Basic Statistics & Plotting

You've already learned *a lot*!

Hopefully you're feeling more comfortable with some of terminology used in programming:

- Objects
- Classes
- Functions
- Arguments
- Vectors
- Data.frames
- Etc.

Uhh...no?

You already know everything you need to do stats & plots!

Statistics

All statistics are computed with functions.

If you know the type of analysis you want to run, find the corresponding function and go for it!

Plotting

All plots are made with functions.

Slightly different is that one particular package is *a lot* better at plotting than `base` R.

Today

- Very basic statistics
- Introduction to plotting with `ggplot2`
    - There will be MUCH more on data visualization later
- PRACTICE PRACTICE PRACTICE

About the MIDUS dataset

Variables available in this data file:

- **Demographic variables**: age, sex
- **Physical health variables**: self-rated physical health, heart problems, father had heart attack, BMI
- **Mental health variables**: self-rated meantal health, self-esteem, life satisfaction *(life overall, work, health, relationship with spouse/partner, relationship with children)*, hostility *(stress reactivity & agression*)

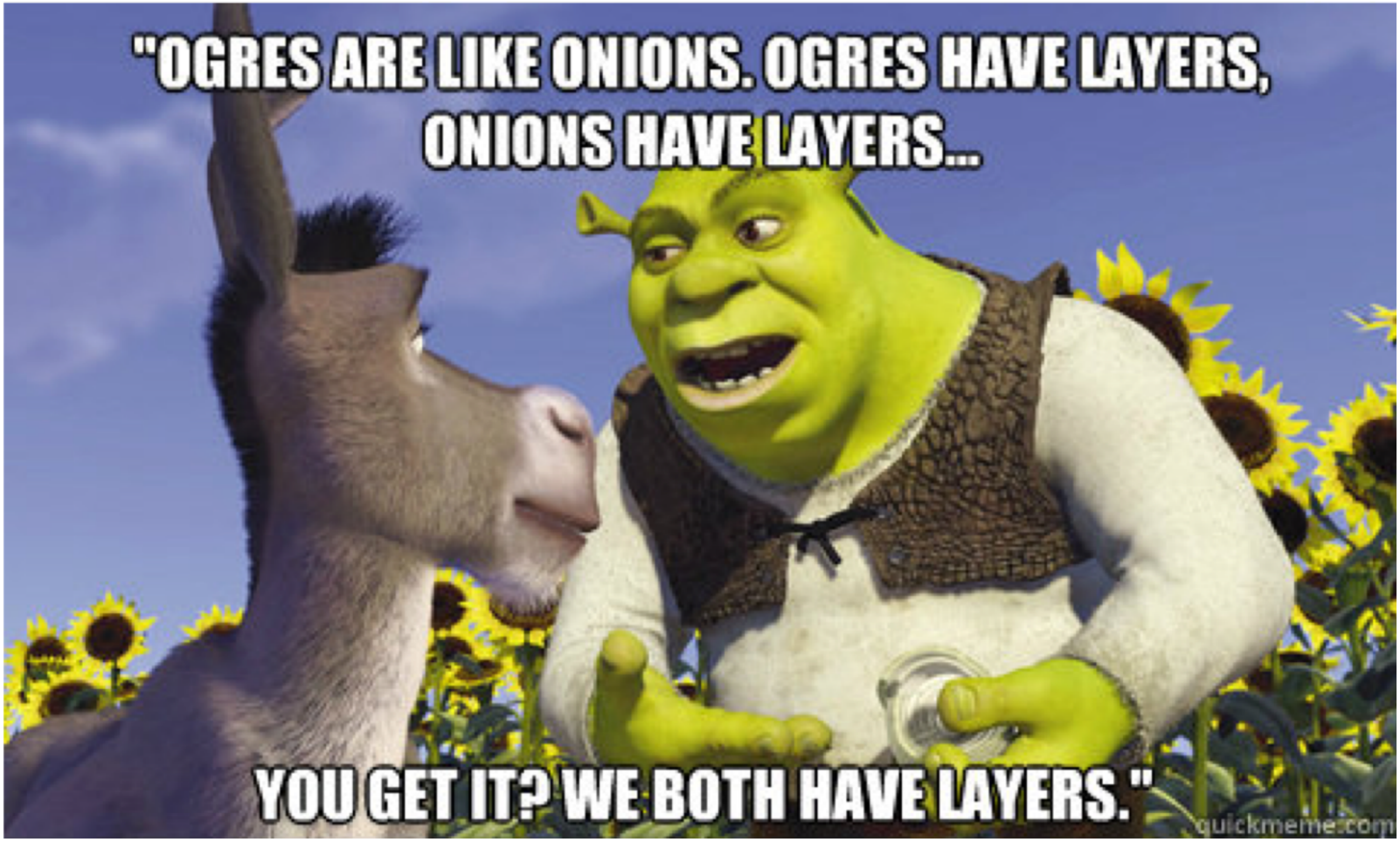
Please load in `midus`, make sure:

- Make sure the variables `sex`, `heart_self`, and `heart_father` are `factor()` variables (rather than characters)
- Use the same `na.omit()` function to remove all `NA` values

Before we begin...

- Check to make sure you have the `ggplot2` package *installed*
- Check to make sure the `ggplot2` package is *loaded*
- If "no" to either, how can you solve this?

Data visualization with `ggplot2`



Plotting with `ggplot2`

`ggplot2` has the following structure:

```
ggplot(things that impact the entire plot) +
  geom_something(things that impact just the something)
```

Plotting with `ggplot2`

`ggplot2` has the following structure:

```
ggplot(things that impact the entire plot) +
  geom_something(things that impact just the something)
```

Things like:

- data.frame used for plotting
- defining your x & y axes

Plotting with `ggplot2`

`ggplot2` has the following structure:

```
ggplot(things that impact the entire plot) +
  geom_something(things that impact just the something)
```

`geom_` typically means **shape**. What shapes do you want to use to represent your data in the plot?

- `geom_histogram` -- histogram
- `geom_density` -- distributions
- `geom_violin` -- distributions
- `geom_point` -- scatter plot
- `geom_col` -- bar plot

Plotting with `ggplot2`

The functions `ggplot()` and `geom_()` can take on different **aesthetics** as an argument, using `aes()`.

Aesthetics are how you control what you want your plot to look like; how can you make it pretty? Examples:

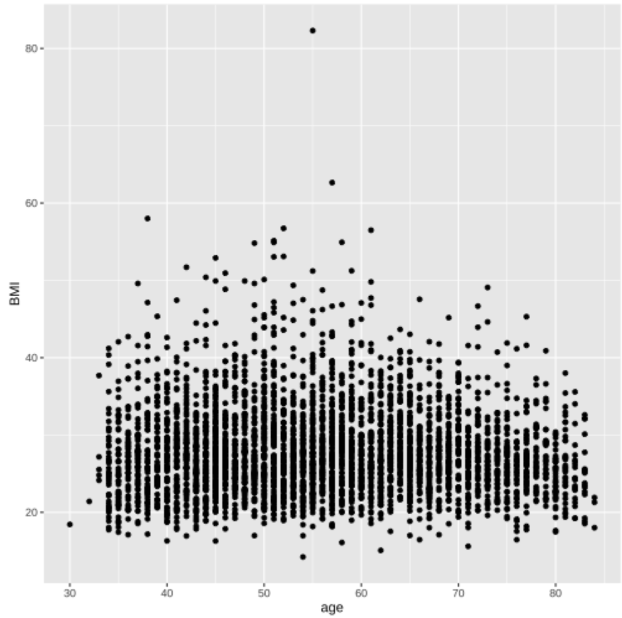
- Which variables are the `x-` and `y-` axes?
- `color` (should you color the plot by some variable?)
- `fill` (very similar to `color`, should you fill the plot in somehow; used for bar graphs and boxplots)
- `shape` (do you want groups to have different shaped points?)
- `size` (how big should plotted data be?)

Note: person that made this package is from New Zealand; the British spellings and American spellings work! Although using tab-complete my auto-fill the British spellings

Plotting with `ggplot2`

- Usually `aes()` contains some information that comes directly from the **data**
- If the information is *not* based on the data, it does not need to be inside an `aes()` argument.

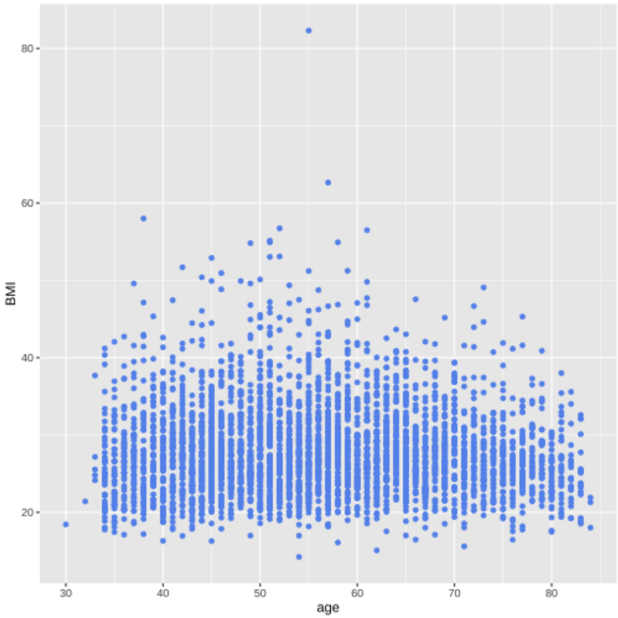
```
ggplot(data = midus, aes(x = age, y = BMI)) +
  geom_point()
```



Plotting with `ggplot2`

- Usually `aes()` contains some information that comes directly from the **data**
- If the information is *not* based on the data, it does not need to be inside an `aes()` argument.

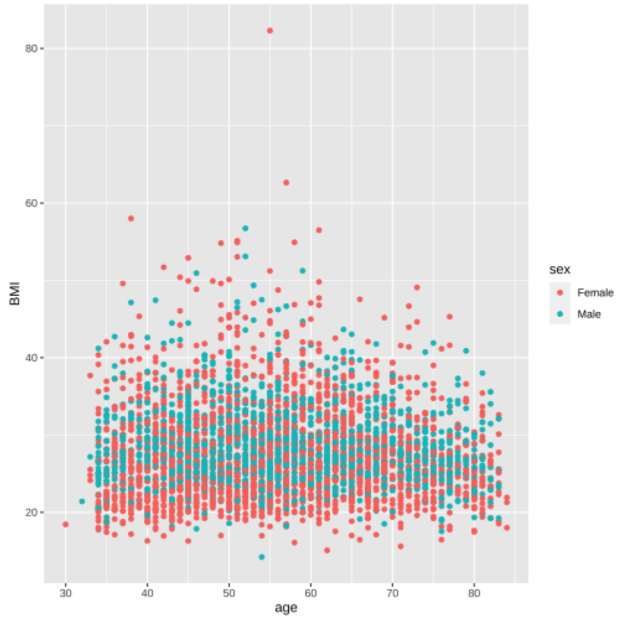
```
ggplot(data = midus, aes(x = age, y = BMI)) +
  geom_point(color = "cornflowerblue")
```



Plotting with `ggplot2`

- Usually `aes()` contains some information that comes directly from the **data**
- If the information is *not* based on the data, it does not need to be inside an `aes()` argument.

```
ggplot(data = midus, aes(x = age, y = BMI)) +
  geom_point(aes(color = sex))
```



Exercise 1

Make a scatter plot of `self_esteem` (x-axis) against `life_satisfaction` (y-axis)

Make the points of the scatter plot a different `shape` based on the `sex` variable (for example, males might be circles and females might be squares)

Make the `color` of the points different based on `sex`

Set the `size` of all points equal to `3`

Remember this???

Statistical Analyses

We're going to practice plotting with `ggplot2` while learning some really basic statistical tests.

Is there a difference in `hostility` between men and women in the `midus` sample?

Statistic: T-test
Plot: boxplot

A note about formulas

You can read the `~` (tilda) as "by" or "predicted by"

`hostility ~ sex` means...

- "hostility by sex"
- "is hostility predicted by sex?"

T-tests

Is there a difference in `hostility` between men and women in the `midus` sample?

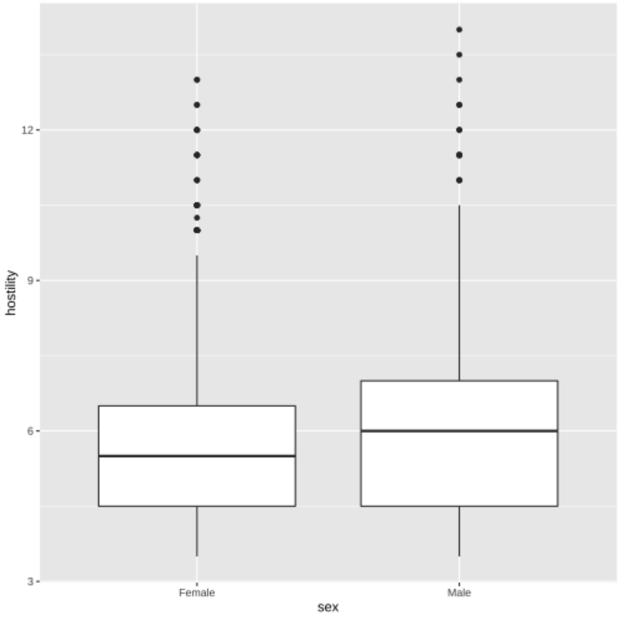
```
t.test(hostility ~ sex,
       data = midus)
```

```
##
##      Welch Two Sample t-test
##
## data:  hostility by sex
## t = -6.097, df = 3519.4, p-value = 1.198e-09
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.4491034 -0.2305455
## sample estimates:
## mean in group Female   mean in group Male
##             5.638040             5.977864
```

T-tests

Is there a difference in `hostility` between men and women in the `midus` sample?

```
ggplot(data = midus, aes(x = sex, y = hostility)) +
  geom_boxplot()
```



You try!

Is there a difference in life satisfaction between people who have had heart problems compared to people who have not had heart problems?

Statistic: T-test
Plot: boxplot

BONUS:

- Look at the help page for `t.test()`. How do you run a one-tailed t-test? Run it! Does your answer change?
- How could you `fill` the boxplots so that males and females are shown in different colors?
- Look at the help page for `labs()` and see if you can give your plot a title and different x- & y-axes labels.

Correlations

Does `self_esteem` correlate with `life_satisfaction`?

Statistic: Correlation

Plot: scatter plot

Lots of options for correlations!

- `cor()` gives straight correlation; no frills
- `cor.test()` gives probabilities but only for one pair of values at a time
- `corr.test()` is part of the `psych` package and reports sample sizes along with probabilities

Correlations

Does `self_esteem` correlate with `life_satisfaction`?

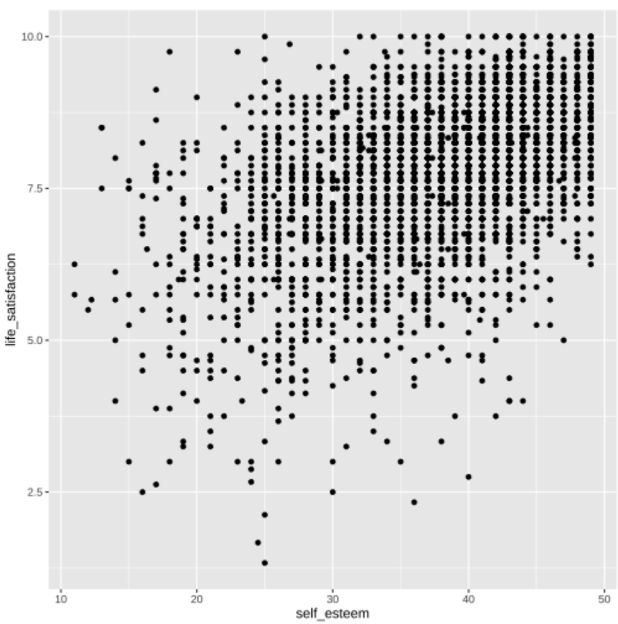
```
# Stored as it's own object. Play with it in your Global Environment!
esteemVsLifeSat <- cor.test(x = midus$self_esteem,
                             y = midus$life_satisfaction)

esteemVsLifeSat
```

```
##
##      Pearson's product-moment correlation
##
## data:  midus$self_esteem and midus$life_satisfaction
## t = 34.292, df = 3738, p-value < 2.2e-16
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.4644257 0.5131989
## sample estimates:
##       cor
## 0.4891947
```

Correlations

Does `self_esteem` correlate with `life_satisfaction`?

```
ggplot(data = midus, aes(x = self_esteem, y = life_satisfaction)) +
  geom_point()
```



You try!

Does age correlate with `BMI`?

Statistic: Correlation
Plot: scatter plot

BONUS:

- set the `size` of all points to 1.5
- change the x- & y-axes labels and add a title and subtitle
- make the shape of the points different based on if they've ever been diagnosed with a heart issue or not

ANOVA

Say you wanted to dichotomize your `self_esteem` variable into those with **high self-esteem** (above the mean) and those with **low self-esteem** (below the mean).

You want to see if `sex` and your newly dichotomized `self_esteem` variables predict `BMI`.

Statistic: 2x2 ANOVA
Plot: bar plot

Dichotomizing variables

As a general rule, don't do this

BUT, it does make for a nice teaching example 😃

```
# create the groups; store as a new variable
midus$self_esteem_di <- ifelse(test =
                                  midus$self_esteem > mean(midus$self_est
                                yes = "high",
                                no = "low")

# make sure the new variable is treated as a factor
midus$self_esteem_di <- factor(midus$self_esteem_di)

# for us to view it
head(midus[,c(1,2,3,12)])
```

```
##        ID    sex age self_esteem_di
## 1   10001   Male  61           high
## 2   10002   Male  69            low
## 6   10011 Female  52           high
## 8   10015 Female  53            low
## 10 10018   Male  49           high
```

ANOVA

Does sex and your newly dichotomized `self_esteem` variable predict `BMI`? (no interaction)

```
anova1 <- aov(BMI ~ sex + self_esteem_di, data = midus)
summary(anova1)
```

```
##                  Df Sum Sq Mean Sq F value   Pr(>F)    
## sex               1    541   541.0   16.39 5.25e-05 ***
## self_esteem_di    1    878   877.5   26.59 2.65e-07 ***
## Residuals      3737 123328    33.0                     
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

ANOVA

Does sex and your newly dichotomized `self_esteem` variable predict `BMI`?
(**WITH** interaction)

```
anova2 <- aov(BMI ~ sex * self_esteem_di, data = midus)
summary(anova2)
```

```
##                       Df Sum Sq Mean Sq F value   Pr(>F)    
## sex                    1    541   541.0  16.411 5.20e-05 ***
## self_esteem_di         1    878   877.5  26.618 2.61e-07 ***
## sex:self_esteem_di     1    162   162.2   4.921   0.0266 *  
## Residuals           3736 123166    33.0                     
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

ANOVA

Does sex and your newly dichotomized `self_esteem` variable predict `BMI`?

Bar plots suck. Height of each bar should reflect that group's **mean**. So we first need to calculate the means, and store them in a data.frame.

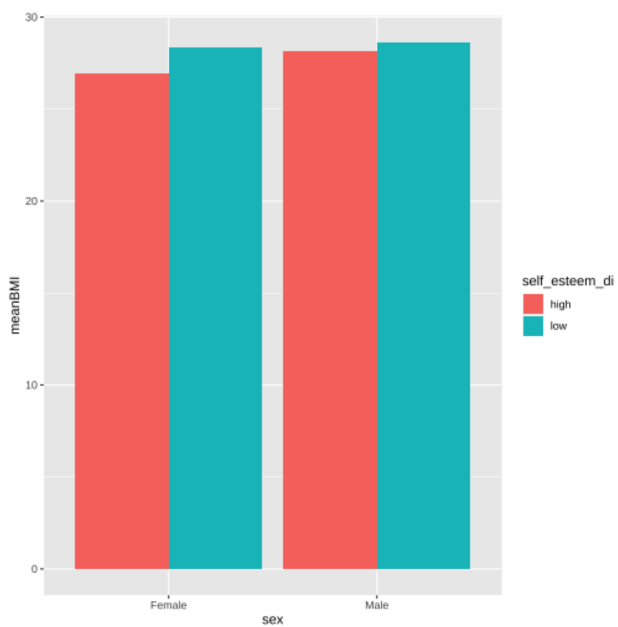
```
femaleHigh <- subset(midus, sex == "Female" & self_esteem_di == "high")
femaleHighMean <- mean(femaleHigh$BMI)

femaleLow <- subset(midus, sex == "Female" & self_esteem_di == "low")
femaleLowMean <- mean(femaleLow$BMI)

maleHigh <- subset(midus, sex == "Male" & self_esteem_di == "high")
maleHighMean <- mean(maleHigh$BMI)

maleLow <- subset(midus, sex == "Male" & self_esteem_di == "low")
maleLowMean <- mean(maleLow$BMI)

meansData <- data.frame(sex = c("Female", "Female", "Male", "Male"),
                        self_esteem_di = c("high", "low", "high", "low")
                        meanBMI = c(femaleHighMean,
                                    femaleLowMean,
                                    maleHighMean,
                                    maleLowMean))
```

ANOVA

Does `sex` and your newly dichotomized `self_esteem` variable predict `BMI`?

Then we can plot, using our **NEW** data.frame *(Note: we will cover a* ***MUCH*** *easier way of doing this when we talk about `tidyverse` in the next section)*

```
ggplot(data = meansData, aes(x = sex, y = meanBMI)) +
  geom_col(aes(fill = self_esteem_di), position = "dodge")
```



You try!

Below is some code that trichotomizes age into the following groups:

- 28-40 -- "young"
- 40-60 -- "middle"
- 60-84 -- "old"

Copy (& run) the following code into your script so you can do the next exercise:

```
midus$age_category <- cut(x = midus$age,
                          breaks = c(28, 40, 60, 84),
                          labels = c("young", "middle", "old"),
                          include.lowest = TRUE)
```

NOW, is there a main effect of `age_category`, a main effect of `heart_self`, and is there a `age_category x heart_self` interaction on `BMI`?

Statistic: 3x2 ANOVA
Plot: bar plot

Fill in the missing bits of this code

```
youngYesHeart <- subset(midus, age_category == "young" & heart_self == '
youngYesHeartMean <- mean(youngYesHeart$BMI)

youngNoHeart <- subset(midus, age_category == "young" & heart_self == "'
youngNoHeartMean <- mean(youngNoHeart$BMI)

middleYesHeart <- subset(midus, age_category == "" & heart_self == "Yes'
middleYesHeartMean <- mean()

middleNoHeart <- subset(midus, age_category == "" & heart_self == "No")
middleNoHeartMean <- mean(BMI)

oldYesHeart <- subset(midus, age_category == "" & heart_self == "")
oldYesHeartMean <- mean()

oldNoHeart <- subset(midus, age_category == "" & heart_self == "")
oldNoHeartMean <- mean()
```

Data prep for bar plot

Now that you've filled in (& run!) the previous code, turn all of that into a data.frame you can use. *(remember, we're going to cover a **MUCH** easier way of doing this when we talk about `tidyverse`)*

```
meansData <- data.frame(age_category = c("young", "young", "middle", "m
                                         "old", "old"),
                        heart_self = c("Yes", "No", "Yes", "No", "Yes",
                        meanBMI = c(youngYesHeartMean,
                                    youngNoHeartMean,
                                    middleYesHeartMean,
                                    middleNoHeartMean,
                                    oldYesHeartMean,
                                    oldNoHeartMean))
```

You try!

Finally, make your bar plot using the new data.frame we just made!

Regression

1. Is `life_satisfaction` predicted by `self_esteem`?
2. Are `self_esteem` and `hostility` both independent predictors of `life_satisfaction`?
3. Is there an interaction between `self_esteem` and `hostility` predicting `life_satsifaction`?

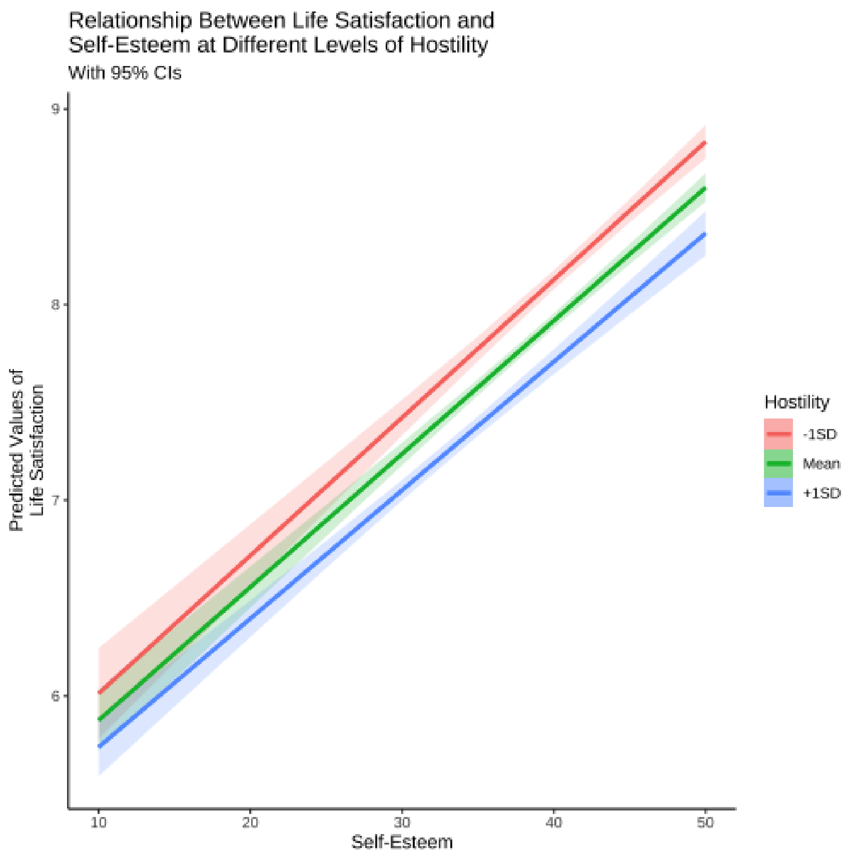
Statistic: Simple & Multiple Regression
Plot: scatter plot with mean, +1SD, and -1SD of `hostility`

Regression

1. Is `life_satisfaction` predicted by `self_esteem`?
    - Simple regression
    - `lm(life_satisfaction ~ self_esteem, data = midus)`
2. Are `self_esteem` and `hostility` both independent predictors of `life_satisfaction`?
    - Multiple regression; no interaction
    - `lm(life_satisfaction ~ self_esteem + hostility, data = midus)`
3. Is there an interaction between `self_esteem` and `hostility` predicting `life_satsifaction`?
    - Multiple regression; with interaction
    - `lm(life_satisfaction ~ self_esteem * hostility, data = midus)`

An extra pacakge: `ggeffects`

Has a function called `ggpredict` that makes it very easy to visualize interactions of continuous variables.



Things to note about regression

- Assign your `lm()` object to your global environment. You can get coefficients, predicted values etc.
- If you want the relationship betwen X1 and Y, *after controlling for* X2, you can make a scatter plot with the model's **fitted* values.
- If you want to view the output table of a regression, use `summary()` (just like we did with ANOVA).
- If you want the R^2, F-statistic etc., assign the `summary(model)` object to your global environment.
- Check out the `broom` package to format your regression outputs into a nice data.frame.

You try!

[MAKE UP AN EXERCISE HERE]

R Resources

The **only** way to get better is to **PRACTICE**! Some helpful resources:

- Online tutorials like Coursera, Code School/Pluralsight, and Code Academy
- `swirl` package helps you learn R from inside RStudio! Strong recommend!
- Favorite websites for reference:
  - Quick-R
  - Cookbook for R
  - **STACK OVERFLOW** (almost always top answer from Google search)
- Reddit has a shocking number of R-related subreddits
- Jenine Harris's new **Statistics with R** book
- **R for Data Science** is very `tidyverse`-heavy; go through our `tidyverse` portion first, then check the book out
- **Learning Statistics with R** by Danielle Navarro; textbook for grad stats
- **#rstats** on Twitter is a huge and welcoming community!

Google, Google, Google!

Congratulations!

You made it through our R Basic Training!

Up next:

- Learn to clean and prepare your data more effectively with **`tidyverse`**. This is a HUGE part of the R ecosystem, so please don't skip this! It will make your life a lot easier!

- How to generate reports (PDF, Word, or HTML) files that integrate your thoughts and your code. This is the core of **`reproducibility`** and will allow you to share code with your advisors, collaborators, and journals in a much prettier and easier manner.

- Here we covered the basics of plotting with `ggplot2`, but learn just how flexible it can be for **`data visualization`**. Make your plots incredible!