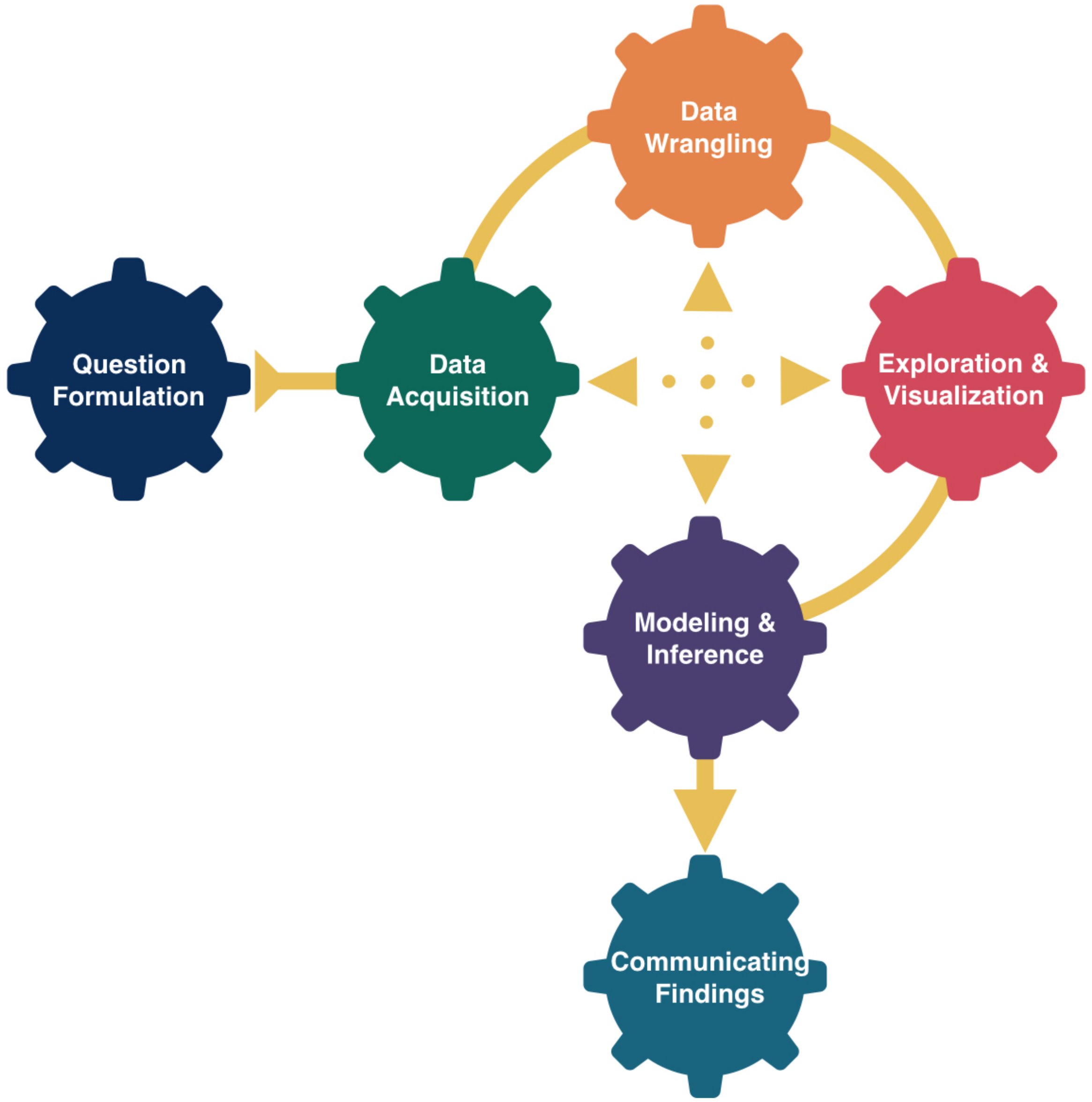

Data Wrangling & Summarization

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Stat 100

Week 3 | Fall 2023

Announcements

- With COVID working its way through campus right now, make sure to check the Sections spreadsheet and the Office hours spreadsheet for updates!
- Let's go through up to upload the pngs of your postcards to the RStudio Server on Posit Cloud.

Goals for Today

- Consider measures for **summarizing** quantitative data
  - Center
  - Spread/variability
- Consider measures for **summarizing** categorical data
- Define **data wrangling**
- Learn to use functions in the `dplyr` package to summarize and wrangle data

Load Necessary Packages

`dplyr` is part of this collection of data science packages.

```
# Load necessary packages
library(tidyverse)
```

Import the Data

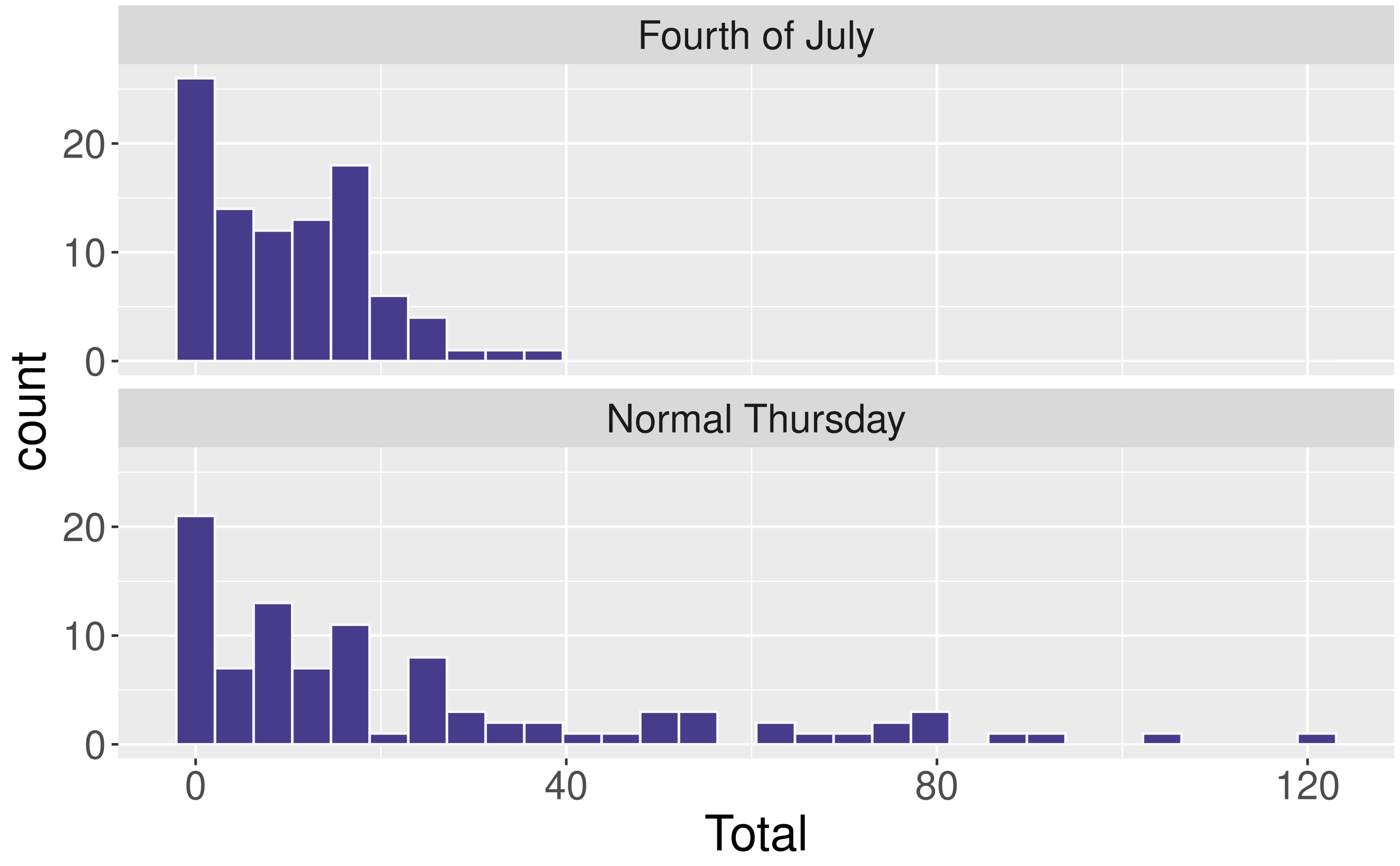
```
july_2019 <- read_csv("data/july_2019.csv")

# Inspect the data
glimpse(july_2019)
```

```
Rows: 192
Columns: 8
$ DateTime  <chr> "07/04/2019 12:00:00 AM", "07/04/2019 12:15:00 AM", "07/04/2…
$ Day       <chr> "Thursday", "Thursday", "Thursday", "Thursday", "Thursday", …
$ Date      <date> 2019-07-04, 2019-07-04, 2019-07-04, 2019-07-04, 2019-07-04,…
$ Time      <time> 00:00:00, 00:15:00, 00:30:00, 00:45:00, 01:00:00, 01:15:00,…
$ Total     <dbl> 2, 3, 2, 0, 3, 2, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 1, …
$ Westbound <dbl> 2, 3, 1, 0, 2, 2, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1, …
$ Eastbound <dbl> 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, …
$ Occasion  <chr> "Fourth of July", "Fourth of July", "Fourth of July", "Fourt…
```

Summarizing Data

DateTime	Day	Date	Time	Total	Westbound	Eastbound	Occasion
07/04/2019 06:00:00 AM	Thursday	2019-07-04	06:00:00	1	1	0	Fourth of July
07/04/2019 06:15:00 AM	Thursday	2019-07-04	06:15:00	4	0	4	Fourth of July
07/04/2019 06:30:00 AM	Thursday	2019-07-04	06:30:00	9	1	8	Fourth of July
07/04/2019 06:45:00 AM	Thursday	2019-07-04	06:45:00	5	0	5	Fourth of July

Summarizing Data Visually



For a quantitative variable, want to answer:

- What is an **average** value?
- What is the **trend/shape** of the variable?
- How much **variation** is there from case to case?

Need to learn key **summary statistics**: Numerical values computed based on the observed cases.

Measures of Center

Mean: Average of all the observations

- n = Number of cases (sample size)
- x_i = value of the i-th observation
- Denote by $\bar{x}$

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

```
# Test out on first 6 values
head(july_2019$Total)
```

```
[1] 2 3 2 0 3 2
```

Compute with a `dplyr` function:

```
summarize(july_2019, mean_bikes = mean(Total))
```

```
# A tibble: 1 × 1
  mean_bikes
       <dbl>
1       17.1
```

Measures of Center

Median: Middle value

- Half of the data falls below the median
- Denote by m
- If n is even, then it is the average of the middle two values

```
# Test out on first 6 values
head(july_2019$Total)
```

```
[1] 2 3 2 0 3 2
```

Compute with a `dplyr` function:

```
summarize(july_2019, median_bikes = median(Total))
```

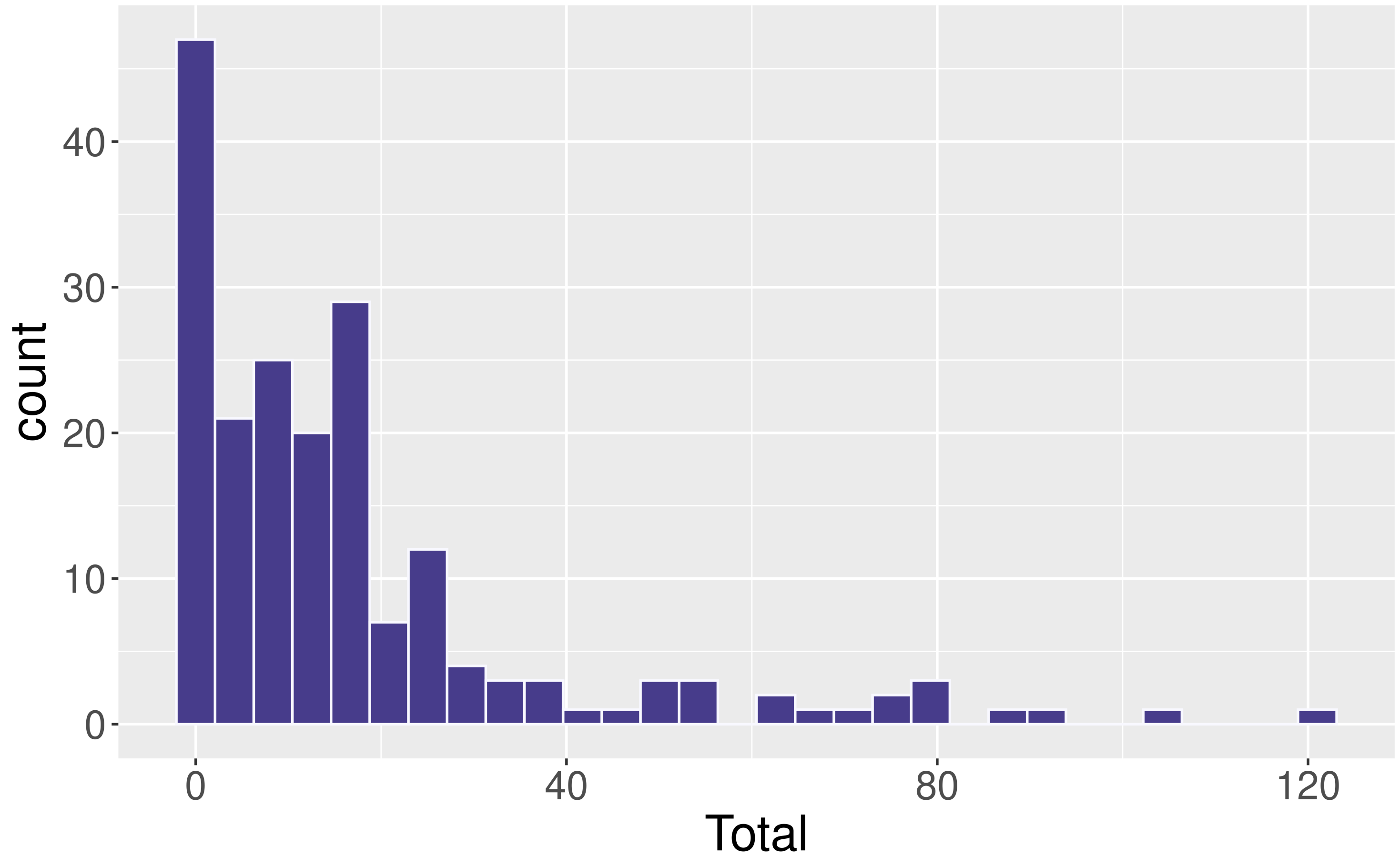
```
# A tibble: 1 × 1
  median_bikes
         <dbl>
1           11
```

Measures of Center

Why is the mean larger than the median?

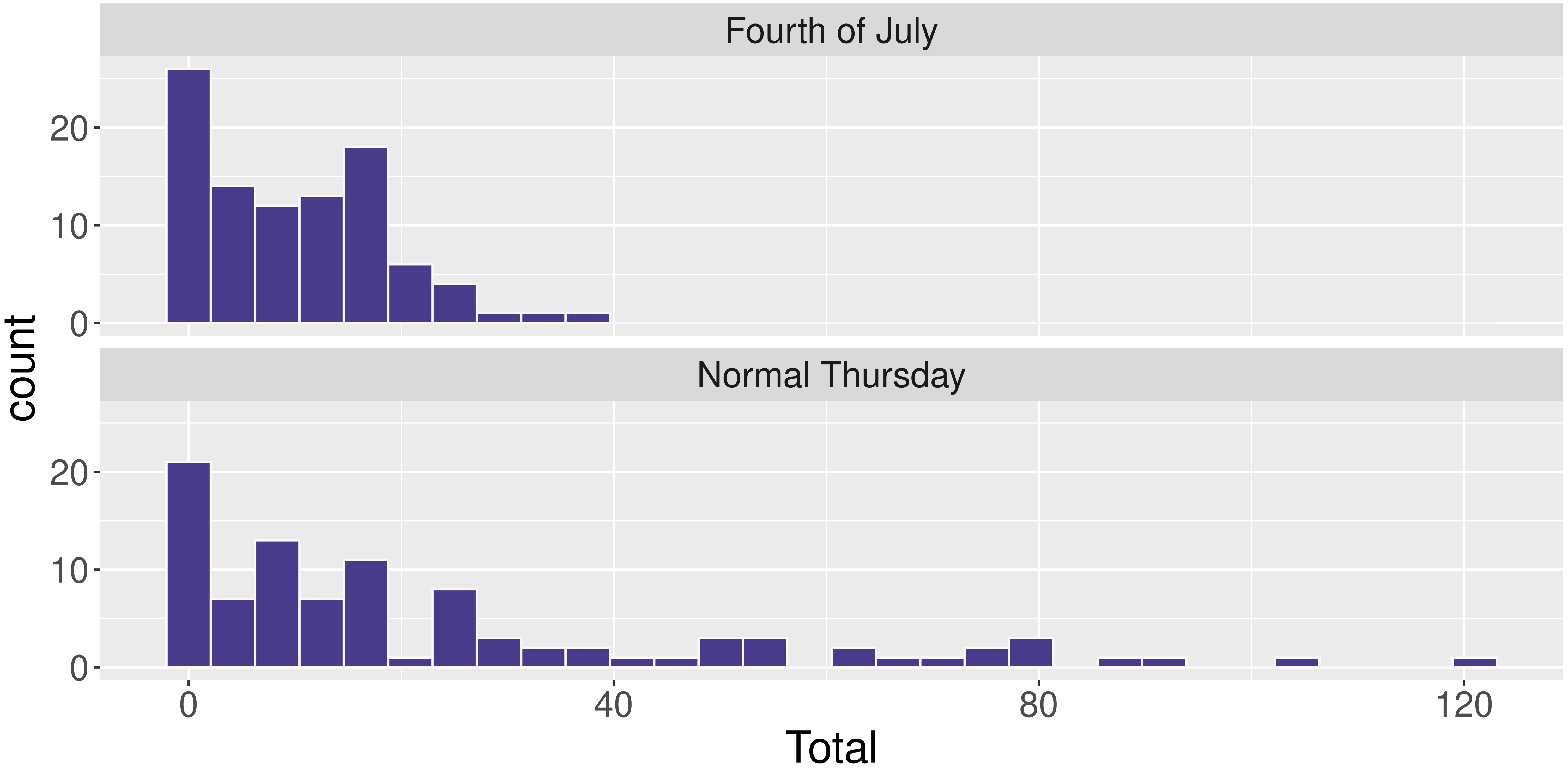
```
summarize(july_2019, mean_bikes = mean(Total),
             median_bikes = median(Total))
```

```
# A tibble: 1 × 2
  mean_bikes median_bikes
       <dbl>        <dbl>
1       17.1           11
```



Computing Measures of Center by Groups

Question: Were there more bikes, on average, for Fourth of July or for the normal Thursday?


Fourth of July
Normal Thursday
count
Total
0
10
20
0
10
20
0
40
80
120

Computing Measures of Center by Groups

Handy `dplyr` function: `group_by()`

```r
july_2019_grouped <- group_by(july_2019, Occasion)
july_2019_grouped
```

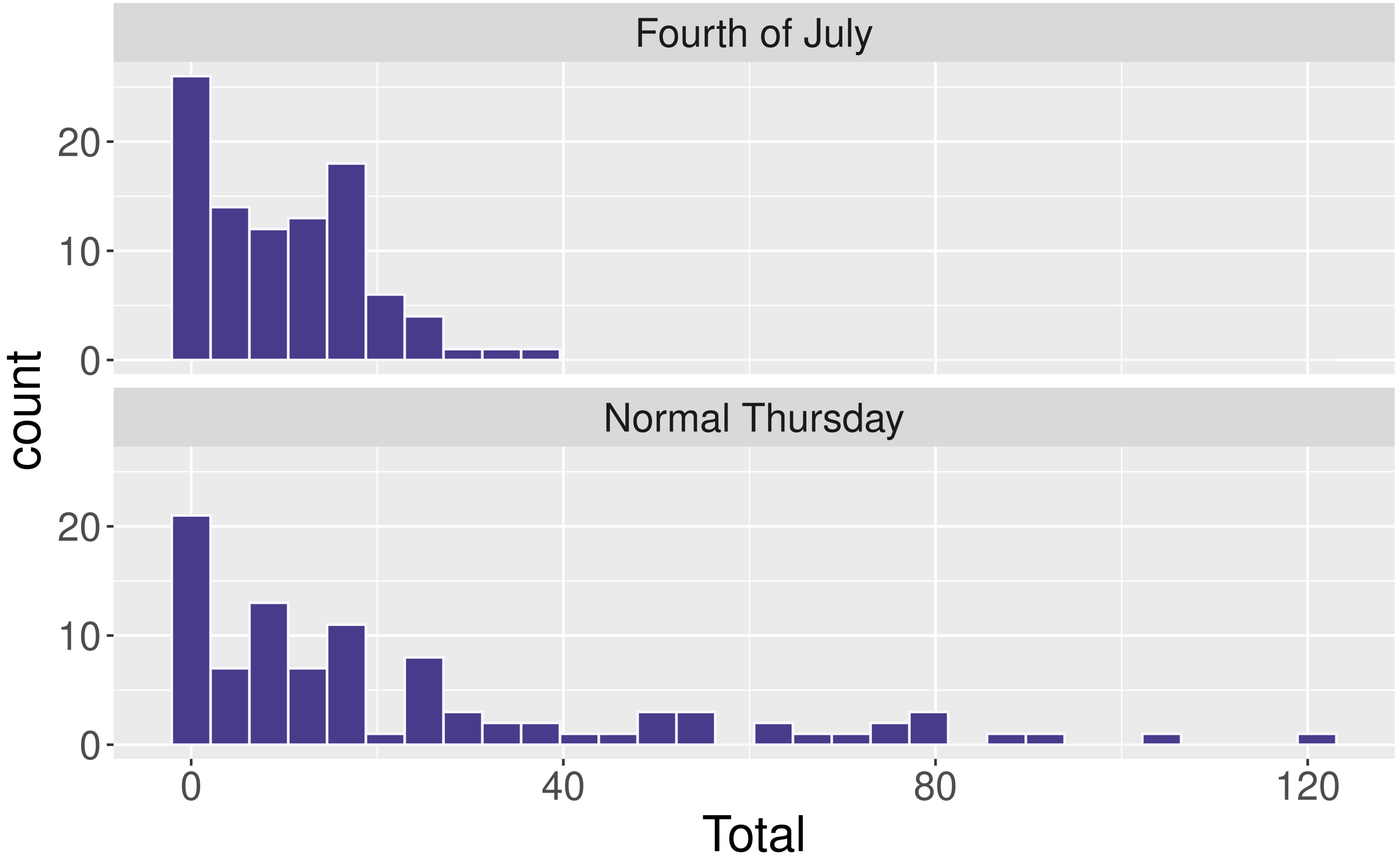
```
# A tibble: 192 × 8
# Groups:   Occasion [2]
   DateTime               Day   Date       Time  Total Westbound Eastbound Occasion
   <chr>                  <chr> <date>     <tim> <dbl>     <dbl>     <dbl> <chr>
 1 07/04/2019 12:00:0… Thur… 2019-07-04 00:00     2         2         0 Fourth …
 2 07/04/2019 12:15:0… Thur… 2019-07-04 00:15     3         3         0 Fourth …
 3 07/04/2019 12:30:0… Thur… 2019-07-04 00:30     2         1         1 Fourth …
 4 07/04/2019 12:45:0… Thur… 2019-07-04 00:45     0         0         0 Fourth …
 5 07/04/2019 01:00:0… Thur… 2019-07-04 01:00     3         2         1 Fourth …
 6 07/04/2019 01:15:0… Thur… 2019-07-04 01:15     2         2         0 Fourth …
 7 07/04/2019 01:30:0… Thur… 2019-07-04 01:30     1         1         0 Fourth …
 8 07/04/2019 01:45:0… Thur… 2019-07-04 01:45     0         0         0 Fourth …
 9 07/04/2019 02:00:0… Thur… 2019-07-04 02:00     0         0         0 Fourth …
10 07/04/2019 02:15:0… Thur… 2019-07-04 02:15     0         0         0 Fourth …
# ℹ 182 more rows
```

Computing Measures of Center by Groups

Compute summary statistics on the grouped data frame:

```
july_2019_grouped <- group_by(july_2019, Occasion)
summarize(july_2019_grouped,
          mean_bikes = mean(Total),
          median_bikes = median(Total))
```

```
# A tibble: 2 × 3
  Occasion        mean_bikes median_bikes
  <chr>                <dbl>        <dbl>
1 Fourth of July        10.0          9
2 Normal Thursday       24.2         14.5
```



And now it is time to learn the pipe: %>%

Chaining `dplyr` Operations

Instead of:

```r
july_2019_grouped <- group_by(july_2019, Occasion)
summarize(july_2019_grouped,
          mean_bikes = mean(Total),
          median_bikes = median(Total))
```

```
# A tibble: 2 × 3
  Occasion         mean_bikes median_bikes
  <chr>                 <dbl>        <dbl>
1 Fourth of July         10.0          9
2 Normal Thursday        24.2         14.5
```

Use the pipe:

```r
july_2019 %>%
  group_by(Occasion) %>%
  summarize(mean_bikes = mean(Total),
            median_bikes = median(Total))
```

```
# A tibble: 2 × 3
  Occasion         mean_bikes median_bikes
  <chr>                 <dbl>        <dbl>
1 Fourth of July         10.0          9
2 Normal Thursday        24.2         14.5
```

- Why pipe?
- You can also use `|>`, which is newer and often referred to as the "base R pipe."

Measures of Variability

- Want a statistic that captures how much observations **deviate** from the mean

- Find how much each observation deviates from the mean.
- Compute the average of the deviations.

```r
# Test out on first 6 values
head(july_2019$Total)
```

```
[1] 2 3 2 0 3 2
```

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

Problem?

Measures of Variability

- Want a statistic that captures how much observations deviate from the mean

Here is my NEW proposal:

- Find how much each observation deviates from the mean.
- Compute the average of the squared deviations.

```r
# Test out on first 6 values
head(july_2019$Total)
```

```
[1] 2 3 2 0 3 2
```

Measures of Variability

- Want a statistic that captures how much observations **deviate** from the mean

Here is my **ACTUAL** formula:

- Find how much each observation deviates from the mean.
- Compute the (nearly) average of the **squared** deviations.
- Called **sample variance** s^2.

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

Compute with a `dplyr` function:

```
summarize(july_2019, var_bikes = var(Total))
```

```
# A tibble: 1 × 1
  var_bikes
      <dbl>
1      454.
```

Measures of Variability

- Want a statistic that captures how much observations **deviate** from the mean

- Find how much each observation deviates from the mean.
- Compute the (nearly) average of the **squared** deviations.
- Called **sample variance** s^2.
- The square root of the sample variance is called the **sample standard deviation** s.

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Compute with a `dplyr` function:

```
summarize(july_2019, var_bikes = var(Total),
                     sd_bikes = sd(Total))
```

```
# A tibble: 1 × 2
  var_bikes sd_bikes
      <dbl>    <dbl>
1      454.     21.3
```

Measures of Variability

- In addition to the sample standard deviation and the sample variance, there is the sample **interquartile range** (IQR):

$$\text{IQR} = Q_3 - Q_1$$

Compute with a `dplyr` function:

```
summarize(july_2019, iqr_bikes = IQR(Total))
```

```
# A tibble: 1 × 1
  iqr_bikes
      <dbl>
1        16
```

Comparing Measures of Variability

- Which is more robust to outliers, the IQR or s?
- Which is more commonly used, the IQR or s?

```r
july_2019 %>%
  group_by(Occasion) %>%
summarize(sd_bikes = sd(Total),
          iqr_bikes = IQR(Total))
```

```
# A tibble: 2 × 3
  Occasion        sd_bikes iqr_bikes
  <chr>              <dbl>     <dbl>
1 Fourth of July      8.30      14  
2 Normal Thursday    27.2       27.2
```

Summarizing Categorical Variables

Return to the Cambridge Dogs

Focus on the dogs with the 5 most common names

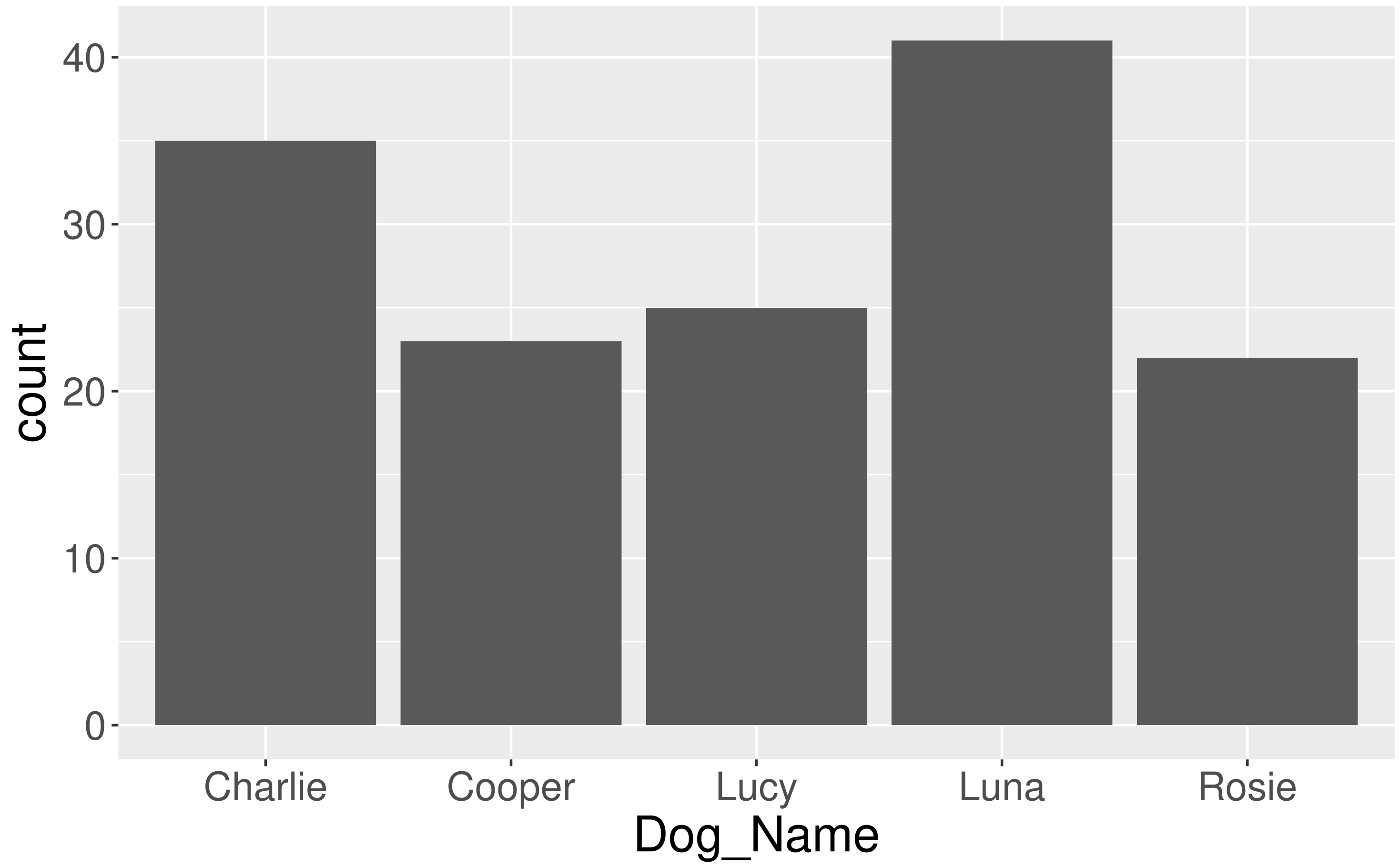
```r
dogs <- read_csv("https://data.cambridgema.gov/api/views/sckh-3xyx/rows.csv")

# Useful wrangling that we will come back to
dogs_top5 <- dogs %>%
  mutate(Breed = case_when(
                       Dog_Breed == "Mixed Breed" ~ "Mixed",
                       Dog_Breed != "Mixed Breed" ~ "Single")) %>%
  filter(Dog_Name %in% c("Luna", "Charlie", "Lucy", "Cooper", "Rosie" ))
```

Frequency Table

```r
count(dogs_top5, Dog_Name)
```

```
# A tibble: 5 × 2
  Dog_Name      n
  <chr>     <int>
1 Charlie      35
2 Cooper       23
3 Lucy         25
4 Luna         41
5 Rosie        22
```

```r
ggplot(data = dogs_top5,
    mapping = aes(x = Dog_Name)) +
  geom_bar()
```



Frequency Table

```
count(dogs_top5, Dog_Name)
```

```
# A tibble: 5 × 2
  Dog_Name     n
  <chr>    <int>
1 Charlie     35
2 Cooper      23
3 Lucy        25
4 Luna        41
5 Rosie       22
```

```
count(dogs_top5, Dog_Name, sort = TRUE)
```

```
# A tibble: 5 × 2
  Dog_Name     n
  <chr>    <int>
1 Luna        41
2 Charlie     35
3 Lucy        25
4 Cooper      23
5 Rosie       22
```

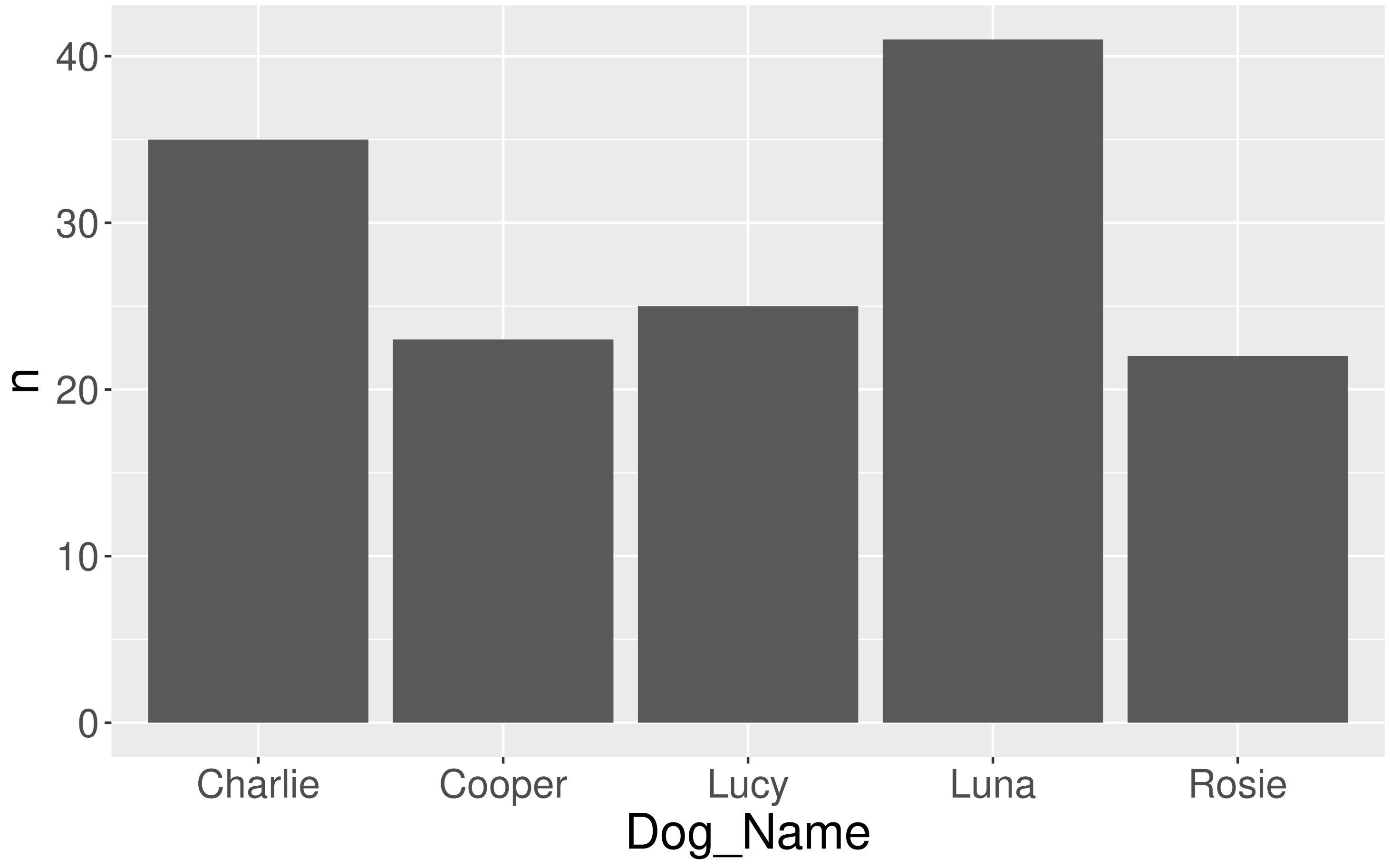
Another ggplot2 geom: geom_col()

If you have already aggregated the data, you will use geom_col() instead of geom_bar().

```
dog_counts <- count(dogs_top5, Dog_Name)
dog_counts
```

```
# A tibble: 5 × 2
  Dog_Name     n
  <chr>    <int>
1 Charlie     35
2 Cooper      23
3 Lucy        25
4 Luna        41
5 Rosie       22
```

```
ggplot(data = dog_counts,
       mapping = aes(x = Dog_Name,
                     y = n)) +
  geom_col()
```



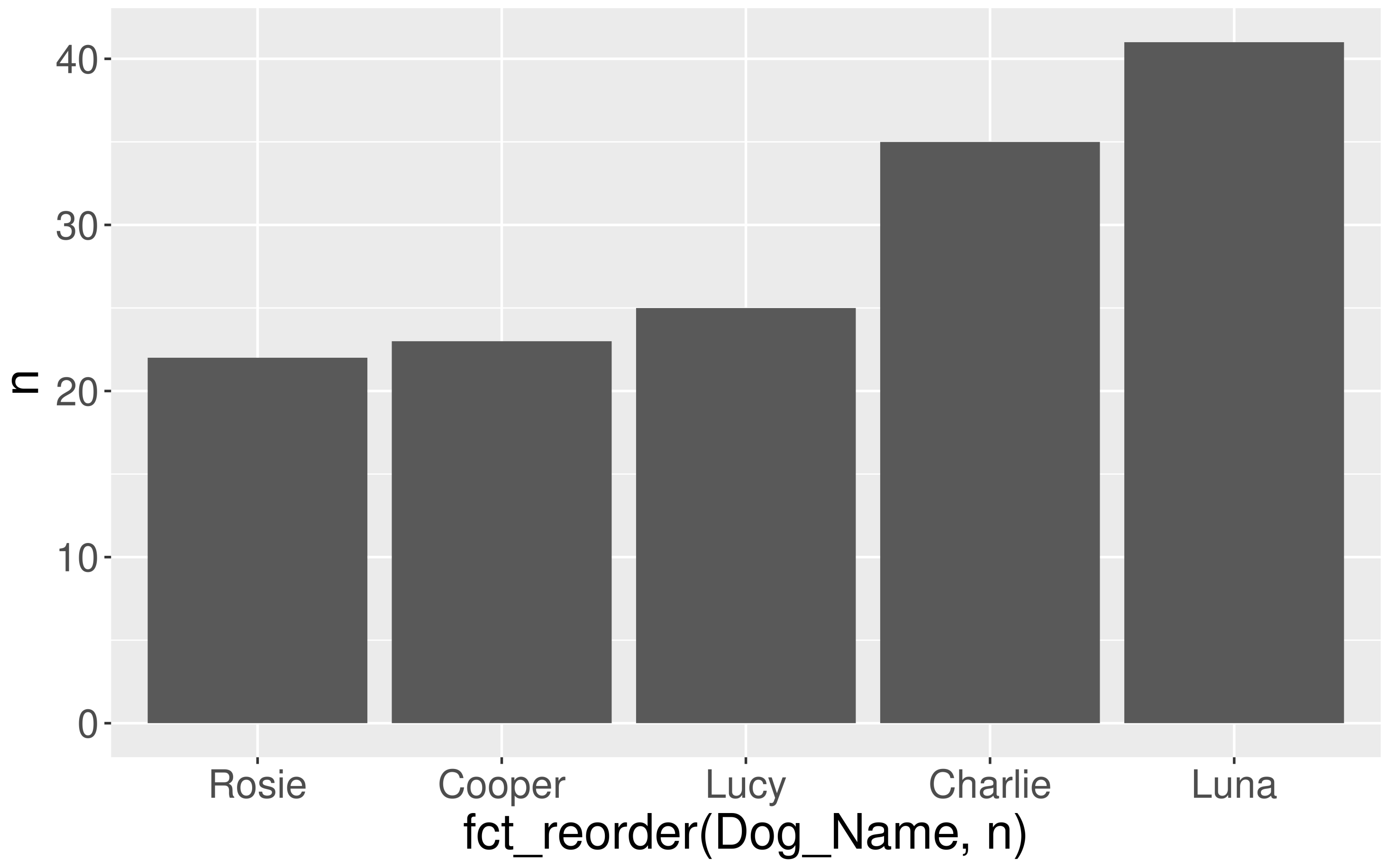
Another ggplot2 geom: geom_col()

And use `fct_reorder()` instead of `fct_infreq()` to reorder bars.

```
dog_counts <- count(dogs_top5, Dog_Name)
dog_counts
```

```
# A tibble: 5 × 2
  Dog_Name      n
  <chr>     <int>
1 Charlie      35
2 Cooper       23
3 Lucy         25
4 Luna         41
5 Rosie        22
```

```
ggplot(data = dog_counts,
       mapping = aes(x = fct_reorder(Dog_Name, n),
                     y = n)) +
  geom_col()
```

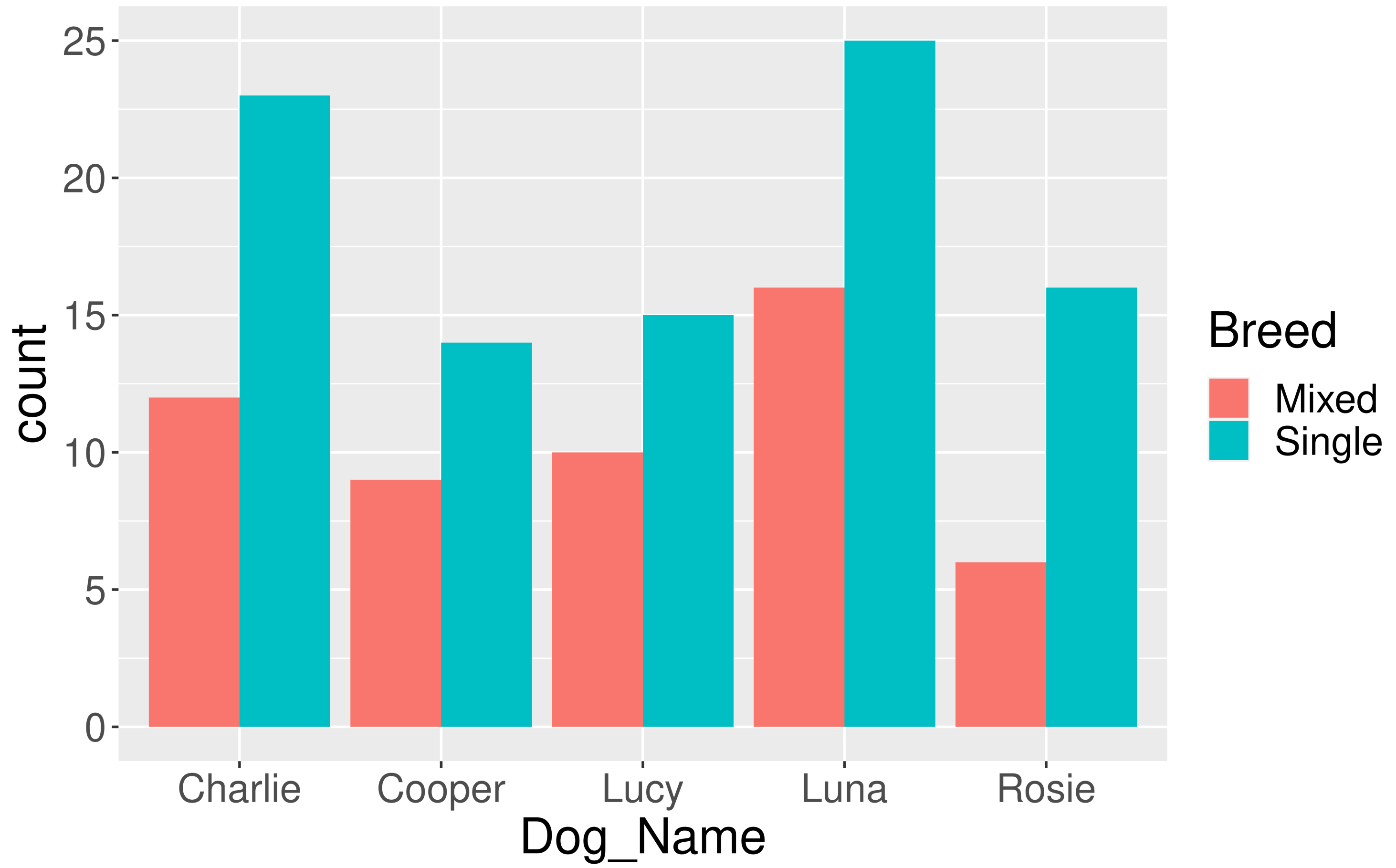


Contingency Table

```r
count(dogs_top5, Dog_Name, Breed)
```

```
# A tibble: 10 × 3
   Dog_Name Breed      n
   <chr>    <chr>  <int>
 1 Charlie  Mixed     12
 2 Charlie  Single    23
 3 Cooper   Mixed      9
 4 Cooper   Single    14
 5 Lucy     Mixed     10
 6 Lucy     Single    15
 7 Luna     Mixed     16
 8 Luna     Single    25
 9 Rosie    Mixed      6
10 Rosie    Single    16
```

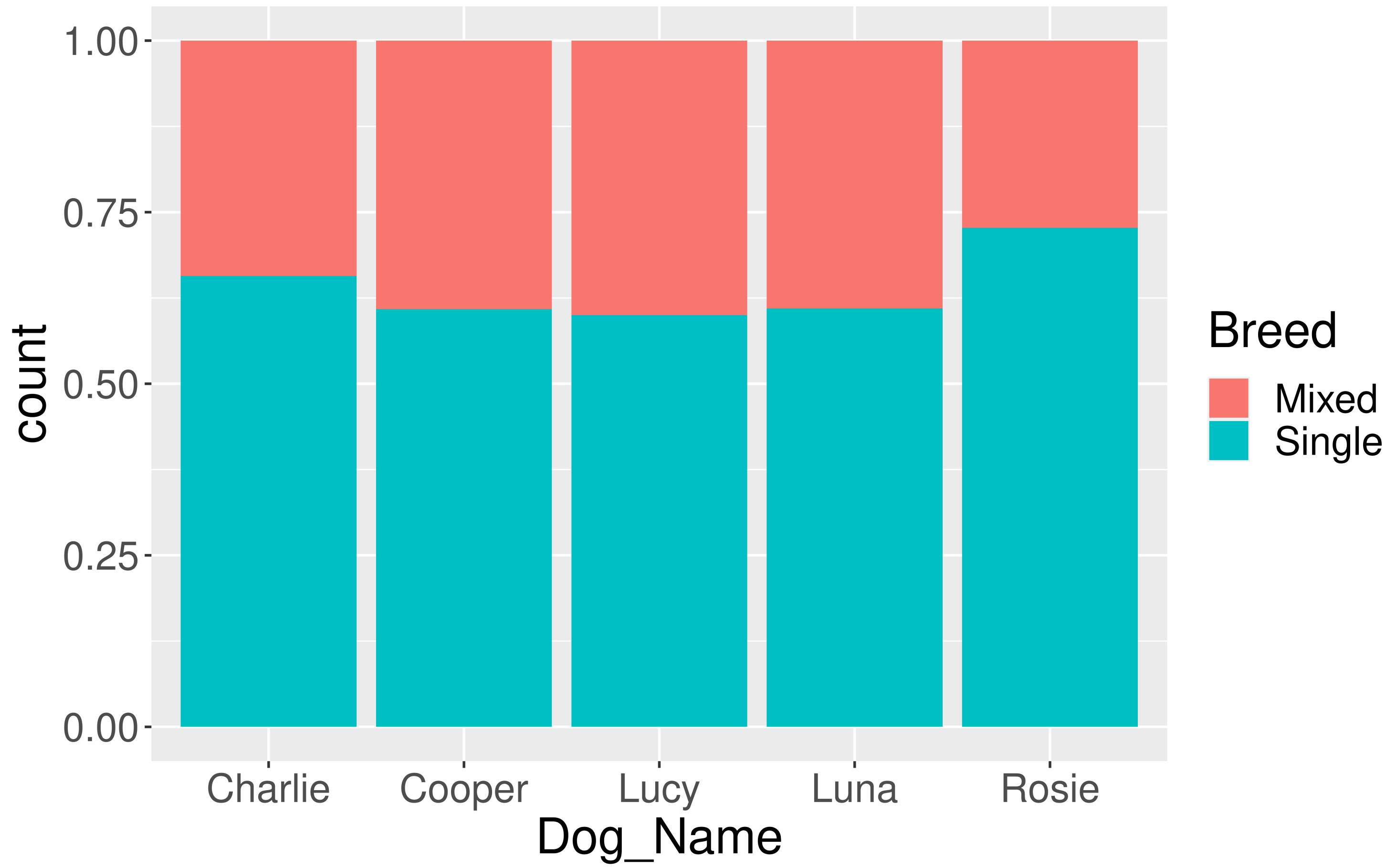
```r
ggplot(data = dogs_top5,
    mapping = aes(x = Dog_Name, fill = Breed)) +
  geom_bar(position = "dodge")
```



Conditional Proportions

- Beyond raw counts, we often summarize categorical data with **conditional** proportions.
  - Especially when looking for relationships!

```r
ggplot(data = dogs_top5,
    mapping = aes(x = Dog_Name, fill = Breed)) +
  geom_bar(position = "fill")
```



Conditional Proportions

```
count(dogs_top5, Dog_Name, Breed)
```

```
# A tibble: 10 × 3
   Dog_Name Breed      n
   <chr>    <chr>  <int>
 1 Charlie  Mixed     12
 2 Charlie  Single    23
 3 Cooper   Mixed      9
 4 Cooper   Single    14
 5 Lucy     Mixed     10
 6 Lucy     Single    15
 7 Luna     Mixed     16
 8 Luna     Single    25
 9 Rosie    Mixed      6
10 Rosie    Single    16
```

```
count(dogs_top5, Dog_Name, Breed) %>%
  group_by(Dog_Name) %>%
  mutate(prop = n/sum(n))
```

```
# A tibble: 10 × 4
# Groups:   Dog_Name [5]
   Dog_Name Breed      n  prop
   <chr>    <chr>  <int> <dbl>
 1 Charlie  Mixed     12 0.343
 2 Charlie  Single    23 0.657
 3 Cooper   Mixed      9 0.391
 4 Cooper   Single    14 0.609
 5 Lucy     Mixed     10 0.4
 6 Lucy     Single    15 0.6
 7 Luna     Mixed     16 0.390
 8 Luna     Single    25 0.610
 9 Rosie    Mixed      6 0.273
10 Rosie    Single    16 0.727
```

- The dplyr function `mutate()` adds new column(s) to your data frame.

Conditional Proportions

```
count(dogs_top5, Dog_Name, Breed) %>%
  group_by(Dog_Name) %>%
  mutate(prop = n/sum(n))
```

```
# A tibble: 10 × 4
# Groups:   Dog_Name [5]
   Dog_Name Breed      n  prop
   <chr>    <chr>  <int> <dbl>
 1 Charlie  Mixed     12 0.343
 2 Charlie  Single    23 0.657
 3 Cooper   Mixed      9 0.391
 4 Cooper   Single    14 0.609
 5 Lucy     Mixed     10 0.4
 6 Lucy     Single    15 0.6
 7 Luna     Mixed     16 0.390
 8 Luna     Single    25 0.610
 9 Rosie    Mixed      6 0.273
10 Rosie    Single    16 0.727
```

```
count(dogs_top5, Dog_Name, Breed) %>%
  group_by(Breed) %>%
  mutate(prop = n/sum(n))
```

```
# A tibble: 10 × 4
# Groups:   Breed [2]
   Dog_Name Breed      n  prop
   <chr>    <chr>  <int> <dbl>
 1 Charlie  Mixed     12 0.226
 2 Charlie  Single    23 0.247
 3 Cooper   Mixed      9 0.170
 4 Cooper   Single    14 0.151
 5 Lucy     Mixed     10 0.189
 6 Lucy     Single    15 0.161
 7 Luna     Mixed     16 0.302
 8 Luna     Single    25 0.269
 9 Rosie    Mixed      6 0.113
10 Rosie    Single    16 0.172
```

How does the interpretation change based on which variable you condition on?


dplyr : go wrangling
dplyr
data
Horst '18

Data Wrangling: Transformations done on the data

Why wrangle the data?

To **summarize** the data.	→ To compute the mean and standard deviation of the bike counts.
To **drop** missing values. (Need to be careful here!)	→ On our P-Set 2, we will see that `ggplot2` will often drop observations before creating a graph.
To **filter** to a particular subset of the data.	→ To subset the bike counts data to 2 days in July of 2019.
To **collapse** the categories of a categorical variable.	→ To go from 86 dog breeds to just mixed or single breed.

Data Wrangling: Transformations done on the data

Why wrangle the data?

To arrange the data to make it easier to display.

→ To sort from most common dog name to least common.

To fix how R stores a variable.

→ For the bike data, I converted `Day` from a character variable/vector to a date variable/vector.

→ To join data frames when information about your cases is stored in multiple places!

Will see examples of this next class!

dplyr for Data Wrangling

- Seven common wrangling verbs:
  - `summarize()`
  - `count()`
  - `mutate()`
  - `select()`
  - `filter()`
  - `arrange()`
  - `---_join()`
- One action:
  - `group_by()`

Return to `mutate()`

Add new variables

```
count(dogs_top5, Dog_Name, Breed) %>%
  group_by(Dog_Name) %>%
  mutate(prop = n/sum(n))
```

```
# A tibble: 10 × 4
# Groups:   Dog_Name [5]
   Dog_Name Breed      n  prop
   <chr>    <chr>  <int> <dbl>
 1 Charlie  Mixed     12 0.343
 2 Charlie  Single    23 0.657
 3 Cooper   Mixed      9 0.391
 4 Cooper   Single    14 0.609
 5 Lucy     Mixed     10 0.4
 6 Lucy     Single    15 0.6
 7 Luna     Mixed     16 0.390
 8 Luna     Single    25 0.610
 9 Rosie    Mixed      6 0.273
10 Rosie    Single    16 0.727
```

Modify existing variables

```
class(july_2019$DateTime)
```

```
[1] "character"
```

```
july_2019 <- july_2019 %>%
  mutate(DateTime = mdy_hms(DateTime))
class(july_2019$DateTime)
```

```
[1] "POSIXct" "POSIXt"
```

`select()`: Extract variables

```
dogs %>%
  select(Dog_Name, Dog_Breed)
```

```
# A tibble: 3,942 × 2
   Dog_Name       Dog_Breed
   <chr>          <chr>
 1 Butch          Mixed Breed
 2 Baxter         Mixed Breed
 3 Bodhi          Golden Retriever
 4 Ocean          Pug
 5 Coco           Pug
 6 Brio           LABRADOODLE
 7 Jolene Almeida German Shorthaired Pointer
 8 Ruger          Labrador Retriever
 9 FLASH          Border Collie
10 Leo            French Bulldog
# ℹ 3,932 more rows
```

Motivation for `filter()`

```r
count(dogs, Dog_Name, sort = TRUE)
```

```
# A tibble: 2,332 × 2
   Dog_Name      n
   <chr>     <int>
 1 Luna         41
 2 Charlie      35
 3 Lucy         25
 4 Cooper       23
 5 Rosie        22
 6 Olive        21
 7 Pepper       20
 8 Teddy        19
 9 Coco         18
10 Lola         17
# ℹ 2,322 more rows
```

filter(): Extract cases

```r
dogs_top5 <- dogs %>%
  filter(Dog_Name %in% c("Luna", "Charlie", "Lucy", "Cooper", "Rosie" ))

count(dogs_top5, Dog_Name, sort = TRUE)
```

```
# A tibble: 5 × 2
  Dog_Name     n
  <chr>    <int>
1 Luna        41
2 Charlie     35
3 Lucy        25
4 Cooper      23
5 Rosie       22
```

`arrange()`: Sort the cases

```r
count(dogs_top5, Dog_Name) %>%
  arrange(n)
```

```
# A tibble: 5 × 2
  Dog_Name      n
  <chr>     <int>
1 Rosie        22
2 Cooper       23
3 Lucy         25
4 Charlie      35
5 Luna         41
```

```r
count(dogs_top5, Dog_Name) %>%
  arrange(desc(n))
```

```
# A tibble: 5 × 2
  Dog_Name      n
  <chr>     <int>
1 Luna         41
2 Charlie      35
3 Lucy         25
4 Cooper       23
5 Rosie        22
```

```r
count(dogs_top5, Dog_Name) %>%
  arrange(Dog_Name)
```

```
# A tibble: 5 × 2
  Dog_Name      n
  <chr>     <int>
1 Charlie      35
2 Cooper       23
3 Lucy         25
4 Luna         41
5 Rosie        22
```

Will see more data wrangling next week!

Reminders

- With COVID working its way through campus right now, make sure to check the Sections spreadsheet and the Office hours spreadsheet for updates!