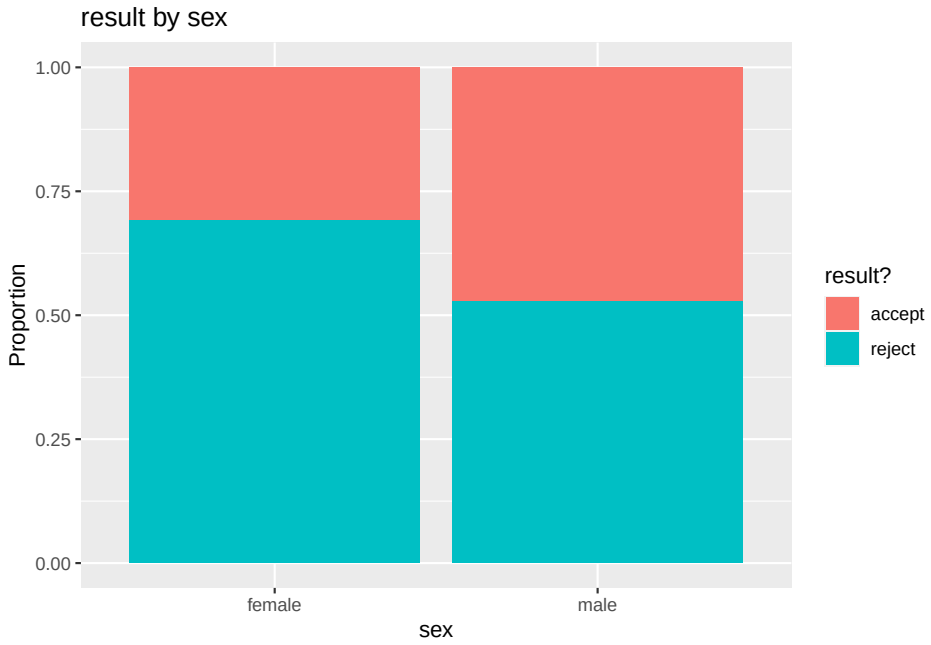
```
barplot(table(grad$result), xlab="application result",
        ylab="Count", main = "Distribution of Results")
```



(e). Stacked bar graph for two variables

Now we can use the `geom_bar` command in this package. Here we get the conditional distribution of `result` given `sex`:

```
library(ggplot2) # don't need if you already entered it for example 1
ggplot(grad, aes(x = sex, fill = result)) +
  geom_bar(position = "fill") +
  labs(y="Proportion", title = "result by sex", fill = "result?", x = "sex")
```



The basic syntax for this function is to let `ggplot` know your data set name (`grad`), then specify the grouping or conditional variable on the x-axis (`sex`) in the `aes` (aesthetic) argument. The `fill` variable is the response variable (`result`). We add (`+`) the `geom_bar` geometry to get a bar graph with the `fill` position specified. Adding an informative label and title complete the graph.

- Verify that this graph is plotting the conditional proportions from part (c)

(f). Subsetting by program type

Finally, we will repeat the previous analysis of result and sex, but this time we will divide (or subset) the data set by program type. To do this we need to know how the values of `program` are coded:

```
table(grad$program)
```

```
program1 program2 program3 program4
     933      585      782      714
```

Here we use the `filter` command available from the `dplyr` package to get only the applicants to program 1:

```
library(dplyr)
grad.p1 <- filter(grad, program == "program1")  # gets rows where program equal progra
head(grad.p1)
```

```
   program  sex result
1 program1 male accept
2 program1 male accept
3 program1 male accept
4 program1 male accept
5 program1 male accept
6 program1 male accept
```

```
dim(grad.p1)
```

```
[1] 933   3
```

Verify that the number of rows in the subsetted program 1 data set matches the number of program 1 applicants shown in the `table` of counts above.

- Repeat the `filter` command to get a data set for program 2 and call the new data set `grad.p2`. Verify that the number of rows in this dataset matches the number of program 2 applicants in the original data set.

```
# enter R code for (f) here
grad.p2 <- filter(grad, program == "program2") # gets rows where program equal program
head(grad.p2)
```

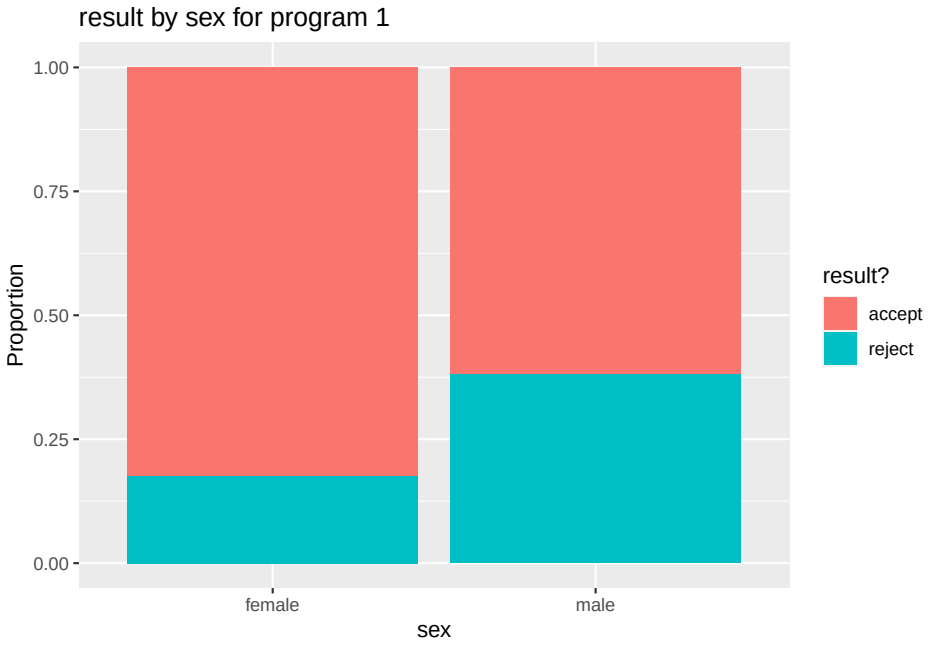
```
   program  sex result
1 program2 male accept
2 program2 male accept
3 program2 male accept
4 program2 male accept
5 program2 male accept
6 program2 male accept
```

(g). Result by sex for program 1.

- Show the distribution of result conditioned on applicant's sex for the program 1 data set. Get both a table of conditional proportions (or percentages) and a stacked bar graph.

Click for answer

```
# enter R code for (g) here
ggplot(grad.p1, aes(x = sex, fill = result)) +
 geom_bar(position = "fill") +
 labs(y="Proportion", title = "result by sex for program 1",
 fill = "result?", x = "sex")
```




```
prop.table(table(grad.p1$sex, grad.p1$result),1)
```

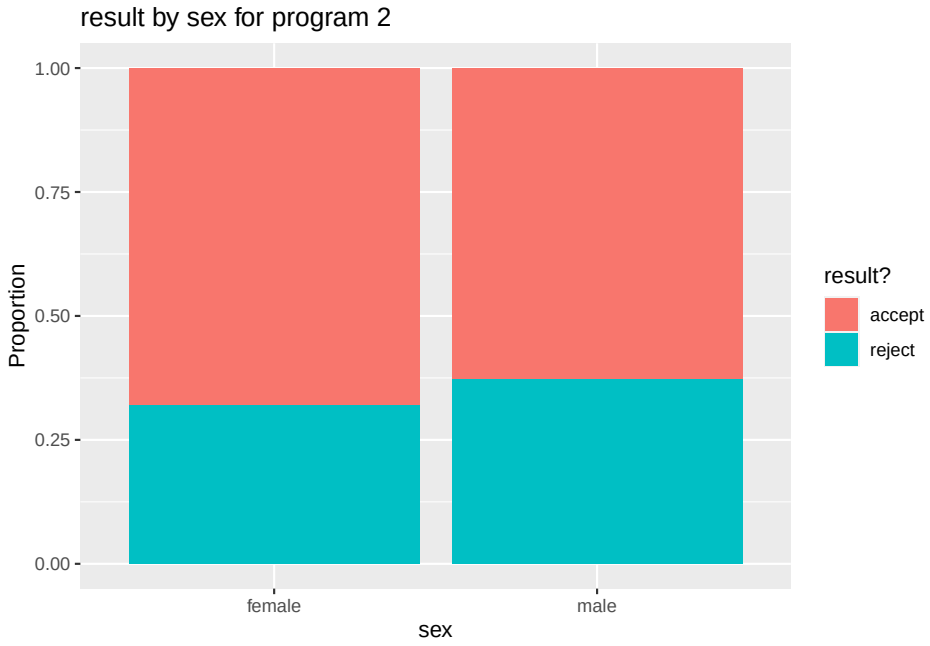
```
          accept    reject
female 0.8240741 0.1759259
male   0.6193939 0.3806061
```

(h). Result by sex for program 2.

- Repeat part (g) but this time use the program 2 data set. Compare the two bar graphs for (g) and (h) and explain how they show that females have a higher acceptance rate after accounting for program type (1 or 2).

Click for answer

```
# enter R code for (h) here
ggplot(grad.p2, aes(x = sex, fill = result)) +
 geom_bar(position = "fill") +
 labs(y="Proportion", title = "result by sex for program 2",
 fill = "result?", x = "sex")
```




```
prop.table(table(grad.p2$sex, grad.p2$result),1)
```

```
          accept    reject
female 0.6800000 0.3200000
male   0.6285714 0.3714286
```

Answer: For both programs 1 and 2, we see that female applicants have a slightly higher rate of acceptance than male applicants. After accounting for program type, we now see that black defendants have a higher rate of death penalty than white defendants. Without accounting for program type, the opposite was true (see parts (c) and (e)).

Why? the confounding affect of program type which is associated with both result and sex:

Click for answer

- females prefer to apply to programs 3 and 4 while males prefer programs 1 and 2 (more than 3 and 4).
  - 44% of females applied to program 3 and 40% to program 4
  - 38% of males applied to program 1 and 26% to program 2

```
prop.table(table(grad$sex, grad$program), 1)
```

```
          program1   program2   program3   program4
  female 0.12720848 0.02944641 0.44169611 0.40164900
  male   0.38106236 0.25866051 0.18799076 0.17228637
```

-Programs 3 and 4 were much harder to get into than programs 1 and 2 - 64% of applicants to program 1 were accepted and 63% of applicants to program 2 were accepted - 6% of applicants to program 4 were accepted and 34% of applicants to program 3 were accepted

```
prop.table(table(grad$program, grad$result), 1)
```

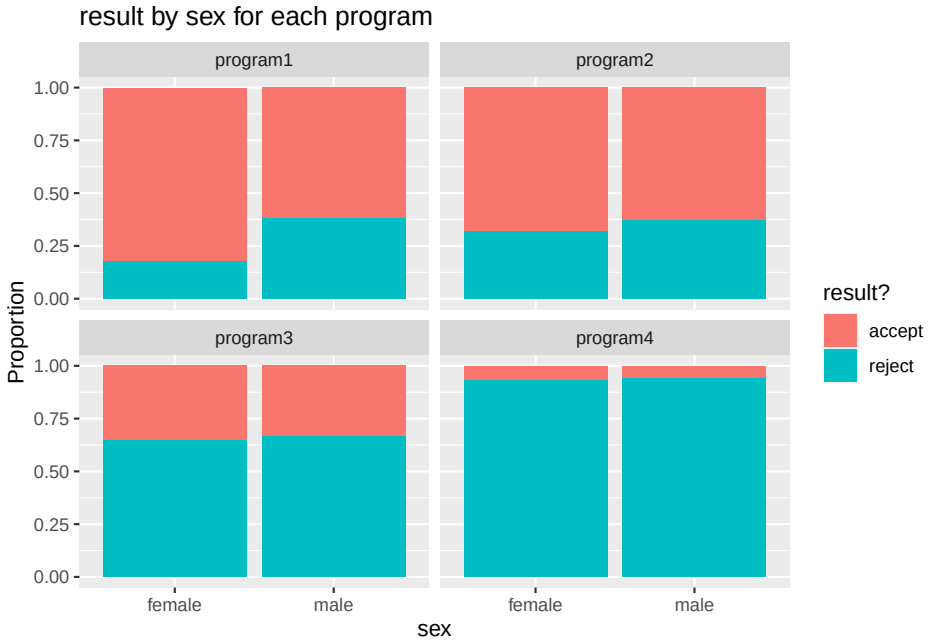
```
              accept     reject
  program1 0.64308682 0.35691318
  program2 0.63076923 0.36923077
  program3 0.34398977 0.65601023
  program4 0.06442577 0.93557423
```

So since the majority of females applied to the toughest programs (as measured by acceptance rates), there overall rate of acceptance was lower for females compared to males. But when we break down these rates by program type, we see that females have higher acceptance rates than males (see the visual in part (i)).

(i). A bar graph with three variables

If we simply want to graph the relationship between result and sex for each type of program, we can avoid subsetting the data by using the `facet_wrap` command in `ggplot2`. It is one simple addition to the stacked bar graph in part (e):

```
ggplot(grad, aes(x = sex, fill = result)) +
  geom_bar(position = "fill") +
  labs(y="Proportion",
       title = "result by sex for each program",
       fill = "result?",
       x = "sex") +
  facet_wrap(~program)
```



- Verify that this command creates side-by-side stacked bar graphs that match your graphs in parts (g) and (h) for programs 1 and 2.

Click for answer

Answer: The graphs match.

4.3 Quiz

1. A two-way table is shown for two groups, 1 and 2, and two possible outcomes, A and B.

	Outcome A	Outcome B	Total
Group 1	40	10	50
Group 2	30	120	150
Total	70	130	200

What proportion of all cases are in Group 1?

A. 0.33

B. 0.20

C. 0.25

D. 0.75

Click for answer

C. 0.25

2. A disruption of a gene called DYXC1 on chromosome 15 for humans may be related to an increased risk of developing dyslexia. Researchers studied the gene in 109 people diagnosed with dyslexia and in a control group of 195 others who had no learning disorder. The DYXC1 break occurred in 10 of those with dyslexia and in 5 of those in the control group. Is this an experiment or an observational study?

A. Experiment

B. Observational Study

Click for answer

Observational Study

3. The data from question 2 can be summarized in a two way table as:

	Gene Break	No Break	Total
Dyslexia Group	10	99	109
Control Group	5	190	195
Total	15	289	304

What is the proportion of Dyslexia group who have the break on the DYXC1 gene? Round your answer to 3 significant digits after the decimal.

A. 0.026

B. 0.667

C. 0.127

D. 0.092

Click for answer

D. 0.092

Chapter 5

Class Activity 5

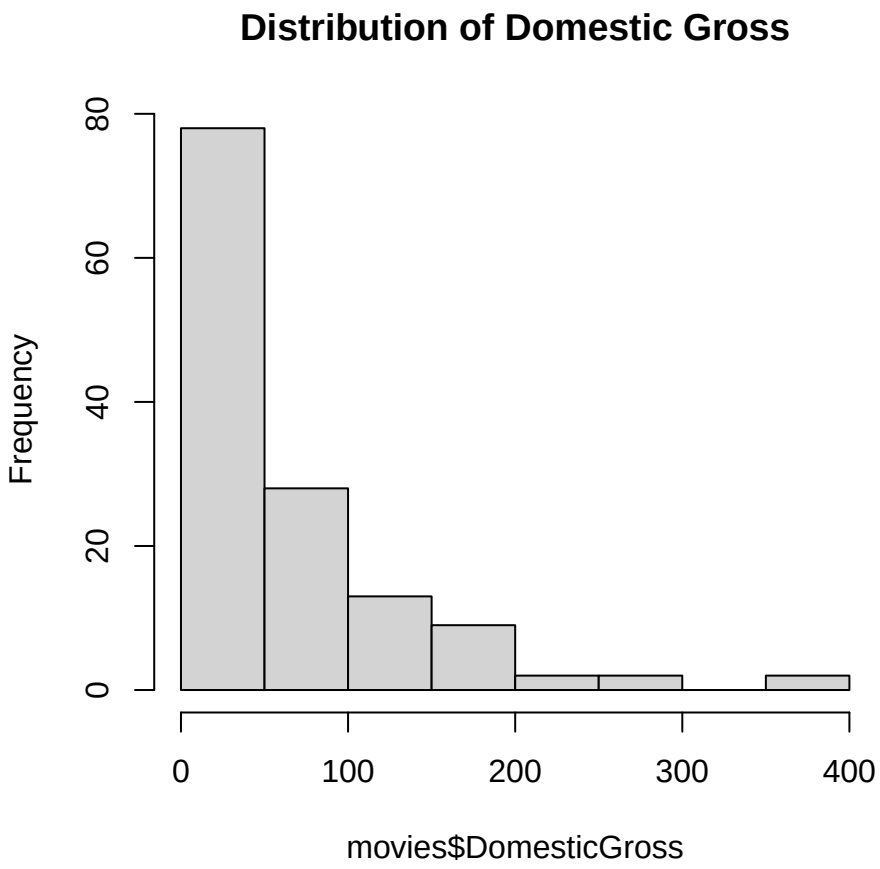
5.1 Your Turn 1

5.1.1 Hollywood Movies Domestic Gross

The dataset `HollywoodMovies2011` provides information on 136 movies that came out of Hollywood in 2011. We will look at the variable `DomesticGross`, which gives US domestic gross income for a movie from all viewers (in millions of dollars).

```
movies <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/HollywoodMovies20
```

```
hist(movies$DomesticGross, main="Distribution of Domestic Gross")
```



(a). Describe the shape of the distribution.

Click for answer

Answer: Skewed to the right

(b). Do there appear to be any outliers? If so, which values?

Click for answer

Answer: Yes, it looks like there are a few high outliers above 300 million.

(c). Finding outliers

We can find the row numbers of cases (movies) that have `DomesticGross` greater than 300 (300 million dollars):

```
which(movies$DomesticGross > 300)
```

```
[1]  4 14
```

Run the `which` command to verify that rows 4 and 14. Then find out which movies these are by subsetting the data frame:

```
movies[c(4,14), ]
```

```
                                      Movie
4  Harry Potter and the Deathly Hallows Part 2
14              Transformers: Dark of the Moon
            LeadStudio RottenTomatoes AudienceScore   Story
4          Warner Bros             96            92 Rivalry
14 DreamWorks Pictures             35            67   Quest
     Genre TheatersOpenWeek BOAverageOpenWeek DomesticGross
4  Fantasy             4375              38672        381.01
14  Action             4088              23937        352.39
   ForeignGross WorldGross Budget Profitability
4        947.10   1328.111    125     10.624888
14       770.81   1123.195    195      5.759974
   OpeningWeekend
4          169.19
14          97.85
```

Note that the `c(4,14)` part of this command creates a **vector** of the numbers 4 and 14 (the `c` stands for combine). Which movies are the outliers?

Click for answer

Answer: Harry Potter and the Deathly Hallows Part 2 and Transformers: Dark of the Moon.

(d). Use the histogram to answer: Is the median less than 100 million, about 100 million, above 100 million?

Click for answer

Answer: It is the point with half the data to the left and half to the right. The median is less than 100 since 100 roughly 110 (80 + 30) cases below it which is well over half the movies in the data set.

(e). Do you expect the mean to be greater than or less than the median. Explain.

Click for answer

Answer: Because the distribution is skewed to the right, we expect the mean to be larger than the median. The large outliers will pull the mean up and won't have much effect on the median.

(f). Computing the mean and median

You can get the mean and median a number of ways. Run these three commands:

```
mean(movies$DomesticGross)
```

```
[1] NA
```

```
median(movies$DomesticGross)
```

```
[1] NA
```

```
summary(movies$DomesticGross)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
   0.02   19.03   37.35   63.22   80.46  381.01       2
```

What does `NA` stand for? How many movies have missing `DomesticGross`? You can subset the data to show you which cases have `NA` values for `DomesticGross`:

```
movies[is.na(movies$DomesticGross), ]
```

```
                            Movie LeadStudio
134                          Hugo  Paramount
136 Never Back Down 2: The Beatdown       Sony
    RottenTomatoes AudienceScore   Story     Genre
134             93            84         Adventure
136             NA            44 Rivalry    Action
    TheatersOpenWeek BOAverageOpenWeek DomesticGross
134             1277              8899            NA
136               NA                NA            NA
    ForeignGross WorldGross Budget Profitability
134           NA         NA     NA            NA
136           NA         NA      3             0
    OpeningWeekend
134          11.36
136           8.60
```

Click for answer

Answer: The `NA` value stands for "Not Available" which is used to code missing values. We can inspect the data frame and see that Hugo and Never Back Down 2 are the two movies that do not have domestic gross values.

(g). Missing data

There are some commands in R that "fail" as a default when missing data (`NA`) are present (`mean`, `median` and `sd` are examples). We can easily turn off this failure feature with the argument `na.rm=TRUE`

```
mean(movies$DomesticGross, na.rm=TRUE)
```

```
[1] 63.22276
```

```
median(movies$DomesticGross, na.rm=TRUE)
```

```
[1] 37.355
```

(h). Stats without outliers

There are a number of ways to "remove" outliers from an analysis. Here we use the square bracket `[]` notation along with a minus `-` to remove row 4 (Harry Potter) from the variable `DomesticGross` before our summary stat calculations:

```
summary(movies$DomesticGross[-4])
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
   0.02   18.88   37.30   60.83   80.36  352.39       2
```

Why does the mean change more than the median when this case is removed? (compare (g) and (h) mean and median values)

Click for answer

Answer: Both values go down after removing the highest grossing movie of the year, but the drop in the mean is more substantial. The mean drops by almost 4% when Harry Potter is removed while the median only drops by about 0.1%.

```
100*(60.83 - 63.22276)/63.22276 # percent change in the mean
```

```
[1] -3.78465
```

```
100*(37.30 - 37.355)/37.355 # percent change in the median
```

```
[1] -0.147236
```

(i). Computing standard deviation

The standard deviation command is `sd`. We need to add the `na.rm` argument to obtain the SD for `DomesticGross`:

```
sd(movies$DomesticGross, na.rm=TRUE)
```

```
[1] 69.41799
```

Look again at the distribution of `DomesticGross` shown in the histogram. Why is SD (variation around the mean) an inadequate measure of variation for this type of distribution?

Click for answer

Answer: The is much more variation (spread) to the data above the mean than below it. Because the distribution is strongly skewed right, we can't use one measure of variation when describing how `DomesticGross` values vary around some central value (like a mean).

(j). Stats by `Genre`

The `tapply(y, x, stat)` command gives the `stat` value of `y` for each level of `x`. Here we get the `summary` of `DomesticGross` for each type of `Genre`:

```
tapply(movies$DomesticGross, movies$Genre, summary)
```

```
$Action
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
   0.54   24.96   40.26   91.02  161.53  352.39       1

$Adventure
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
     NA      NA      NA     NaN      NA      NA       1

$Animation
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  21.39   51.41  115.67  104.62  142.86  191.45

$Comedy
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   5.79   23.21   37.41   56.51   69.75  254.46

$Drama
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   0.38    4.40   13.30   32.37   51.16  169.22

$Fantasy
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   1.32   96.24  191.16  191.16  286.09  381.01
```

```
$Horror
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   0.02   17.69   24.05   34.87   38.18  127.00

$Romance
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   0.03   18.51   39.05   61.40   70.26  260.80

$Thriller
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   0.02   31.18   40.49   41.44   62.50   79.25
```

- Which movies genre has the highest median domestic gross?
- Why are there no summary stats for the adventure genre?

Click for answer

Answer: To help answer these questions you really should explore the number of movies in each genrewith the table command.

- The fantasy genre has the highest median domestic gross ($381 million). But note that only two movies have this classification in 2011. The action genre was second highest at $352 million and there were 12 movies in this category.
- The adventure genre only has one movie (Hugo) and this movie is also missing a value for `DomesticGross`!

```
table(movies$Genre)
```

```
   Action Adventure Animation    Comedy     Drama   Fantasy
       32         1        12        27        21         2
   Horror   Romance  Thriller
       17        11        13
```

```
which(movies$Genre == "Adventure")
```

```
[1] 134
```

```
movies[134, ]
```

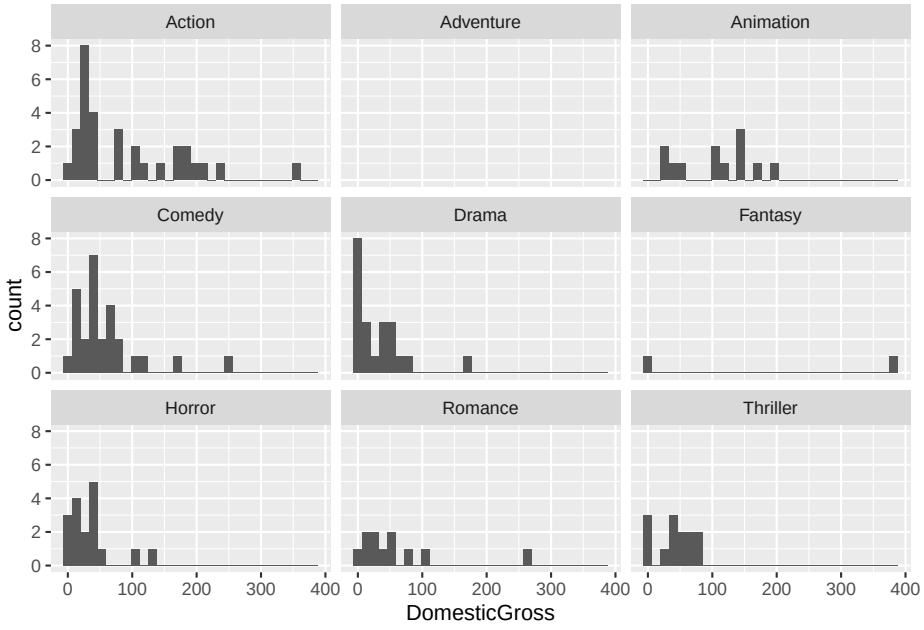
```
    Movie LeadStudio RottenTomatoes AudienceScore Story
134  Hugo  Paramount             93            84
```

```
        Genre TheatersOpenWeek BOAverageOpenWeek
134 Adventure             1277              8899
    DomesticGross ForeignGross WorldGross Budget
134            NA           NA         NA     NA
    Profitability OpeningWeekend
134            NA          11.36
```

(k). Extra: Histogram of `DomesticGross` by `Genre`

(Not in Lab Manual) The `ggplot2` package allows you to create histograms separated by a categorical variable using the `facet_wrap` command. Assuming that `ggplot2` is already installed, all you need to do is load it with `library` then create your graph:

```
library(ggplot2)
ggplot(movies, aes(x=DomesticGross)) +
  geom_histogram() +
  facet_wrap(~Genre)
```



Which genre has the most variability in domestic gross?

Click for answer

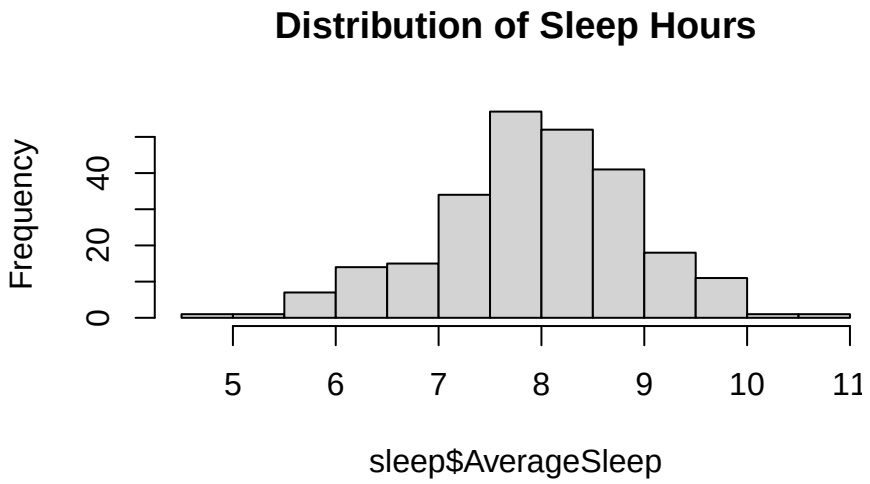
Answer: The action genre has the largest range of values.

5.2 Your turn 2

5.2.1 Example 2: Sleep

This histogram shows the distribution of hours or sleep per night for a large sample of students.

```
sleep <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/SleepStudy.csv")
hist(sleep$AverageSleep, main="Distribution of Sleep Hours")
```



(a). Estimate the average hours of sleep per night.

Click for answer

Answer: The mean is around 8 hours

(b). Use the 95% rule to estimate the standard deviation for this data.

Click for answer

Answer: Most of the data is between about 6 and 10, with a mean around 8 (due to the roughly symmetric distribution). So two standard deviations is about 2 hours of sleep, making one standard deviation about 1 hours of sleep.

Let's check the rule. Here are the actual mean and SD:

```
mean(sleep$AverageSleep)
```

```
[1] 7.965929
```

```
sd(sleep$AverageSleep)
```

```
[1] 0.9648396
```

5.3 Example 3: Z-scores for Test Scores

The ACT test has a population mean of 21 and standard deviation of 5. The SAT has a population mean of 1500 and a standard deviation of 325. You earned 28 on the ACT and 2100 on the SAT.

(a). Which test did you do better on?

Click for answer

Answer:

- ACT: The z-score for the score of 28 is $z = (28 - 21)/5 = 1.4$.
- SAT: The z-score for the score of 2100 is $z = (2100 - 1500)/325 = 1.85$.
- The SAT score is 1.85 standard deviations above average while the ACT score is only 1.4 standard deviations above. You did better on the SAT.

(b). For each test, find the interval that is likely to contain about 95% of all test scores.

Click for answer

Answer:

- ACT: Two standard deviations is $2(5) = 10$. About 95% of ACT scores are between $28 - 10 = 13$ and $28 + 10 = 38$. This claim assumes that ACT scores follow a bell-shaped distribution.
- SAT: Two standard deviations is $2(325) = 650$. About 95% of SAT scores are between $1500 - 650 = 850$ and $1500 + 650 = 2150$. This claim assumes that SAT scores follow a bell-shaped distribution.

5.4 Example 4: 5 number summaries

For each five number summary below, indicate whether the data appear to be symmetric, skewed to the right, or skewed to the left.

(a). (2, 10, 15, 20, 69)

```
my_vector1 <- c(1, 10, 15, 20, 69)
summary(my_vector1)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
      1      10      15      23      20      69
```

Click for answer

Answer: Skewed right. It has a longer right tail than left since $max - Q3 >> Q1 - min$

(b). (10, 57, 85, 88, 93)

```
my_vector2 <- c(10, 57, 85, 88, 93)
summary(my_vector2)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   10.0    57.0    85.0    66.6    88.0    93.0
```

Click for answer

Answer: Skewed left since mean is less than median.

(c). (200, 300, 400, 500, 600)

```
my_vector3 <- c(200, 300, 400, 500, 600)
summary(my_vector3)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
    200     300     400     400     500     600
```

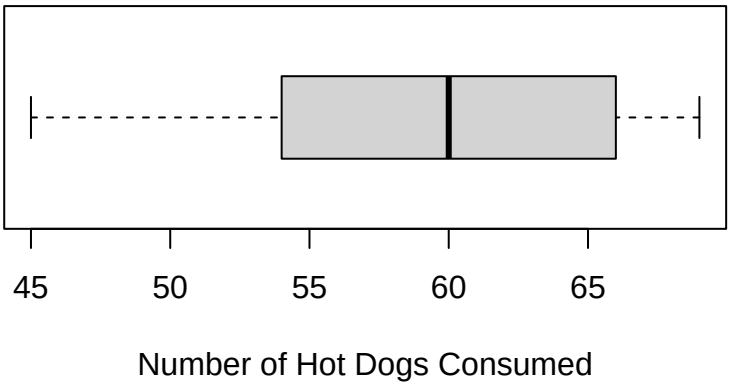
Click for answer

Answer: Symmetric since mean is same as median.

5.5 Example 5: Hot dog

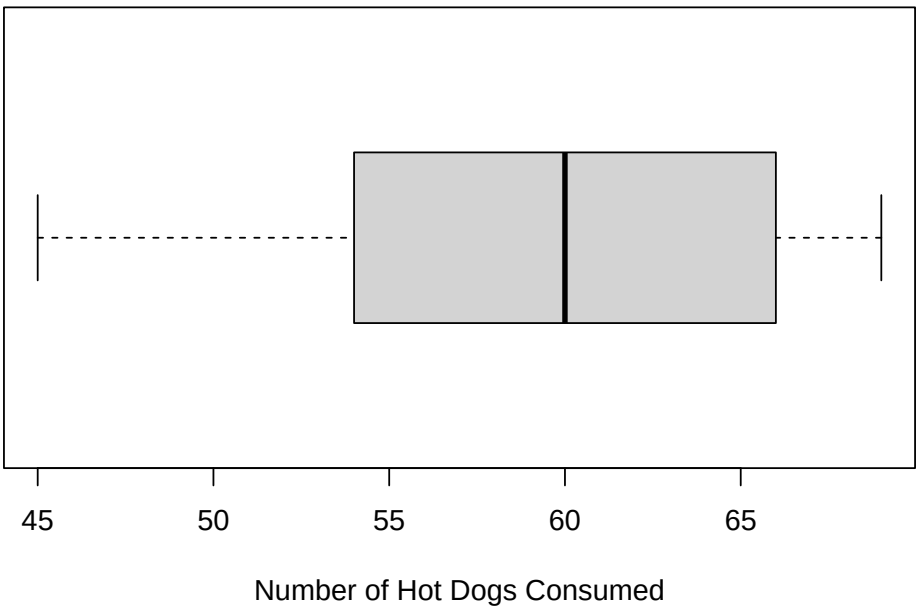
This boxplot shows the number of hot dogs eaten by the winners of Nathan's Famous hot dog eating contests from 2002-2011.

```
hotdogs <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/HotDogs.csv")
boxplot(hotdogs$HotDogs, xlab="Number of Hot Dogs Consumed", horizontal=T)
```



(a). Use the boxplot to estimate the 5 number summary and IQR for this data.

```
boxplot(hotdogs$HotDogs, xlab="Number of Hot Dogs Consumed", horizontal=T)
```



Click for answer

Answer: min = 45, Q1 = 50, m = 54, Q3 = 62, max = 67. IQR is about 62-50 or 12 hotdogs

(b). Computing 5 number summaries

R doesn't have '5 number summary' command, but `summary` gives you a "6" number summary by adding the mean to the 5 number summary. You can also use `IQR` to get the IQR:

```
summary(hotdogs$HotDogs)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  45.00   54.00   60.00   58.64   65.00   69.00
```

```
IQR(hotdogs$HotDogs)
```

```
[1] 11
```

How close were your guesses from the boxplot to the values given by this command?

Click for answer

(Answers will vary) Within one hotdog of the R values.

(c). Use the boxplot outlier rule to verify that there are no outliers in this data.

Click for answer

Answer:

- $1.5IQR = 18$ hotdogs.
- Lower fence: $Q1 - 1.5IQR = 50 - 18 = 32 < min$ so there are no low outliers.
- Upper fence: $Q3 + 1.5IQR = 62 + 18 = 80 > max$ so there are no high outliers.

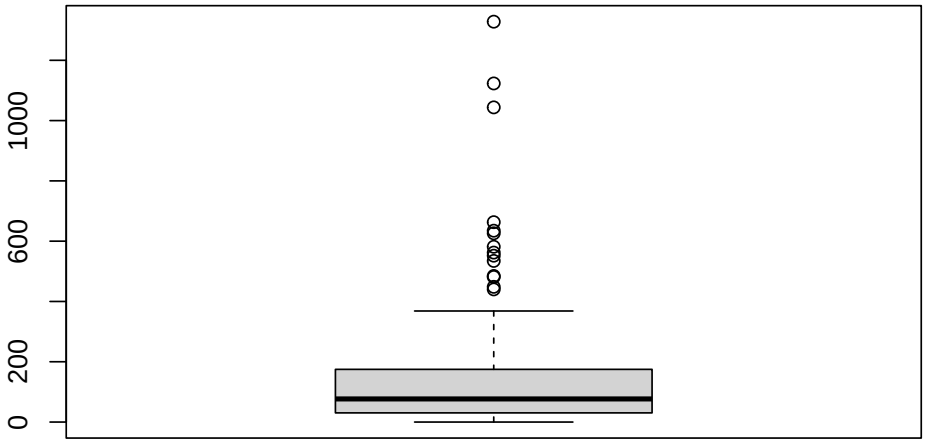
5.6 Examples 6: Hollywood Movies World Gross revisited

Let's revist the `WorldGross` analysis from the Hollywood movies data set:

```
movies <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/HollywoodMovies20
```

(a). Draw a boxplot of `WorldGross`.

```
boxplot(movies$WorldGross)
```



How many movies are identified as outliers for world gross?

Click for answer

Answer: Just using the boxplot, there looks to be about 10 movies that are high outliers

(b). Calculating boxplot values

Use the boxplot outlier rule to find the "fence" (cutoff) between an outlier and non-outlier for `WorldGross`. Then determine the value (of `WorldGross`) that the upper "whisker" (non-outlier) extends to.

```
summary(movies$WorldGross)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  0.025  30.706  76.659 150.742 173.691 1328.111
   NA's
      2
```

```
IQR(movies$WorldGross, na.rm = TRUE)
```

```
[1] 142.985
```

Click for answer

- $1.5IQR = 1.5(142.985) = 214.48$ hundred million dollars
- Lower fence: $Q1 - 1.5IQR = 30.710 - 214.48 = -183.8 < min$ so there are no low outliers.
- Upper fence: $Q3 + 1.5IQR = 173.7 + 214.48 = 388.18 < max$ so there are high outliers.

- The upper whisker extends to the largest movie value that is below the fence of 388.18. You could look at the data spreadsheet and find which movie comes closest to this fence, but a quicker way is to use R. First we can use which to find out the row numbers of the movies with less than 388.18 in WorldGross. Then use this set to find out the max of the WorldGross within this group of movies, which turns out to be 368.404 hundred million dollars.

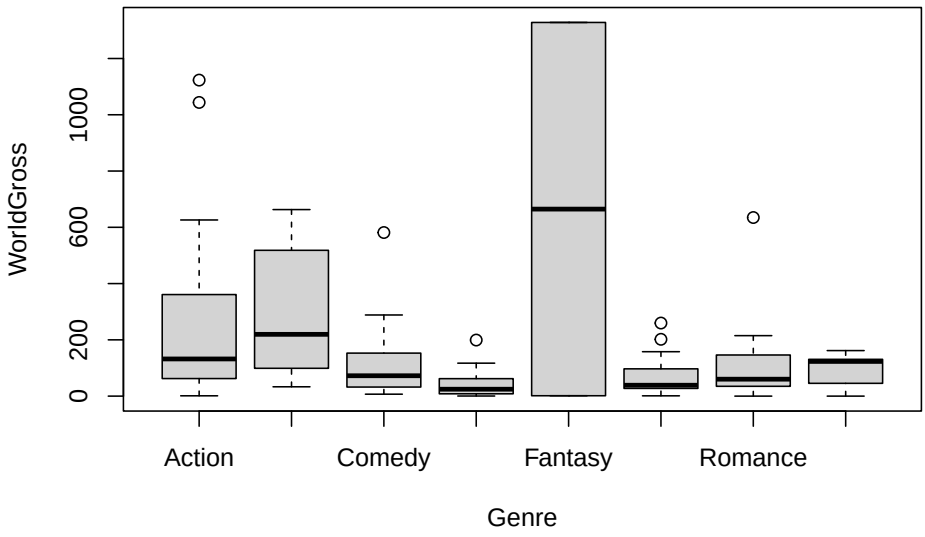
```
1.5*IQR(movies$WorldGross, na.rm = TRUE)
[1] 214.4775
30.710 - 214.48
[1] -183.77
173.7 + 214.48
[1] 388.18
```

```
notoutliers <- which(movies$WorldGross < 388.18)
max(movies$WorldGross[notoutliers])
[1] 368.404
which(movies$WorldGross == 368.404)
[1] 49
movies[49,]
                              Movie LeadStudio
49 Captain America: The First Avenger     Disney
   RottenTomatoes AudienceScore         Story  Genre
49             78            75 Metamorphosis Action
   TheatersOpenWeek BOAverageOpenWeek DomesticGross
49             3715             17512        176.65
   ForeignGross WorldGross Budget Profitability
49       191.75    368.404    140      2.631457
   OpeningWeekend
49          65.06
```

(c). Side-by-side boxplot

We can compare boxplots of `WorldGross` across `Genre` categories:

```
boxplot(WorldGross ~ Genre, data=movies)
```



- What does this type of graph illustrate well about the relationship between `WorldGross` and `Genre`?

Click for answer

Answer: Does a good job comparing median values and extremes

- What does this type of graph not illustrate well about the relationship between `WorldGross` and `Genre`?

Click for answer

Answer: It doesn't illustrate sample sizes well, e.g. the fantacy genre only has 2 movies in it

- What is one issue with the default version of this graph?

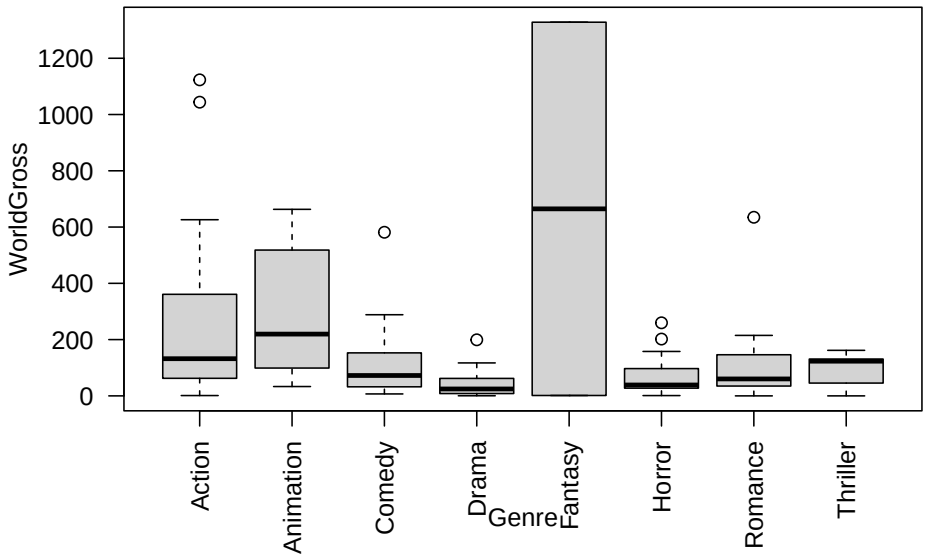
Click for answer

Answer: The genre labels are not all present.

(d). Improving the default boxplot

There are many values in `Genre` for this data and their values (levels) have longer names. This can cause issues when using these names to label graphs, like the x-axis in your boxplot. The are many (many, many) ways to modify graphs in R. Here is one way to change the label orientation on your x-axis.

```
boxplot(WorldGross ~ Genre, data=movies, las=2)
```



The `las` arguments let's you change the orientation of the axis labels relative to the axis. The value of 2 makes the labels perpendicular to the axis.

5.7 Example 8: Ants on a Sandwich

The number of ants climbing on a piece of a peanut butter sandwich left on the ground near an anthill for a few minutes was measured 7 different times and the results are: $43, 59, 22, 25, 36, 47, 19$

(a). Calculate the mean number of ants.

Click for answer

Answer: $\bar{x} = 35.857$

(b). Calculate the median number of ants.

Click for answer

Answer: Order data then find middle value: $19, 22, 25, 36, 43, 47, 59$. Then $m = 36$

(c). Calculate the quartiles for the number of ants.

Click for answer

Answer: Since $m = 36$, the first quartile will be the median of $19, 22, 25 : Q1 = 22$. The third quartile will be the median of $43, 47, 59 : Q3 = 47$.

Chapter 6

(PART*) Basics R

Chapter 7

What is R?

R is a free and open source statistical programming language that facilitates statistical computation. There are a myriad of application that can be done in R, thanks to a huge online support community and dedicated packages. However, R has no graphical user interface and it has to be run by typing commands into a text interface.

7.1 What is RStudio?

RStudio provides graphical interface to R! You can think of RStudio as a graphical front-end to R that that provides extra functionality. The use of the R programming language with the RStudio interface is an essential component of this course.

7.2 R Studio Server

The quickest way to get started is to go to https://maize.mathcs.carleton.edu, which opens an R Studio window in your web browser. Once logged in, I recommend that you do the following:

- Step 1: Create a folder for this course where you can save all of your work. In the Files window, click on New Folder.
- Step 2: Click on Tools -> Global Options -> R Markdown. Then uncheck the box that says "Show output inline…"

(It is also possible to download RStudio on your own laptop. Instructions may be found at the end of this document.)

7.3 R Markdown Basics

An R Markdown file (.Rmd file) combines R commands and written analyses, which are 'knit' together into an HTML, PDF, or Microsoft Word document.

An R Markdown file contains three essential elements:

- Header: The header (top) of the file contains information like the document title, author, date and your preferred output format (pdf_document, word_document, or html_document).
- Written analysis: You write up your analysis after the header and embed R code where needed. The online help below shows ways to add formatting details like bold words, lists, section labels, etc to your final pdf/word/html document. For example, adding ** before and after a word will bold that word in your compiled document.
- R chunks: R chunks contain the R commands that you want evaluated. You embed these chunks within your written analysis and they are evaluated when you compile the document.

7.4 Installing R/RStudio (not needed if you are using the maize server)

- Download the latest version of R:
  - Windows: http://cran.r-project.org/bin/windows/base/
  - Mac: http://cran.r-project.org/bin/macosx/
- Download the free Rstudio desktop version (Windows or Mac): https://www.rstudio.com/products/rstudio/download/

Use the default download and install options for each.

7.5 Install LaTeX (for knitting R Markdown documents to PDF):

If you want to compile R Markdown to .pdf files, you also need a LaTeX distribution (Note: this is not necessary if you choose to compile as a Word document.) Click instructions for Windows or instructions for Mac, depending on your operating system to complete the installation.

7.6 Updating R/RStudio (not needed if you are using the maize server)

If you have used a local version of R/RStudio before and it is still installed on your machine, then you should make sure that you have the most recent versions of each program.

- To check your version of R, run the command `getRversion()` and compare your version to the newest version posted on https://cran.r-project.org/. If you need an update, then install the newer version using the installation directions above.
- In RStudio, check for updates with the menu option `Help > Check for updates`. Follow directions if an update is needed.

7.7 Instructions

If using Rstudio on your computer, using the **File>Open File** menu to find and open this .Rmd file.

If using Maize Rstudio from your browser:

- In the Files tab, select **Upload** and **Choose File** to find the .Rmd that you downloaded. Click *OK* to upload to your course folder/location in the maize server account.
- Click on the .Rmd file in the appropriate folder to open the file.

Extra notes:

- You can run a line of code by placing your cursor in the line of code and clicking **Run Selected Line(s)**
- You can run an entire chunk by clicking the green triangle on the right side of the code chunk.
- After each small edit or code addition, **Knit** your Markdown. If you wait until the end to Knit, it will be harder to find errors in your work.
- Format output type: You can use any of pdf_document, html_document type, or word_document type.
- **Maize users**: You may also need to allow for "pop-up" in your web browser when knitting documents.

7.8 Few More Instructions

The default setting in Rstudio when you are running chunks is that the "output" (numbers, graphs) are shown **inline** within the Markdown Rmd. If you prefer to have your plots appear on the right of the console and not below the chunk, then change the settings as follows:

1. Select Tools > Global Options.
2. Click the R Markdown section and uncheck (if needed) the option Show output inline for all R Markdown documents.
3. Click OK.

Now try running R chunks in the .Rmd file to see the difference. You can recheck this box if you prefer the default setting.

Chapter 8

R Markdown

This is a R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see http://rmarkdown.rstudio.com.

You can use asterisk mark to provide emphasis, such as `*italics* or **bold**`.

You can create lists with a dash:

```
- Item 1
- Item 2
- Item 3
  + Subitem 1
* Item 4
```

- Item 1
- Item 2
- Item 3
    - Subitem 1
- Item 4

You can embed Latex equations in-line, $\frac{1}{n}\sum_{i=1}^{n} x_i$ or in a new line as

$$\text{Var}(X) = \frac{1}{n-1}\sum_{i-1}^{n}(x_i - \bar{x})^2$$

Embed an R code chunk:

Use

```
```r
Use back ticks to
create a block of code
```
```

to produce:

```
Use back ticks to
create a block of code
```

You can also evaluate and display the results of R code. Each tasks can be accomplished in a suitably labeled chunk like the following:

```
summary(cars)
```

```
     speed           dist       
 Min.   : 4.0   Min.   :  2.00  
 1st Qu.:12.0   1st Qu.: 26.00  
 Median :15.0   Median : 36.00  
 Mean   :15.4   Mean   : 42.98  
 3rd Qu.:19.0   3rd Qu.: 56.00  
 Max.   :25.0   Max.   :120.00  
```

```
fit <- lm(dist ~ speed, data = cars)
fit
```

```

Call:
lm(formula = dist ~ speed, data = cars)

Coefficients:
(Intercept)        speed  
    -17.579        3.932  
```

8.1 Including Plots

You can also embed plots. See Figure 8.1 for example:

```
par(mar = c(0, 1, 0, 1))
pie(
  c(280, 60, 20),
  c('Sky', 'Sunny side of pyramid', 'Shady side of pyramid'),
```

```
  col = c('#0292D8', '#F7EA39', '#C4B632'),
  init.angle = -50, border = NA
)
```

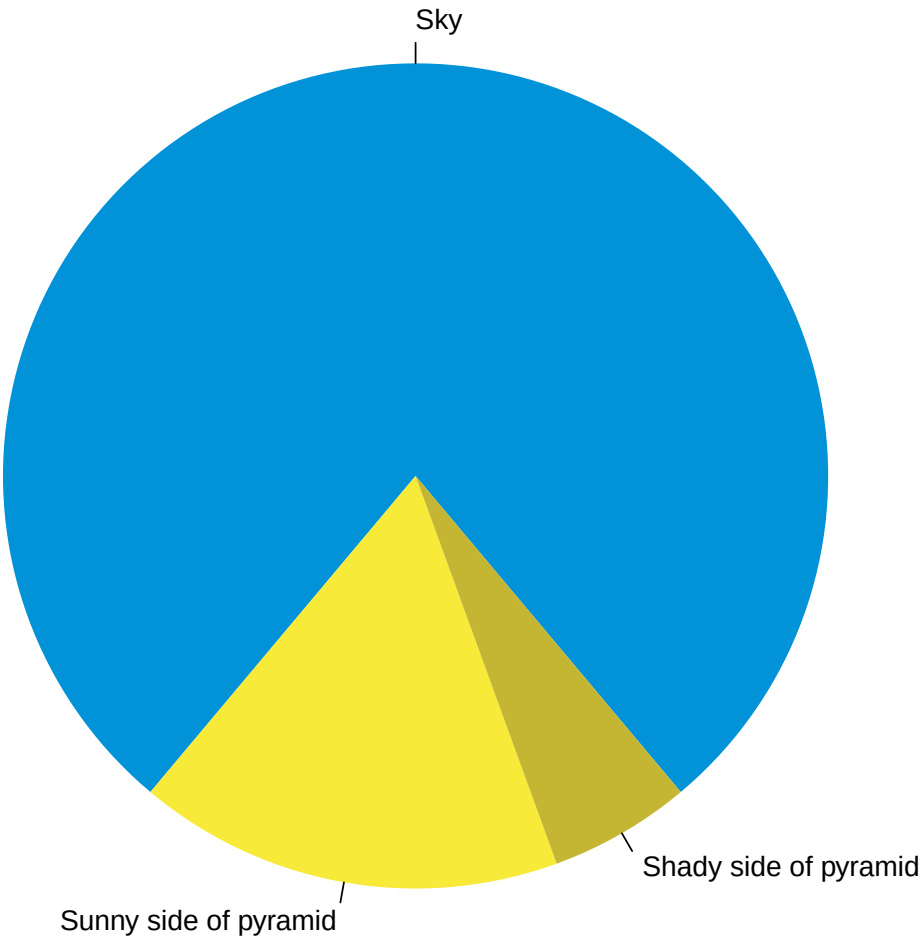


Figure 8.1: A fancy pie chart.

(Credit: Yihui Xie)

8.2 Read in data files

```
simple_data <- read.csv("https://deepbas.io/data/simple-1.dat", )
summary(simple_data)
```

```
  initials            state                age
Length:3           Length:3           Min.   :45.0
Class :character   Class :character   1st Qu.:47.5
Mode  :character   Mode  :character   Median :50.0
                                      Mean   :52.0
                                      3rd Qu.:55.5
                                      Max.   :61.0

    time
Length:3
Class :character
Mode  :character
```

```
knitr::kable(simple_data)
```

initials	state	age	time
vib	MA	61	6:01
adc	TX	45	5:45
kme	CT	50	4:19

8.3 Hide the code

If we enter the `echo = FALSE` option in the R chunk (see the .Rmd file). This prevents the R code from being printed to your document; you just see the results.

initials	state	age	time
vib	MA	61	6:01
adc	TX	45	5:45
kme	CT	50	4:19