

Intro to R

Data Summarization

Data Summarization

- Basic statistical summarization
 - `mean(x)`: takes the mean of x
 - `sd(x)`: takes the standard deviation of x
 - `median(x)`: takes the median of x
 - `quantile(x)`: displays sample quantiles of x. Default is min, IQR, max
 - `range(x)`: displays the range. Same as `c(min(x), max(x))`
 - `sum(x)`: sum of x
 - `max(x)`: maximum value in x
 - `min(x)`: minimum value in x
 - **all have a** `na.rm` for missing data
- Transformations
 - `log` - log (base e) transformation
 - `log10` - log base 10 transform
 - `sqrt` - square root

Statistical summarization

The vector getting summarized goes inside the parentheses:

```
x <- c(1, 5, 7, 4, 2, 8)  
mean(x)
```

```
[1] 4.5
```

```
range(x)
```

```
[1] 1 8
```

```
sum(x)
```

```
[1] 27
```

Statistical summarization

Note that many of these functions have additional inputs regarding missing data, typically requiring the `na.rm` argument ("remove NAs").

```
x <- c(1, 5, 7, 4, 2, 8, NA)
mean(x)
```

```
[1] NA
```

```
mean(x, na.rm = TRUE)
```

```
[1] 4.5
```

```
quantile(x)
```

```
Error in quantile.default(x): missing values and NaN's not allowed if 'na.rm' is FALSE
```

```
quantile(x, na.rm = TRUE)
```

0%	25%	50%	75%	100%
1.0	2.5	4.5	6.5	8.0

Some examples

We can use the `jhu_cars` to explore different ways of summarizing data. The `head` command displays the first rows of an object:

```
library(jhur)
head(jhu_cars)
```

	car	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
1	Mazda RX4	21.0	6	160	110	3.90	2.620	16.46	0	1	4	4
2	Mazda RX4 Wag	21.0	6	160	110	3.90	2.875	17.02	0	1	4	4
3	Datsun 710	22.8	4	108	93	3.85	2.320	18.61	1	1	4	1
4	Hornet 4 Drive	21.4	6	258	110	3.08	3.215	19.44	1	0	3	1
5	Hornet Sportabout	18.7	8	360	175	3.15	3.440	17.02	0	0	3	2
6	Valiant	18.1	6	225	105	2.76	3.460	20.22	1	0	3	1

Statistical summarization

Note - the `$` references/selects columns from a `data.frame/tibble`:

```
mean(jhu_cars$hp)
```

```
[1] 146.6875
```

```
quantile(jhu_cars$hp)
```

0%	25%	50%	75%	100%
52.0	96.5	123.0	180.0	335.0

Statistical summarization

The “tidy” way:

```
jhu_cars %>% pull(hp) %>% mean() # alt: pull(jhu_cars, hp) %>% mean()
```

```
[1] 146.6875
```

```
jhu_cars %>% pull(hp) %>% quantile()
```

```
 0%   25%   50%   75%  100%  
52.0  96.5 123.0 180.0 335.0
```

Statistical summarization

```
jhu_cars %>% pull(wt) %>% median()
```

```
[1] 3.325
```

```
jhu_cars %>% pull(wt) %>% quantile(probs = 0.6)
```

```
60%  
3.44
```


Data Summarization on data frames

- Basic statistical summarization
 - `rowMeans (x)`: takes the means of each row of `x`
 - `colMeans (x)`: takes the means of each column of `x`
 - `rowSums (x)`: takes the sum of each row of `x`
 - `colSums (x)`: takes the sum of each column of `x`
 - `summary (x)`: for data frames, displays the quantile information

TB Incidence

Let's read in a `tibble` of values from TB incidence.

If you have the `jhur` package installed successfully:

```
tb <- jhur::read_tb()
```

If not, download the `xlsx` file from this link and read it in using `read_csv()`:
http://jhudatascience.org/intro_to_R_class/data/tb_incidence.xlsx

TB Incidence

Check out the data:

```
head(tb)
```

```
# A tibble: 6 x 19
  `TB incidence, all fo...` `1990` `1991` `1992` `1993` `1994` `1995` `1996` `1997`
  <chr>          <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
1 Afghanistan      168    168    168    168    168    168    168    168
2 Albania           25     24     25     26     26     27     27     28
3 Algeria           38     38     39     40     41     42     43     44
4 American Samoa    21      7      2      9      9     11      0     12
5 Andorra           36     34     32     30     29     27     26     26
6 Angola           205    209    214    218    222    226    231    236
# ... with 10 more variables: 1998 <dbl>, 1999 <dbl>, 2000 <dbl>, 2001 <dbl>,
# 2002 <dbl>, 2003 <dbl>, 2004 <dbl>, 2005 <dbl>, 2006 <dbl>, 2007 <dbl>
```

```
colnames(tb)
```

```
[1] "TB incidence, all forms (per 100 000 population per year)"
[2] "1990"
[3] "1991"
[4] "1992"
[5] "1993"
[6] "1994"
[7] "1995"
[8] "1996"
[9] "1997"
[10] "1998"
[11] "1999"
```

Indicator of TB

Before we go further, let's rename the first column to be the country measured using the `rename` function in `dplyr`.

In this case, we have to use the backticks (```) because there are spaces and funky characters in the name:

```
library(dplyr)
tb <- tb %>% rename(country = `TB incidence, all forms (per 100 000 population per year)`)
```

`colnames` will show us the column names and show that country is renamed:

```
colnames(tb)
```

```
[1] "country" "1990"    "1991"    "1992"    "1993"    "1994"    "1995"
[8] "1996"    "1997"    "1998"    "1999"    "2000"    "2001"    "2002"
[15] "2003"    "2004"    "2005"    "2006"    "2007"
```

Summarize the data: **dplyr** **summarize** function

`dplyr::summarize` will allow you to summarize data. Format is `new = SUMMARY`.

```
# General format - Not the code!
```

```
{data object to update} <- {data to use} %>%  
  summarize({summary column name} = {operator(source column)})
```

```
tb %>% summarize(mean_2006 = mean(`2006`, na.rm = TRUE))
```

```
# A tibble: 1 x 1
```

```
  mean_2006
```

```
    <dbl>
```

```
1      135.
```

Summarize the data: **dplyr** summarize function

`summarize` can do multiple operations at once. Just separate by a comma.

```
tb %>%
  summarize(mean_2006 = mean(`2006`, na.rm = TRUE),
            median_2007 = median(`2007`, na.rm = TRUE),
            median(`2004`, na.rm = TRUE))

# A tibble: 1 x 3
  mean_2006 median_2007 `median(\`2004\`, na.rm = TRUE)`
    <dbl>      <dbl>          <dbl>
1    135.         53           56
```

Notice how when we forget to provide a new name, output is still provided, but the column name is messy.

Iterative summaries: **dplyr** **summarize** and **across** functions

Use the [across](#) function with `summarize` to summarize across multiple columns of your data.

```
tb %>%  
  summarize(across( c(`1990`, `1991`, `1992`, `1993`), ~ sum(.x, na.rm = TRUE)))
```

```
# A tibble: 1 x 4  
  `1990` `1991` `1992` `1993`  
  <dbl> <dbl> <dbl> <dbl>  
1  21855  22288  22421  22836
```

```
tb %>%  
  summarize(across( starts_with("2"), ~ range(.x, na.rm = TRUE)))
```

```
# A tibble: 2 x 8  
  `2000` `2001` `2002` `2003` `2004` `2005` `2006` `2007`  
  <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>  
1      0      0      3      0      0      0      0      0  
2    801    916    994   1075   1127   1141   1169   1198
```

Row means

colMeans and rowMeans require **all numeric data**.

Let's see what the mean is across each row (country):

```
tb_2 <- column_to_rownames(tb, "country") # opposite of rownames_to_column() !
head(tb_2, 2)
```

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Afghanistan	168	168	168	168	168	168	168	168	168	168	168	168	168
Albania	25	24	25	26	26	27	27	28	28	27	25	23	23
	2003	2004	2005	2006	2007								
Afghanistan	168	168	168	168	168								
Albania	22	21	20	18	17								

```
rowMeans(tb_2, na.rm = TRUE)
```

Afghanistan	Albania
168.000000	24.000000
Algeria	American Samoa
46.388889	7.611111
Andorra	Angola
24.944444	243.888889
Anguilla	Antigua and Barbuda
22.833333	7.222222
Argentina	Armenia
43.666667	57.611111
Australia	Austria
6.444444	16.333333
Azerbaijan	Bahamas

Row means

`colMeans` gives you very similar output to functions we've seen previously in this lecture (`summarize` and `across`).

```
colMeans(tb_2, na.rm = TRUE)
```

	1990	1991	1992	1993	1994	1995	1996	1997
	105.5797	107.6715	108.3140	110.3188	111.9662	114.1981	115.3527	118.8792
	1998	1999	2000	2001	2002	2003	2004	2005
	121.5169	125.0435	127.8454	130.7488	136.1739	136.1932	136.9662	135.6683
	2006	2007						
	134.6106	133.3865						

```
tb_2 %>%  
  summarize(across( colnames(tb_2), ~ mean(.x, na.rm = TRUE)))
```

	1990	1991	1992	1993	1994	1995	1996	1997
1	105.5797	107.6715	108.314	110.3188	111.9662	114.1981	115.3527	118.8792
	1998	1999	2000	2001	2002	2003	2004	2005
1	121.5169	125.0435	127.8454	130.7488	136.1739	136.1932	136.9662	135.6683
	2006	2007						
1	134.6106	133.3865						

summary Function

Using `summary` can give you rough snapshots of each column, but you would likely use `mean`, `min`, `max`, and `quantile` when necessary (and number of NAs):

```
summary(tb)
```

country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Length:208	Min. : 0.0	Min. : 4.0	Min. : 2.0	Min. : 4.0	Min. : 0	Min. : 3.0	Min. : 0.0	Min. : 0.0	Min. : 0.0	Min. : 0.0	Min. : 0.0	Min. : 0.0
Class :character	1st Qu.: 27.5	1st Qu.: 27.0	1st Qu.: 27.0	1st Qu.: 27.5	1st Qu.: 26	1st Qu.: 26.5	1st Qu.: 25.5	1st Qu.: 24.5	1st Qu.: 23.5	1st Qu.: 22.5	1st Qu.: 21.5	1st Qu.: 19.0
Mode :character	Median : 60.0	Median : 58.0	Median : 56.0	Median : 56.0	Median : 57	Median : 58.0	Median : 60.0	Median : 64.0	Median : 63.0	Median : 66.0	Median : 60.0	Median : 59.0
	Mean :105.6	Mean :107.7	Mean :108.3	Mean :110.3	Mean :112	Mean :114.2	Mean :115.4	Mean :118.9	Mean :121.5	Mean :125.0	Mean :127.8	Mean :130.7
	3rd Qu.:165.0	3rd Qu.:171.0	3rd Qu.:171.5	3rd Qu.:171.0	3rd Qu.:174	3rd Qu.:177.5	3rd Qu.:179.0	3rd Qu.:181.0	3rd Qu.:188.5	3rd Qu.:192.5	3rd Qu.:191.0	3rd Qu.:189.5
	Max. :585.0	Max. :594.0	Max. :606.0	Max. :618.0	Max. :630	Max. :642.0	Max. :655.0	Max. :668.0	Max. :681.0	Max. :695.0	Max. :801.0	Max. :916.0
	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1	NA's :1

Lab Part 1

[Website](#)

Youth Tobacco Survey

Here we will be using the Youth Tobacco Survey data:

http://jhudatascience.org/intro_to_R_class/data/Youth_Tobacco_Survey_YTS_Data.csv

```
yts <- jhur::read_yts()
head(yts)
```

```
# A tibble: 6 x 31
  YEAR LocationAbbr LocationDesc TopicType TopicDesc MeasureDesc DataSource
<dbl> <chr>         <chr>         <chr>    <chr>    <chr>    <chr>
1  2015 AZ          Arizona      Tobacco U.. Cessation.. Percent of C... YTS
2  2015 AZ          Arizona      Tobacco U.. Cessation.. Percent of C... YTS
3  2015 AZ          Arizona      Tobacco U.. Cessation.. Percent of C... YTS
4  2015 AZ          Arizona      Tobacco U.. Cessation.. Quit Attempt... YTS
5  2015 AZ          Arizona      Tobacco U.. Cessation.. Quit Attempt... YTS
6  2015 AZ          Arizona      Tobacco U.. Cessation.. Quit Attempt... YTS
# ... with 24 more variables: Response <chr>, Data_Value_Unit <chr>,
#   Data_Value_Type <chr>, Data_Value <dbl>, Data_Value_Footnote_Symbol <chr>,
#   Data_Value_Footnote <chr>, Data_Value_Std_Err <dbl>,
#   Low_Confidence_Limit <dbl>, High_Confidence_Limit <dbl>, Sample_Size <dbl>,
#   Gender <chr>, Race <chr>, Age <chr>, Education <chr>, GeoLocation <chr>,
#   TopicTypeId <chr>, TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>,
#   StratificationID2 <chr>, StratificationID3 <chr>, StratificationID4 <chr>,
#   SubMeasureID <chr>, DisplayOrder <dbl>
```

Length and unique

`unique(x)` will return the unique elements of `x`

```
locations <- yts %>% pull(LocationDesc)  
unique(locations) %>% head()
```

```
[1] "Arizona"      "Connecticut" "Georgia"      "Hawaii"      "Illinois"  
[6] "Louisiana"
```

`length` will tell you the length of a vector. Combined with `unique`, tells you the number of unique elements:

```
length(unique(locations))
```

```
[1] 50
```

table and dplyr: count

table(x) will return a frequency table of unique elements of x

```
table(locations)
```

locations

Alabama	Arizona	Arkansas
378	240	210
California	Colorado	Connecticut
96	48	384
Delaware	District of Columbia	Florida
312	48	96
Georgia	Guam	Hawaii
282	48	270
Idaho	Illinois	Indiana
48	282	264
Iowa	Kansas	Kentucky
276	186	255
Louisiana	Maine	Maryland
240	48	96
Massachusetts	Michigan	Minnesota
48	138	141
Mississippi	Missouri	National (States and DC)
567	294	26
Nebraska	New Hampshire	New Jersey
234	180	387
New Mexico	New York	North Carolina
24	90	366
North Dakota	Ohio	Oklahoma
330	255	318

table and dplyr: count

Use count directly on a data.frame and column without needing to use pull.

```
yts %>% count(LocationDesc)
```

```
# A tibble: 50 x 2
```

	LocationDesc	n
	<chr>	<int>
1	Alabama	378
2	Arizona	240
3	Arkansas	210
4	California	96
5	Colorado	48
6	Connecticut	384
7	Delaware	312
8	District of Columbia	48
9	Florida	96
10	Georgia	282

```
# ... with 40 more rows
```

table and dplyr: count

Multiple columns listed further subdivides the count.

```
yts %>% count(LocationDesc, TopicDesc)
```

```
# A tibble: 146 x 3
  LocationDesc TopicDesc      n
  <chr>        <chr>    <int>
1 Alabama      Cessation (Youth)      90
2 Alabama      Cigarette Use (Youth) 144
3 Alabama      Smokeless Tobacco Use (Youth) 144
4 Arizona      Cessation (Youth)      60
5 Arizona      Cigarette Use (Youth)   99
6 Arizona      Smokeless Tobacco Use (Youth) 81
7 Arkansas      Cessation (Youth)      42
8 Arkansas      Cigarette Use (Youth)   78
9 Arkansas      Smokeless Tobacco Use (Youth) 90
10 California   Cessation (Youth)      24
# ... with 136 more rows
```


Grouping

Perform Operations By Groups: dplyr

`group_by` allows you group the data set by grouping variables:

```
#
yts

# A tibble: 9,794 x 31
  YEAR LocationAbbr LocationDesc TopicType TopicDesc MeasureDesc DataSource
<dbl> <chr>         <chr>         <chr>      <chr>      <chr>      <chr>
1  2015 AZ          Arizona      Tobacco U... Cessation... Percent of ... YTS
2  2015 AZ          Arizona      Tobacco U... Cessation... Percent of ... YTS
3  2015 AZ          Arizona      Tobacco U... Cessation... Percent of ... YTS
4  2015 AZ          Arizona      Tobacco U... Cessation... Quit Attemp... YTS
5  2015 AZ          Arizona      Tobacco U... Cessation... Quit Attemp... YTS
6  2015 AZ          Arizona      Tobacco U... Cessation... Quit Attemp... YTS
7  2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
8  2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
9  2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
10 2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
# ... with 9,784 more rows, and 24 more variables: Response <chr>,
# Data_Value_Unit <chr>, Data_Value_Type <chr>, Data_Value <dbl>,
# Data_Value_Footnote_Symbol <chr>, Data_Value_Footnote <chr>,
# Data_Value_Std_Err <dbl>, Low_Confidence_Limit <dbl>,
# High_Confidence_Limit <dbl>, Sample_Size <dbl>, Gender <chr>, Race <chr>,
# Age <chr>, Education <chr>, GeoLocation <chr>, TopicTypeId <chr>,
# TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>,
# StratificationID2 <chr>, StratificationID3 <chr>, StratificationID4 <chr>,
# SubMeasureID <chr>, DisplayOrder <dbl>
```

Perform Operations By Groups: dplyr

`group_by` allows you group the data set by grouping variables:

```
yts <- yts %>% group_by(Response)
yts
```

```
# A tibble: 9,794 x 31
# Groups:   Response [4]
  YEAR LocationAbbr LocationDesc TopicType TopicDesc MeasureDesc DataSource
  <dbl> <chr>         <chr>         <chr>    <chr>      <chr>      <chr>
1  2015 AZ          Arizona      Tobacco U... Cessation... Percent of ... YTS
2  2015 AZ          Arizona      Tobacco U... Cessation... Percent of ... YTS
3  2015 AZ          Arizona      Tobacco U... Cessation... Percent of ... YTS
4  2015 AZ          Arizona      Tobacco U... Cessation... Quit Attemp... YTS
5  2015 AZ          Arizona      Tobacco U... Cessation... Quit Attemp... YTS
6  2015 AZ          Arizona      Tobacco U... Cessation... Quit Attemp... YTS
7  2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
8  2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
9  2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
10 2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
# ... with 9,784 more rows, and 24 more variables: Response <chr>,
# Data_Value_Unit <chr>, Data_Value_Type <chr>, Data_Value <dbl>,
# Data_Value_Footnote_Symbol <chr>, Data_Value_Footnote <chr>,
# Data_Value_Std_Err <dbl>, Low_Confidence_Limit <dbl>,
# High_Confidence_Limit <dbl>, Sample_Size <dbl>, Gender <chr>, Race <chr>,
# Age <chr>, Education <chr>, GeoLocation <chr>, TopicTypeId <chr>,
# TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>,
# StratificationID2 <chr>, StratificationID3 <chr>, StratificationID4 <chr>,
# SubMeasureID <chr>, DisplayOrder <dbl>
```

Summarize the grouped data

It's grouped! Grouping doesn't change the data in any way, but how **functions operate on it**. Now we can summarize `Data_Value` (percent of respondents) by group:

```
yts %>% summarize(avg_percent = mean(Data_Value, na.rm = TRUE))
```

```
# A tibble: 4 x 2
  Response avg_percent
  <chr>      <dbl>
1 Current    9.68
2 Ever      26.1
3 Frequent   3.48
4 <NA>      53.5
```

Using the **pipe** to connect these

Pipe `yts` into `group_by`, then pipe that into `summarize`:

```
yts %>%  
  group_by(Response) %>%  
  summarize(avg_percent = mean(Data_Value, na.rm = TRUE),  
            max_percent = max(Data_Value, na.rm = TRUE))
```

```
# A tibble: 4 x 3  
  Response avg_percent max_percent  
  <chr>      <dbl>      <dbl>  
1 Current      9.68      40.6  
2 Ever        26.1       98  
3 Frequent     3.48      23.9  
4 <NA>        53.5      81.9
```

Ungroup the data

The `ungroup` function will allow you to clear the groups from the data. You can also overwrite the first `group_by` with a new one.

```
yts = ungroup(yts)
yts
```

```
# A tibble: 9,794 x 31
  YEAR LocationAbbr LocationDesc TopicType TopicDesc MeasureDesc DataSource
<dbl> <chr>         <chr>         <chr>      <chr>      <chr>      <chr>
1  2015 AZ          Arizona      Tobacco U... Cessation... Percent of ... YTS
2  2015 AZ          Arizona      Tobacco U... Cessation... Percent of ... YTS
3  2015 AZ          Arizona      Tobacco U... Cessation... Percent of ... YTS
4  2015 AZ          Arizona      Tobacco U... Cessation... Quit Attemp... YTS
5  2015 AZ          Arizona      Tobacco U... Cessation... Quit Attemp... YTS
6  2015 AZ          Arizona      Tobacco U... Cessation... Quit Attemp... YTS
7  2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
8  2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
9  2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
10 2015 AZ          Arizona      Tobacco U... Cigarette... Smoking Sta... YTS
# ... with 9,784 more rows, and 24 more variables: Response <chr>,
# Data_Value_Unit <chr>, Data_Value_Type <chr>, Data_Value <dbl>,
# Data_Value_Footnote_Symbol <chr>, Data_Value_Footnote <chr>,
# Data_Value_Std_Err <dbl>, Low_Confidence_Limit <dbl>,
# High_Confidence_Limit <dbl>, Sample_Size <dbl>, Gender <chr>, Race <chr>,
# Age <chr>, Education <chr>, GeoLocation <chr>, TopicTypeId <chr>,
# TopicId <chr>, MeasureId <chr>, StratificationID1 <chr>,
# StratificationID2 <chr>, StratificationID3 <chr>, StratificationID4 <chr>,
# SubMeasureID <chr>, DisplayOrder <dbl>
```

group_by with mutate - just add data

We can also use `mutate` to calculate the mean value for each year and add it as a column:

```
yts %>%  
  group_by(YEAR) %>%  
  mutate(year_avg = mean(Data_Value, na.rm = TRUE)) %>%  
  select(LocationDesc, Data_Value, year_avg)
```

```
# A tibble: 9,794 x 4
```

```
# Groups:   YEAR [17]
```

	YEAR	LocationDesc	Data_Value	year_avg
	<dbl>	<chr>	<dbl>	<dbl>
1	2015	Arizona	NA	15.2
2	2015	Arizona	NA	15.2
3	2015	Arizona	NA	15.2
4	2015	Arizona	NA	15.2
5	2015	Arizona	NA	15.2
6	2015	Arizona	NA	15.2
7	2015	Arizona	3.2	15.2
8	2015	Arizona	3.2	15.2
9	2015	Arizona	3.1	15.2
10	2015	Arizona	12.5	15.2

```
# ... with 9,784 more rows
```

Counting

There are other functions, such as `n()` count the number of observations.

```
yts %>%  
  group_by(YEAR) %>%  
  summarize(n = n(),  
            mean = mean(Data_Value, na.rm = TRUE))
```

```
# A tibble: 17 x 3  
  YEAR      n  mean  
  <dbl> <int> <dbl>  
1  1999   372  26.1  
2  2000  1224  26.7  
3  2001   426  23.4  
4  2002  1016  25.2  
5  2003   498  21.3  
6  2004   611  20.7  
7  2005   636  21.8  
8  2006   518  21.8  
9  2007   516  20.0  
10 2008   483  18.2  
11 2009   686  18.3  
12 2010   447  17.8  
13 2011   521  17.8  
14 2012   244  15.5  
15 2013   685  16.7  
16 2014   334  15.7  
17 2015   577  15.2
```


Lab Part 2

[Website](#)

Preview: plotting

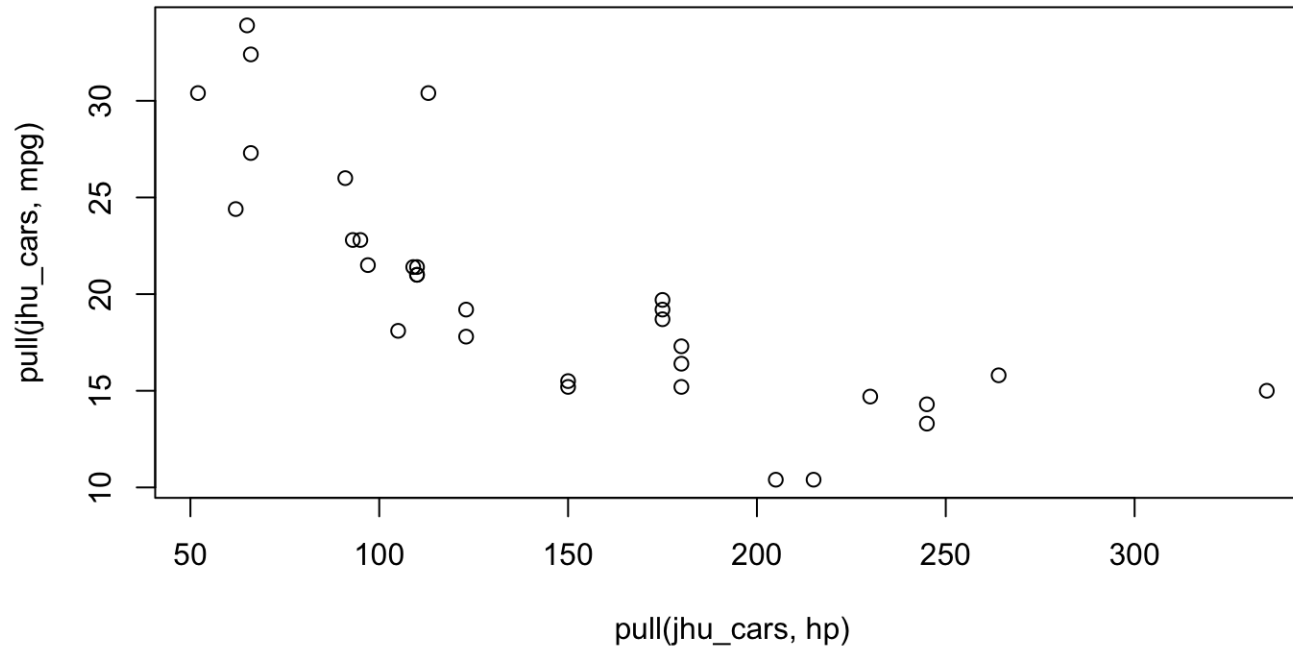
Basic Plots

Plotting is an important component of exploratory data analysis. These are some rough one-line plots that you can use in realtime while exploring your data. We will go over formatting and making plots look nicer in additional lectures.

- Basic summarization plots:
 - `plot(x, y)`: scatterplot of x and y
 - `boxplot(y~x)`: boxplot of y against levels of x
 - `hist(x)`: histogram of x
 - `plot(density(x))`: kernel density plot of x

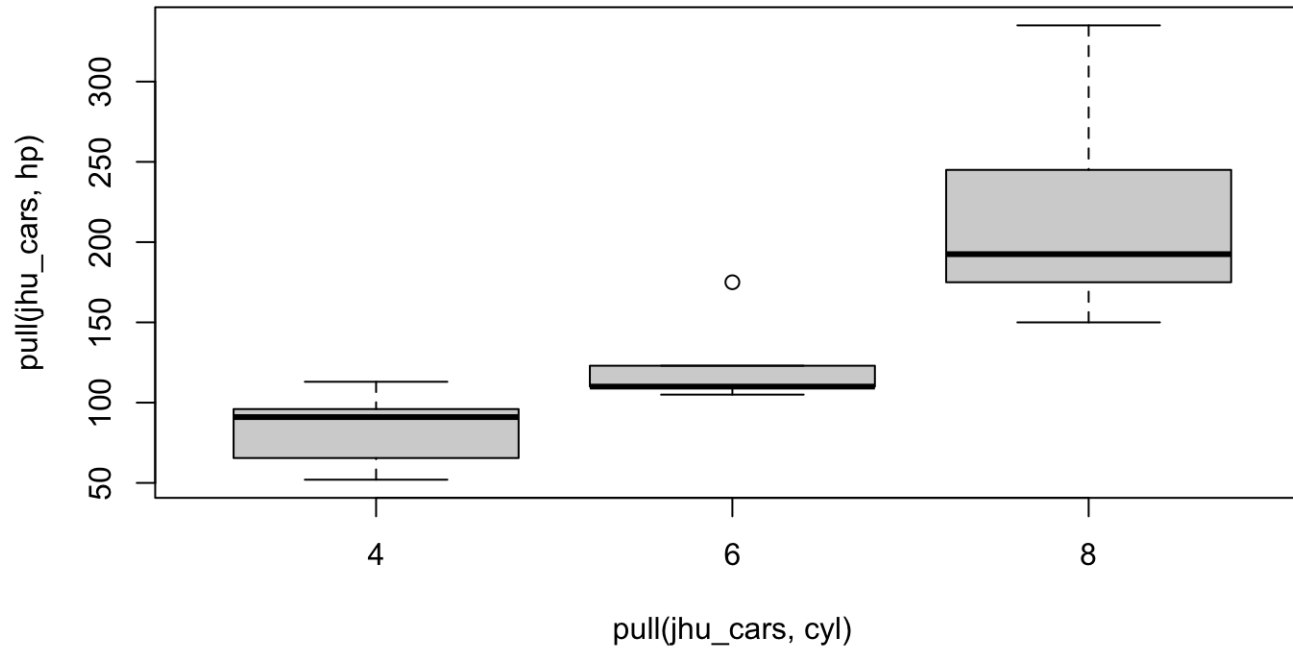
Scatterplot

```
plot( pull(jhu_cars, hp), pull(jhu_cars, mpg) ) # alt: plot(jhu_cars$hp, jhu_cars$mpg)
```



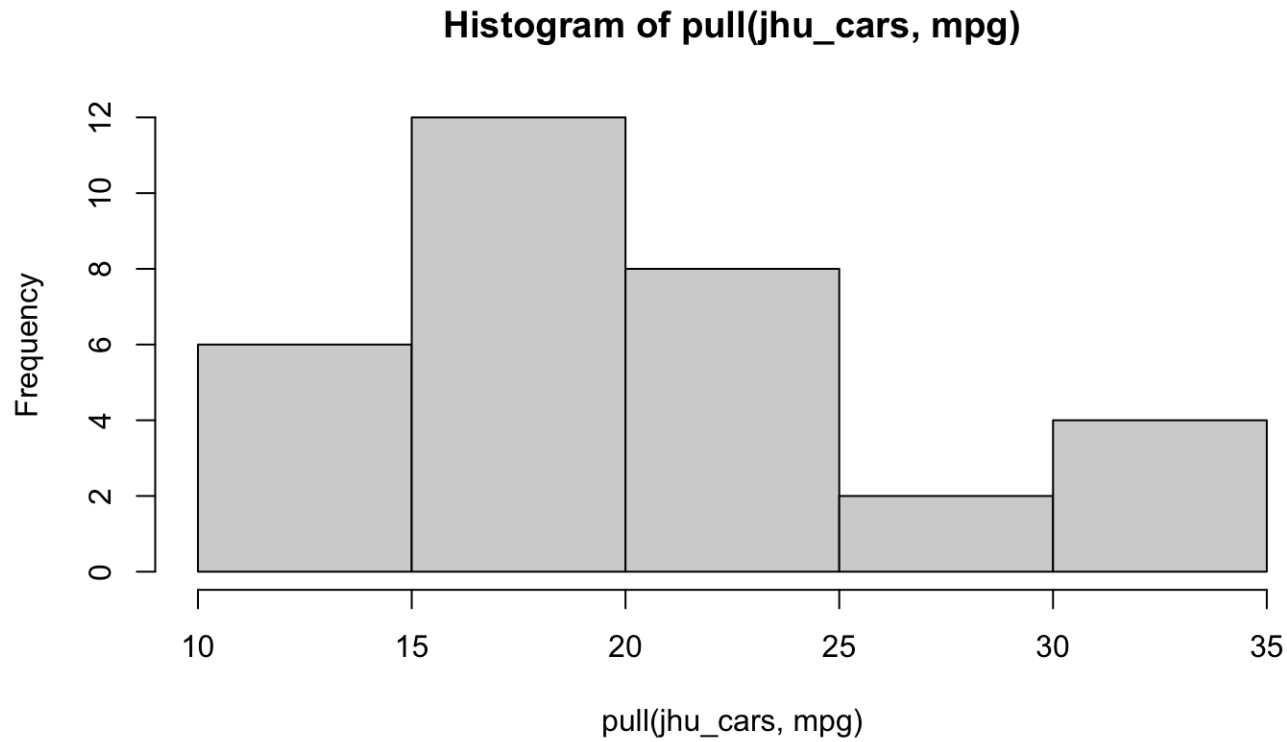
Boxplot

```
boxplot( pull(jhu_cars, hp) ~ pull(jhu_cars, cyl) )
```



Histogram

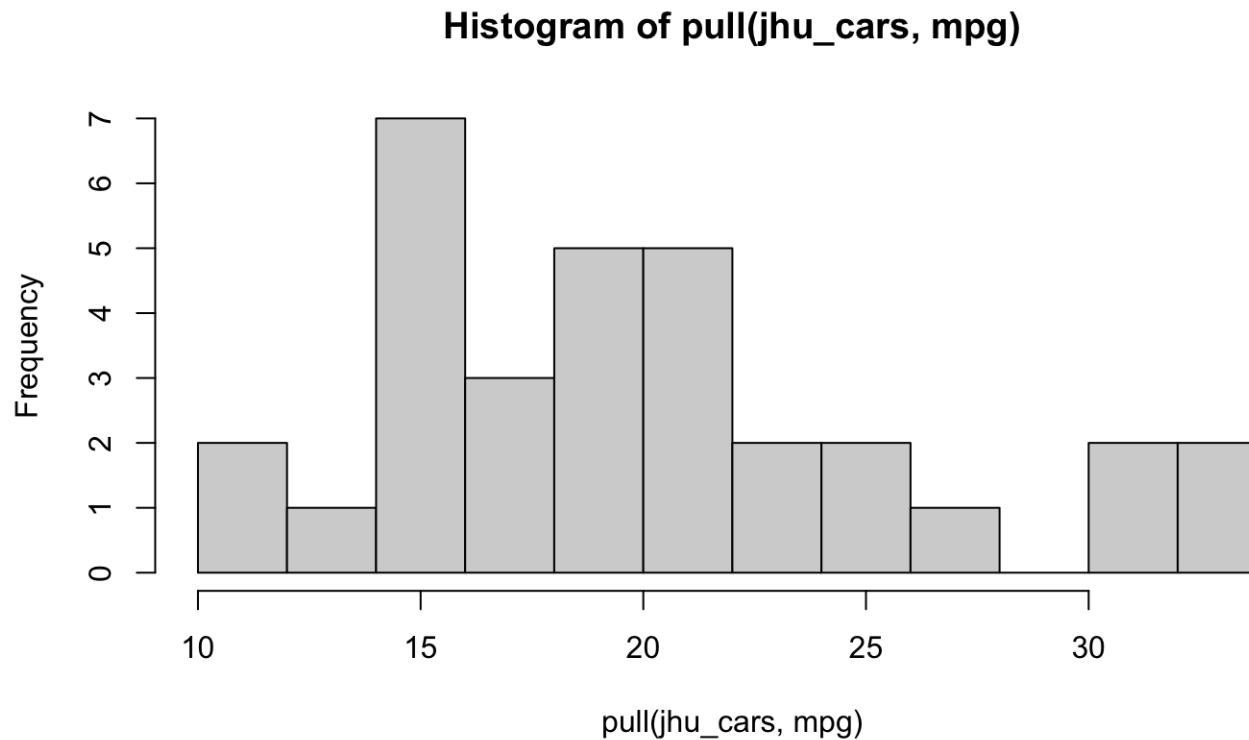
```
hist(pull(jhu_cars, mpg))
```



Histogram

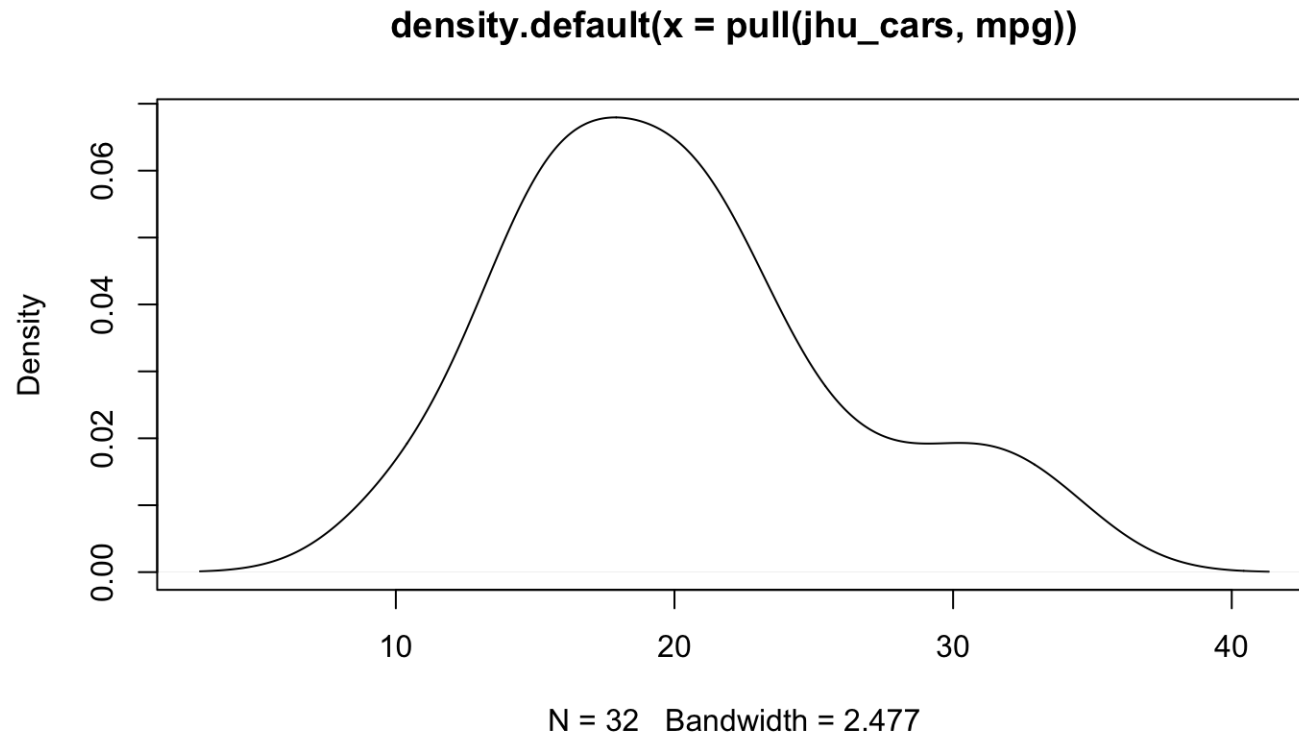
Use the `breaks` = argument to tweak the resolution:

```
hist(pull(jhu_cars, mpg), breaks = 10)
```



Density

```
plot(density(pull(jhu_cars, mpg)))
```



Lab Part 3

[Website](#)