

# 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 mental health, self-esteem, life satisfaction (*life overall, work, health, relationship with spouse/partner, relationship with children*), hostility (*stress reactivity & aggression*)

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)
```



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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**
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```
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)
```

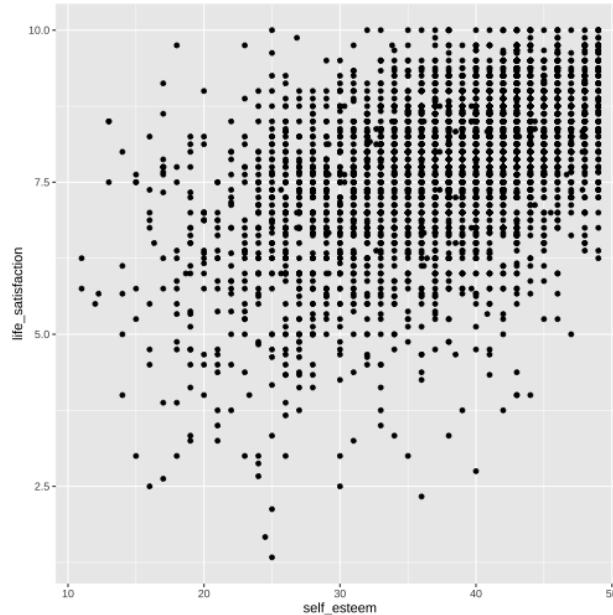
```
esteemVsLifeSat
```

```
##
##      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_esteem),
                                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)

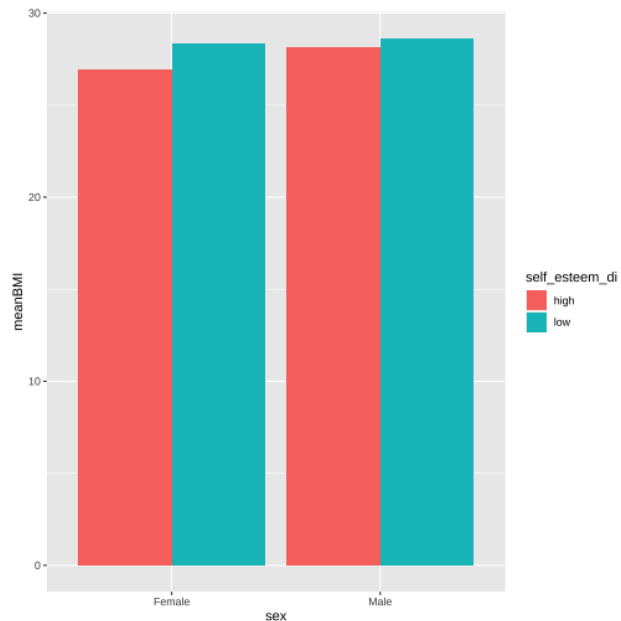
meansData <- data.frame(sex = c("Female", "Female", "Male", "Male"),
                        self_esteem_di = c("high", "low", "high", "low"),
                        meanBMI = c(femaleHighMean,
                                    femaleLowMean,
                                    maleHighMean,
    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

**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`?

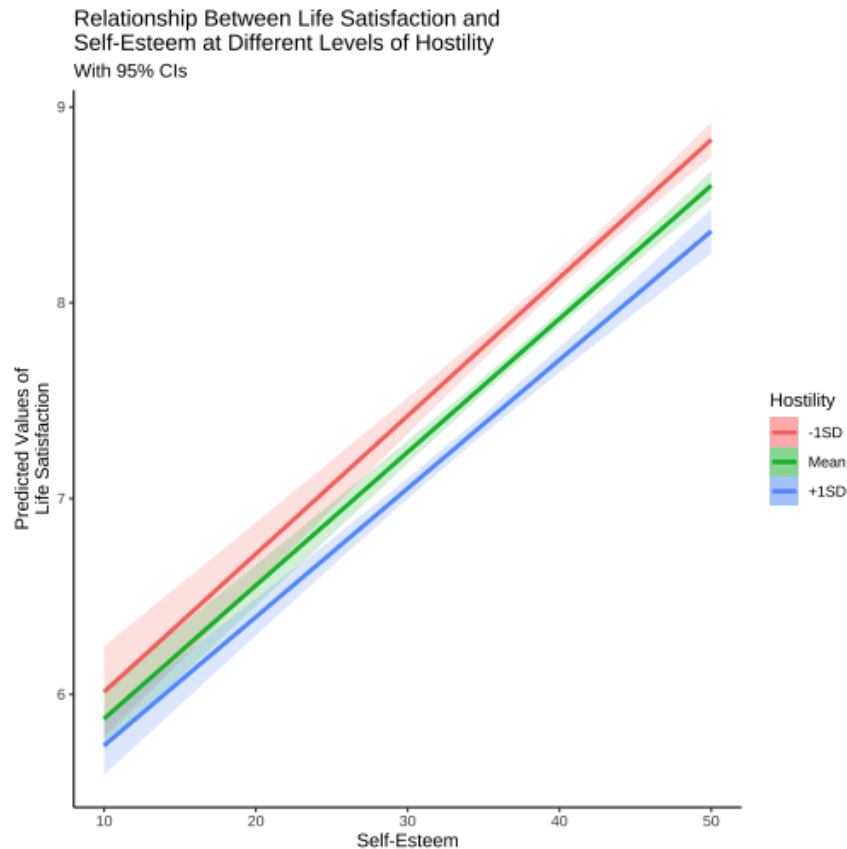
- Multiple regression; no interaction
- `lm(life_satisfaction ~ self_esteem + hostility, data = midus)`

3. Is there an interaction between `self_esteem` and `hostility` predicting `life_satisfaction`?

- Multiple regression; with interaction
- `lm(life_satisfaction ~ self_esteem * hostility, data = midus)`

# An extra package: 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 between 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!

