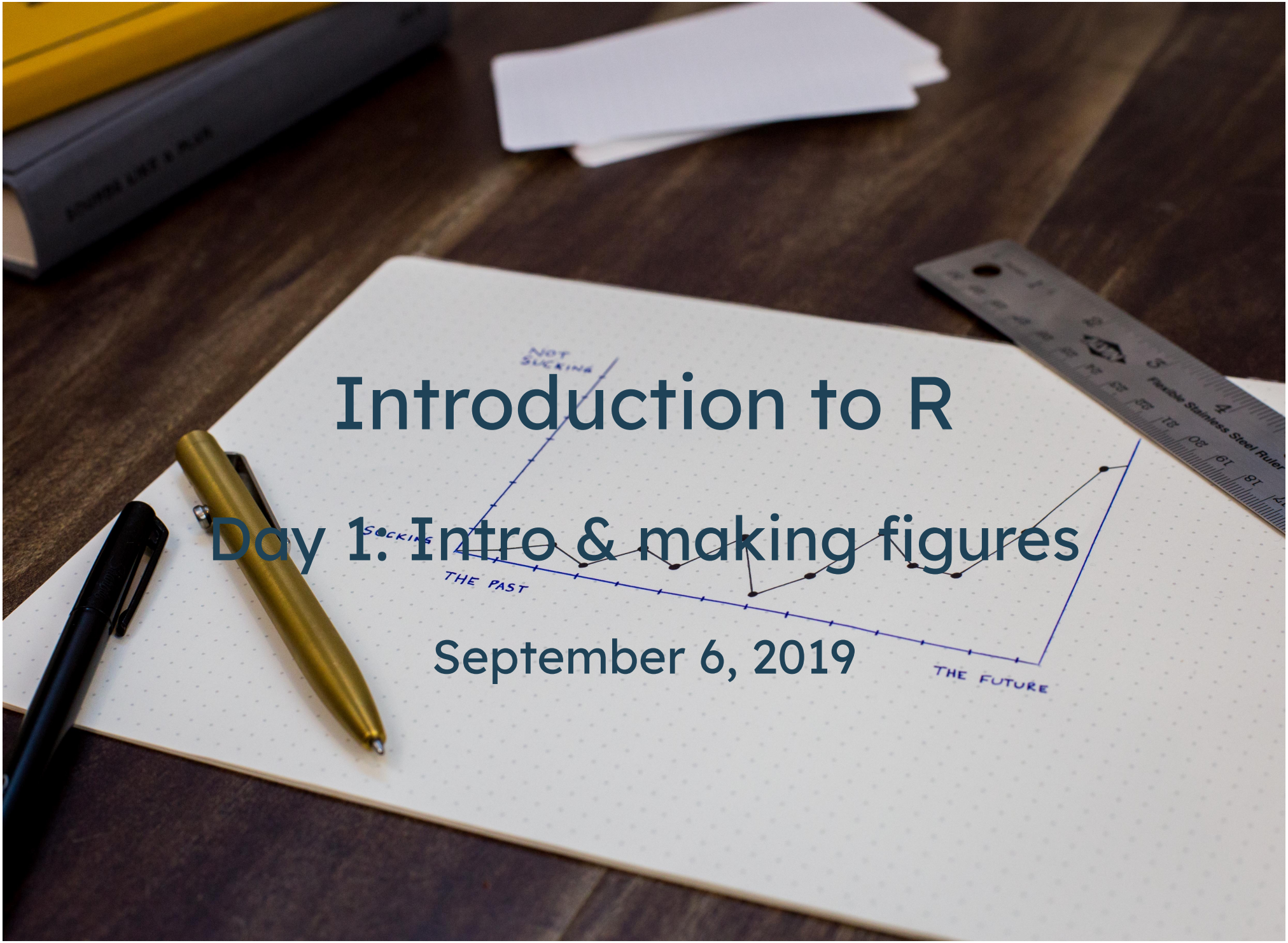


Introduction to R

Day 1: Intro & making figures

September 6, 2019

About this class

- Non-credit
- 5 sessions
- "Challenges" but no homework

Work hard with each other during class

Try to figure it out on your own before you ask for help

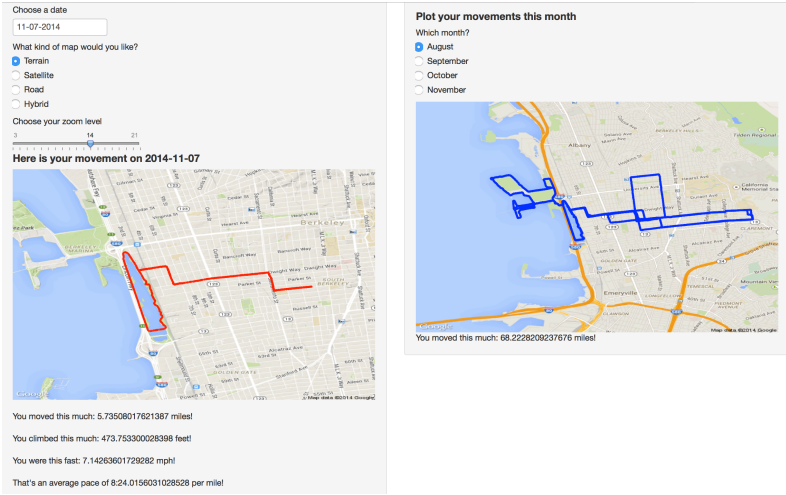
Practice by yourself in between classes

You are not going to break anything!

Anyone can learn to use R, it's just a matter of sitting down and doing it. Now's your chance!

About me

- 4th-year PhD candidate in Epidemiology
- Started using R during my masters (so 5 years of experience); learned mostly by doing
- Problem sets, manuscripts, slides, website all in R (www.louisahsmith.com)
- Almost 100 R projects on my computer, including over 1000 R scripts

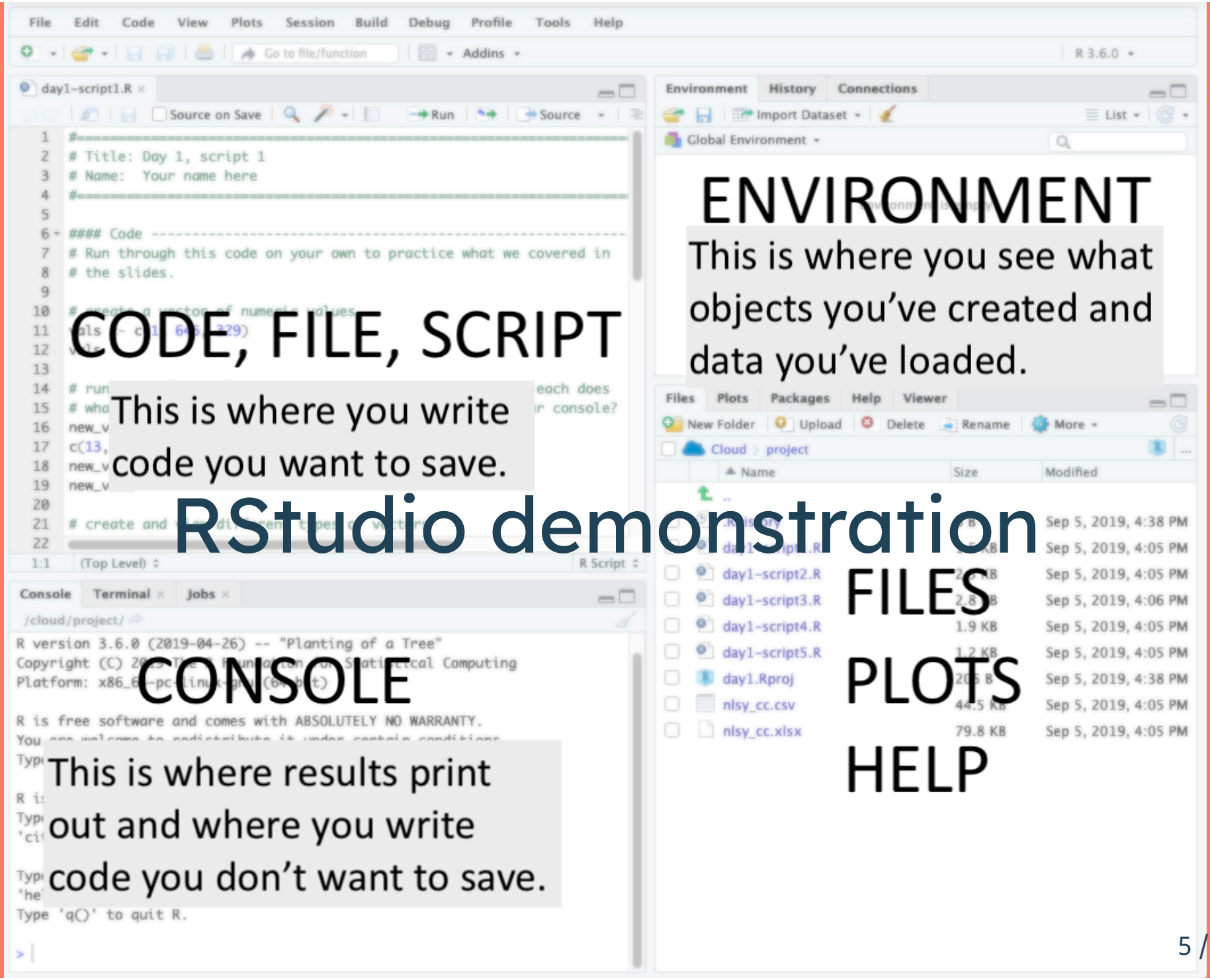


I have to Google things literally every time I use R!

An IDE for R

An *integrated development environment* is software that makes coding easier

- see objects you've imported and created
- autocomplete
- syntax highlighting
- run part or all of your code


File Edit Code View Plots Session Build Debug Profile Tools Help
Addins
R 3.6.0
day1-script1.R
Source on Save
Run
Source
Environment History Connections
Import Dataset
List
Global Environment
ENVIRONMENT
This is where you see what objects you've created and data you've loaded.
CODE, FILE, SCRIPT
This is where you write code you want to save.
RStudio demonstration
Files Plots Packages Help Viewer
New Folder
Upload
Delete
Rename
More
Cloud project
Name
Size
Modified
day1-script2.R
day1-script3.R
day1-script4.R
day1-script5.R
day1.Rproj
nlsy_cc.csv
nlsy_cc.xlsx
FILES
PLOTS
HELP
Console Terminal Jobs
/cloud/project/
R version 3.6.0 (2019-04-26) -- "Planting of a Tree"
R is free software and comes with ABSOLUTELY NO WARRANTY.
Type 'q()' to quit R.
CONSOLE
This is where results print out and where you write code you don't want to save.

R uses <- for assignment

Create an object `vals` that contains and sequence of numbers:

```
# create values
vals <- c(1, 645, 329)
```

Put your cursor at the end of the line and hit ctrl/cmd + enter.

Now `vals` holds those values.

We can see them again by running just the name (put your cursor after the name and press ctrl/cmd + enter again).

```
vals
```

```
## [1]   1 645 329
```

No assignment arrow means that the object will be printed to the console.

Types of data (*classes*)

We could also create a character *vector*:

```
chars <- c("dog", "cat", "rhino")
chars
```

```
## [1] "dog"   "cat"   "rhino"
```

Or a *logical* vetor:

```
logs <- c(TRUE, FALSE, FALSE)
logs
```

```
## [1]  TRUE FALSE FALSE
```

We'll see more options as we go along!

Types of objects

We created *vectors* with the `c()` function (`c` stands for concatenate)

We could also create a *matrix* of values with the `matrix()` function:

```
# turn the vector of numbers into a 2-row matrix
mat <- matrix(c(234, 7456, 12, 654, 183, 753), nrow = 2)
mat
```

```
##      [,1] [,2] [,3]
## [1,]  234   12  183
## [2,] 7456  654  753
```

The numbers in square brackets are *indices*, which we can use to pull out values:

```
# extract second row
mat[2, ]
```

```
## [1] 7456  654  753
```

Exercises 1

1. Extract `645` from `vals` using square brackets
2. Extract `"rhino"` from `chars` using square brackets
3. You saw how to extract the second row of `mat`. Figure out how to extract the second column.
4. Extract `183` from `mat` using square brackets
5. Figure out how to get the following errors:

```
## [1] "incorrect number of dimensions"
```

```
## [1] "subscript out of bounds"
```

Dataframes

We usually do analysis in R with dataframes (or some variant).

Dataframes are basically like spreadsheets: columns are variables, and rows are observations.

```
gss_cat
```

```
## # A tibble: 21,483 x 9
##     year marital         age race  rincome      partyid       relig        deno
##    <int> <fct>         <int> <fct> <fct>        <fct>         <fct>        <fct
##  1  2000 Never marr…      26 White $8000 to 99… Ind,near rep  Protestant   Sout
##  2  2000 Divorced         48 White $8000 to 99… Not str repu… Protestant   Bapt
##  3  2000 Widowed          67 White Not applica… Independent   Protestant   No d
##  4  2000 Never marr…      39 White Not applica… Ind,near rep  Orthodox-ch… Not
##  5  2000 Divorced         25 White Not applica… Not str demo… None         Not
##  6  2000 Married          25 White $20000 - 24… Strong democ… Protestant   Sout
##  7  2000 Never marr…      36 White $25000 or m… Not str repu… Christian    Not
##  8  2000 Divorced         44 White $7000 to 79… Ind,near dem  Protestant   Luth
##  9  2000 Married          44 White $25000 or m… Not str demo… Protestant   Othe
## 10  2000 Married          47 White $25000 or m… Strong repub… Protestant   Sout
## # … with 21,473 more rows
```

tibble???

Packages in R

Although R comes with a number of functions (and datasets! try running `data()`), you can also add on lots of **packages**.

Many packages can be found on CRAN, which is what R goes to automatically when you run `install.packages("packagename")`.

Other packages live only on GitHub, or in other repositories. To download these, you will have to use something like `remotes::install_github("developer/package")` or similar.

You only need to install a package once (until it needs to be updated, or you update R). But every time you want to use a package, you need to include `library(packagename)` at the top of your script, and run that before you run any functions.

tidyverse

The tidyverse is a collection of packages for R that are designed to make working with data easy and intuitive.

You might hear it contrasted with "base R" or the package `data.table`. You can (and should!) learn as many coding techniques and strategies as possible, then choose the best option (in terms of speed, readability, etc.) for you.

I find tidyverse the quickest and most intuitive way to get up and running with R.

```
install.packages("tidyverse")
library(tidyverse)
# installs and loads ggplot2, dplyr, tidyr, readr,
# purrr, tibble, stringr, forcats
```

and tibbles are the quickest and most intuitive way to make and read a dataset

```
dat1 <- tibble(
  age = c(24, 76, 38),
  height_in = c(70, 64, 68),
  height_cm = height_in * 2.54
)
dat1
```

```
## # A tibble: 3 x 3
##     age height_in height_cm
##   <dbl>     <dbl>     <dbl>
## 1    24        70      178.
## 2    76        64      163.
## 3    38        68      173.
```

```
dat2 <- tribble(
  ~n, ~food, ~animal,
  39, "banana", "monkey",
  21, "milk", "cat",
  18, "bone", "dog"
)
dat2
```

```
## # A tibble: 3 x 3
##       n food   animal
##   <dbl> <chr>  <chr>
## 1    39 banana monkey
## 2    21 milk   cat
## 3    18 bone   dog
```

tibbles are basically just pretty dataframes

```
as_tibble(gss_cat)[, 1:5]
```

```
# A tibble: 21,483 x 5
    year marital         age race  rincome
   <int> <fct>         <int> <fct> <fct>
 1  2000 Never married    26 White $8000 to 9999
 2  2000 Divorced         48 White $8000 to 9999
 3  2000 Widowed          67 White Not applicable
 4  2000 Never married    39 White Not applicable
 5  2000 Divorced         25 White Not applicable
 6  2000 Married          25 White $20000 - 24999
 7  2000 Never married    36 White $25000 or more
 8  2000 Divorced         44 White $7000 to 7999
 9  2000 Married          44 White $25000 or more
10  2000 Married          47 White $25000 or more
# … with 21,473 more rows
```

```
as.data.frame(gss_cat)[, 1:5]
```

```
   year       marital age  race       rin
1  2000 Never married  26 White  $8000 to
2  2000      Divorced  48 White  $8000 to
3  2000       Widowed  67 White Not applic
4  2000 Never married  39 White Not applic
5  2000      Divorced  25 White Not applic
6  2000       Married  25 White $20000 - 2
7  2000 Never married  36 White $25000 or
8  2000      Divorced  44 White  $7000 to
9  2000       Married  44 White $25000 or
10 2000       Married  47 White $25000 or
11 2000       Married  53 White $25000 or
12 2000       Married  52 White $25000 or
13 2000       Married  52 White $25000 or
14 2000       Married  51 White $25000 or
15 2000      Divorced  52 White $25000 or
16 2000       Married  40 Black $25000 or
```

National Longitudinal Survey of Youth | 1979

NLSY79

We'll use some data from the National Longitudinal Survey of Youth 1979, a cohort of American young adults aged 14-22 at enrollment in 1979. They continue to be followed to this day, and there is a wealth of publicly available data online. I've downloaded the answers to a survey question about whether respondents wear glasses, a scale about their eyesight with glasses, whether they are black or white/hispanic, their sex, their family's income in 1979, and their age at the birth of their first child.

Read in data

```
nlsy <- read_csv("nlsy_cc.csv")
nlsy
```

```
## # A tibble: 1,205 x 14
##   H0012400 H0012500 H0022300 H0022500 R0000100 R0009100 R0173600 R0214700 R02
##      <dbl>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>    <dbl>
## 1        0        1        5        7        3        3        5        3
## 2        1        2        6        7        6        1        1        3
## # … with 1,203 more rows, and 4 more variables: R0217900 <dbl>, R0402800 <dbl
## #   R7090700 <dbl>, T4120500 <dbl>
```

Ugh...

```
colnames(nlsy)
```

```
##  [1] "H0012400" "H0012500" "H0022300" "H0022500" "R0000100" "R0009100" "R0173
##  [9] "R0214800" "R0216400" "R0217900" "R0402800" "R7090700" "T4120500"
```

```
colnames(nlsy) <- c("glasses", "eyesight", "sleep_wkdy", "sleep_wknd",
                    "id", "nsibs", "samp", "race_eth", "sex", "region",
                    "income", "res_1980", "res_2002", "age_bir")
```

Explore your data

```
summary(nlsy$glasses)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  0.0000  0.0000  1.0000  0.5178  1.0000  1.0000
```

```
mean(nlsy$age_bir)
```

```
## [1] 23.44813
```

```
?cor
```

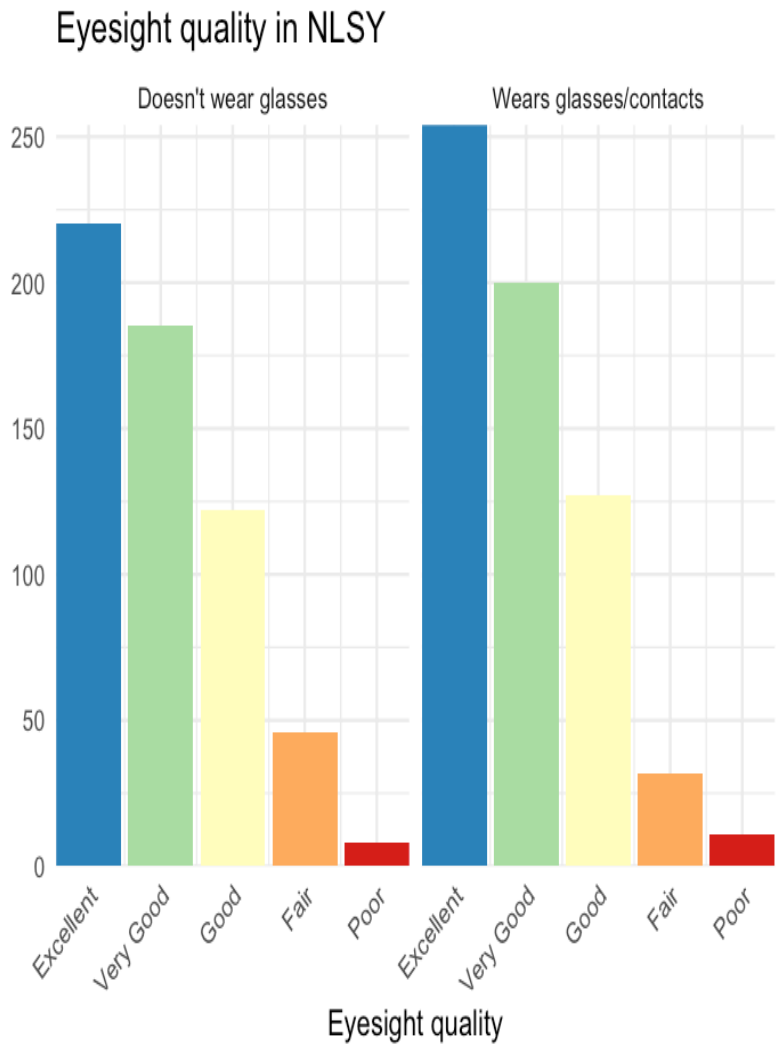
Get help!

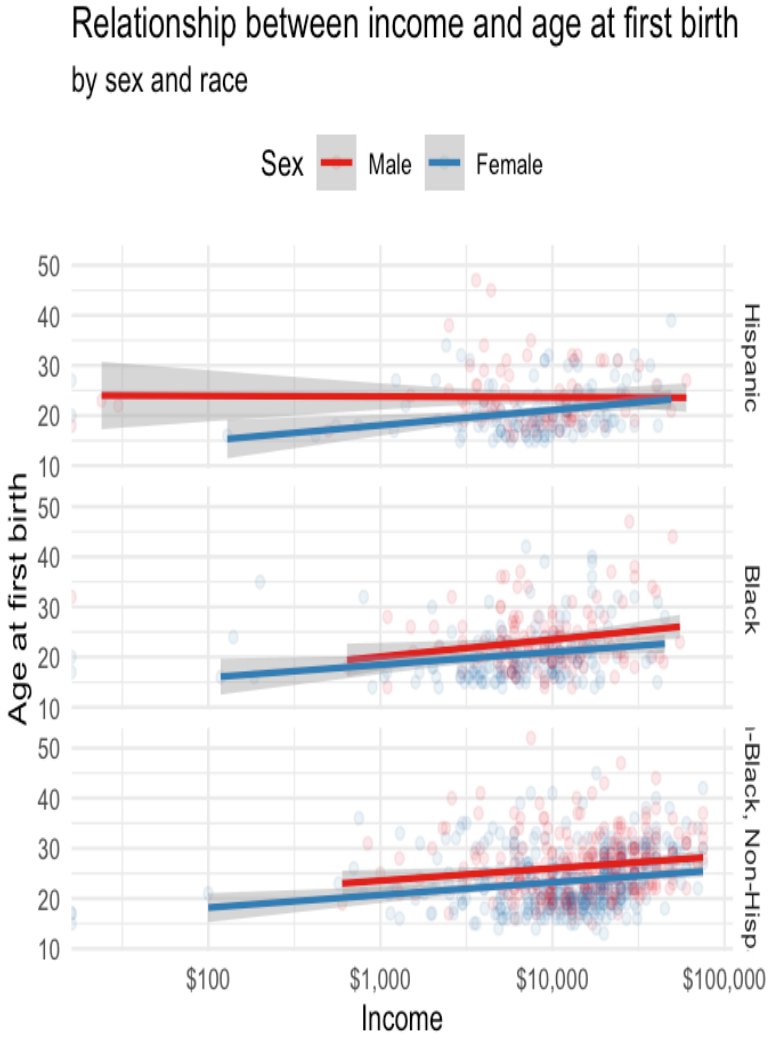
- `help(cor)`
- https://www.rdocumentation.org
- https://rdrr.io
- https://www.r-project.org/help.html
- SO. MUCH. MORE.

Exercises 2

1. How many people are in the NLSY? How many variables are in this dataset? What are two ways you can answer these questions?
2. Can you find an R function(s) we haven't discussed that answers question 2? (Hint: Google)
3. What's the Spearman correlation between hours of sleep on weekends and weekdays in this data?
4. I've also provided you with the same dataset as an Excel document, but it's not on the first sheet, and there's an annoying header. Load the `readxl` package (you already installed with with `tidyverse`, but it doesn't load automatically).

#goals

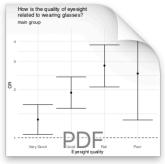

Eyesight quality in NLSY
Doesn't wear glasses
Wears glasses/contacts
250
200
150
100
50
0
Excellent
Very Good
Good
Fair
Poor
Excellent
Very Good
Good
Fair
Poor
Eyesight quality


Relationship between income and age at first birth
by sex and race
Sex
Male
Female
Age at first birth
50
40
30
20
10
Hispanic
Black
Non-Black, Non-Hisp
$100
$1,000
$10,000
$100,000
Income

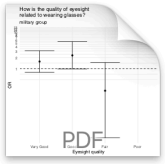
#goals

```
run_analysis(group = "main")
run_analysis(group = "supplementary")
run_analysis(group = "military")
```

Ta da!



figure_main.pdf



figure_military.pdf

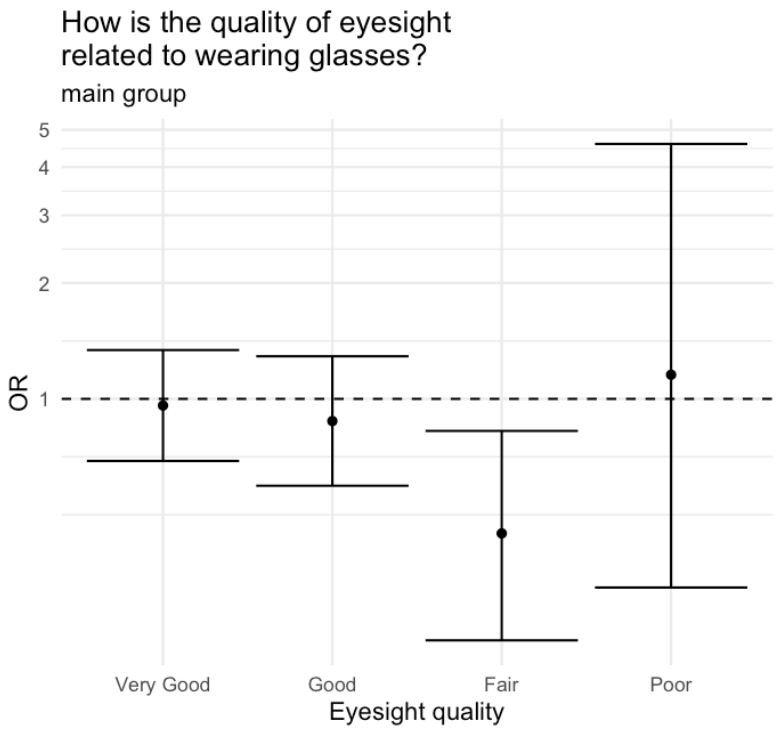
figure_supplementary.pdf

table_main.csv

table_military.csv

table_supplementary.csv

#goals



Eyesight	OR (95% CI)	P-value
Excellent	1 (ref)	NA
Very Good	0.96 (0.69, 1.34)	0.814
Good	0.88 (0.59, 1.29)	0.501
Fair	0.45 (0.24, 0.83)	0.011
Poor	1.16 (0.32, 4.59)	0.826

Basic structure of a ggplot

```
ggplot(data = {data}) +
      <geom>(aes(x = {xvar}, y = {yvar}, <characteristic> = {othvar}, ...),
             <characteristic> = "value", ...) +
      ...
```

- `{data}`: must be a dataframe (or tibble!)
- `{xvar}` and `{yvar}` are the column names (unquoted) of the variables on the x- and y-axes
- `{othvar}` is some other unquoted variable name that defines a grouping or other characteristic you want to map to an aesthetic

- `<geom>`: the geometric feature you want to use; e.g., point (scatterplot), line, histogram, bar, etc.
- `<characteristic>`: you can map `{othvar}` or a fixed `"value"` to any of a number of aesthetic features of the figure; e.g., color, shape, size, linetype, etc.

- `"value"`: a fixed value that defines some characteristic of the figure; e.g., "red", 10, "dashed"

- ... : there are numerous other options to discover!

```
ggplot(data = nlsy,
  aes(income, age_bir, col = factor(s
) +
  geom_point(alpha = 0.1) +
  scale_color_brewer(palette = "Set1"
    name = "Sex",
    labels = c("Male", "Female")) +
  scale_x_log10(labels = scales::doll
  geom_smooth(aes(
    group = factor(sex)),
    method = "lm") +
  facet_grid(rows = vars(race_eth),
    labeller = labeller(race_eth = c(
      "1" = "Hispanic",
      "2" = "Black",
      "3" = "Non-Black, Non-Hispanic"
  theme_minimal() +
  theme(legend.position = "top")
```

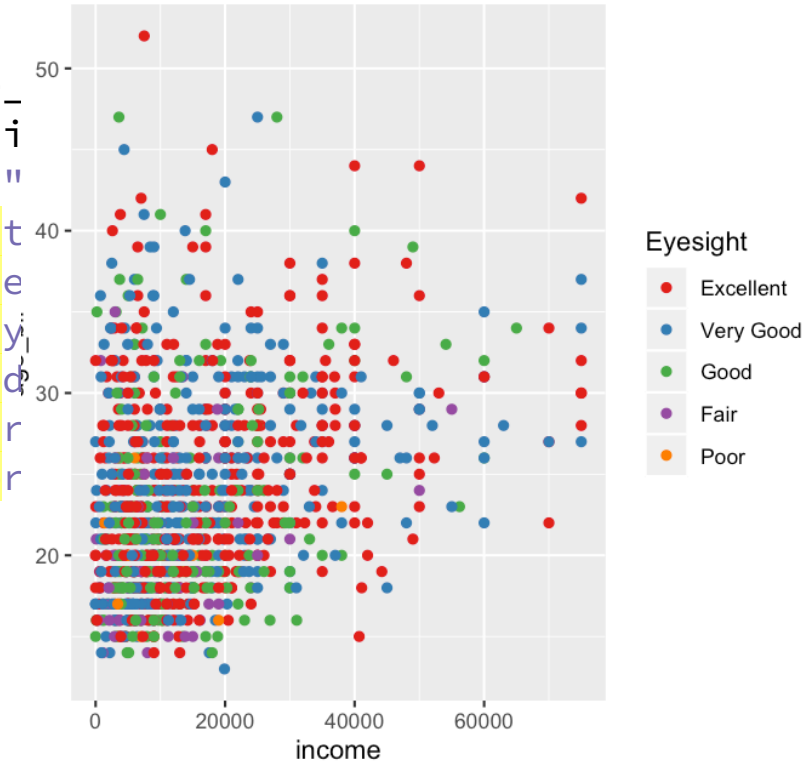
Basic example

```
ggplot(data = nlsy, aes(x = income, y = age_bir, <characteristic> = {othvar}, ..
      geom_point(<characteristic> = "value", ...) +
      ...
```

We could also put the aesthetics (the variables that are being mapped to the plot) in the initial `ggplot()` function

This will be helpful when we want multiple geoms (say, points and a line)

```
ggplot(data = nlsy) +
  geom_point(aes(x = income, y = age_
                 color = factor(eyesi
  scale_color_brewer(palette = "Set1"
                     name = "Eyesight
                     labels = c("Exce
                                "Very
                                "Good
                                "Fair
                                "Poor
```



Each of the `scale_color_()` functions has a lot of the same arguments

Make sure if you are labelling a factor variable in a plot like this that you get the names right!

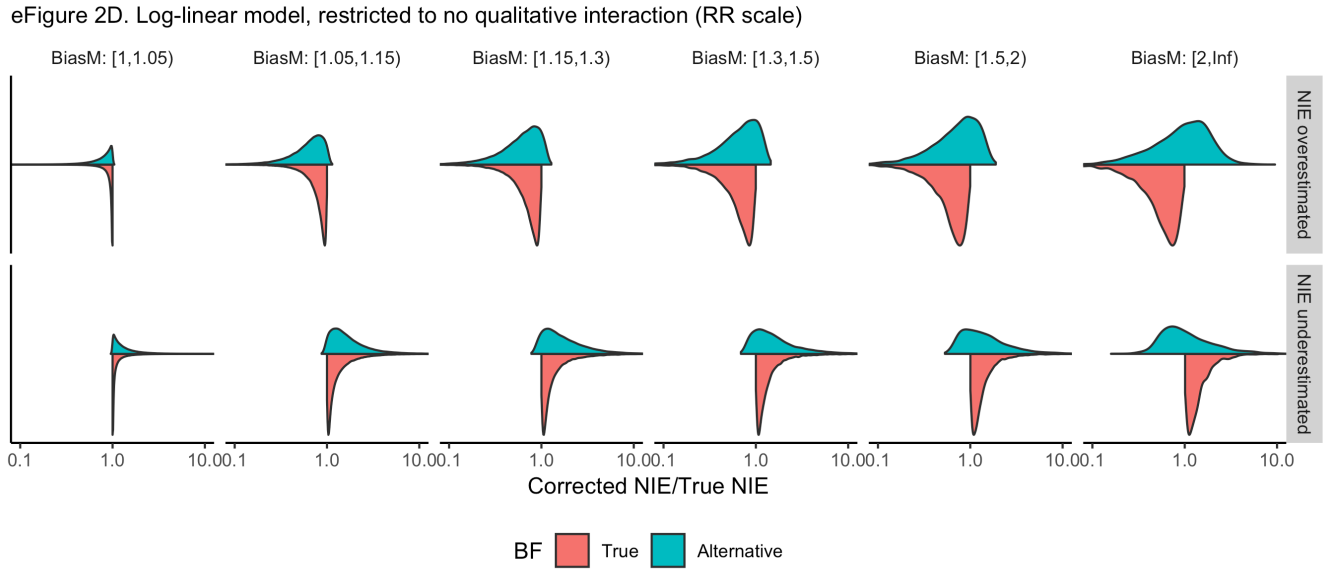
Exercises 3

1. Using the NLSY data, make a scatter plot of the relationship between hours of sleep on weekends and weekdays. Color it according to region (where 1 = northeast, 2 = north central, 3 = south, and 4 = west).
2. Replace `geom_point()` with `geom_jitter()`. What does this do? Why might this be a good choice for this graph? Play with the `width =` and `height =` options. This site may help: https://ggplot2.tidyverse.org/reference/geom_jitter.html
3. Use the `shape =` argument to map the sex variable to different shapes. Change the shapes to squares and diamonds. (Hint: how did we manually change colors to certain values? This page might also help: https://ggplot2.tidyverse.org/articles/ggplot2-specs.html)

Facets

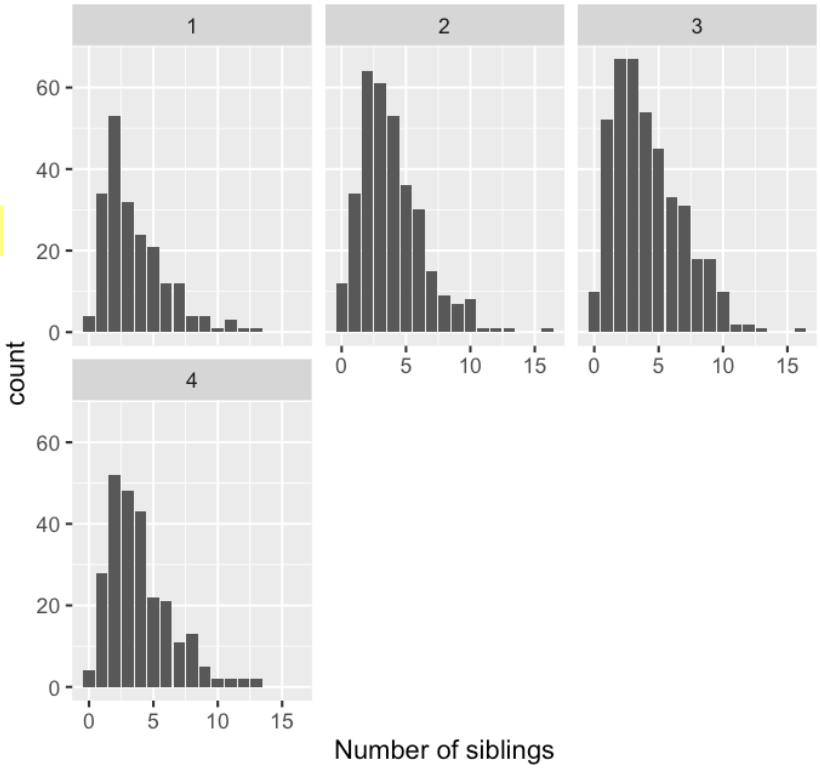
One of the most useful features of `ggplot2` is the ability to "facet" a graph by splitting it up according to the values of some variable.

You might use this to show results for a lot of outcomes or exposures at once, for example, or see how some relationship differs by something like age or geographic region



```
ggplot(data = nlsy) +
  geom_bar(aes(x = nsibs)) +
  labs(x = "Number of siblings") +
  facet_wrap(vars(region),
             ncol = 3)
```

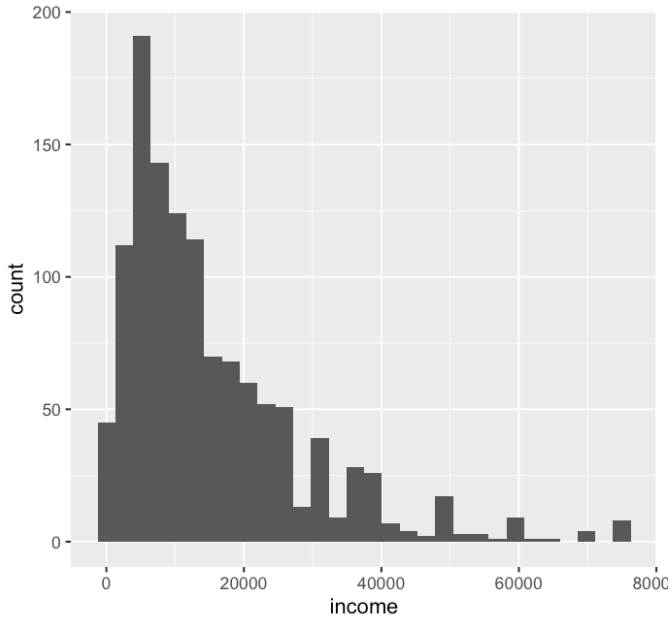
It tries to make a good decision, but you can override how many columns you want!



Wait, these look like histograms!

When we have a variable with a lot of possible values, we may want to bin them with a histogram

```
ggplot(nlsy) +
  geom_histogram(aes(x = income))
```



`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.

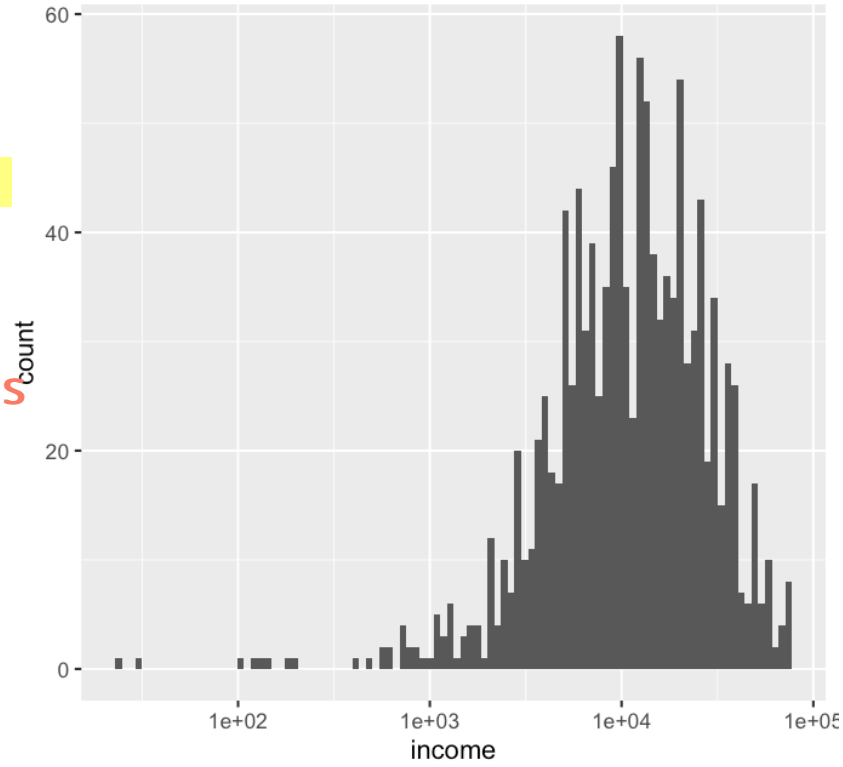
We used discrete values with `geom_bar()`, but with `geom_histogram()` we're combining values: the default is into 30 bins.

This is one of the most common warning messages I get in R!

```
ggplot(data = nlsy) +
  geom_histogram(aes(x = income),
                 bins = 100) +
  scale_x_log10()
```

We can change the values of the axis just like we changed the values of the colors

There are a lot of `scale_x_()` and `scale_y_()` functions for you to explore!

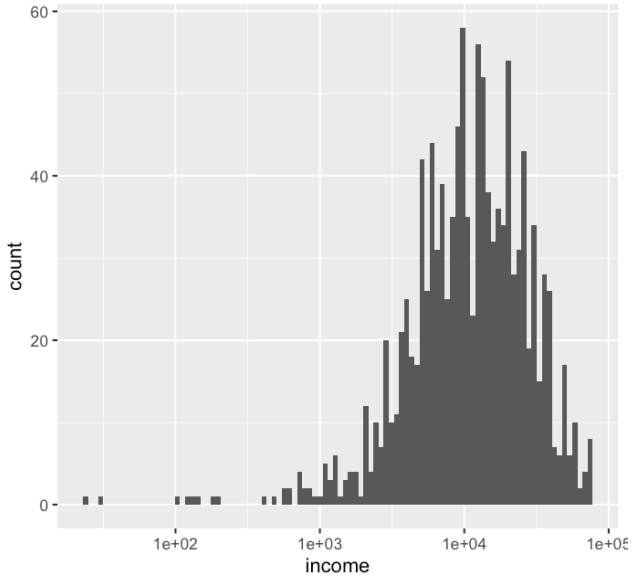


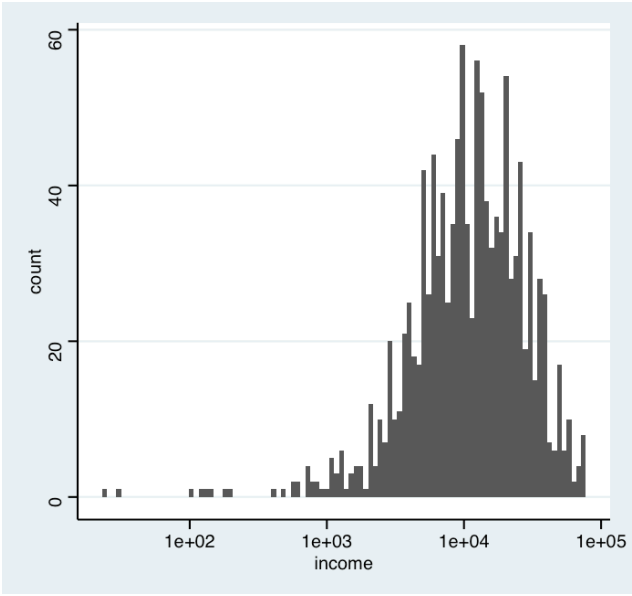
Exercises 4

1. When we're comparing distributions with very different numbers of observations, instead of scaling the y-axis like we did with the `facet_grid()` function, we might want to make density histograms. Use google to figure out how to make a density histogram of income. Facet it by region.
2. Make each of the regions in your histogram from part 1 a different color. (Hint: compare what `col =` and `fill =` do to histograms).
3. Instead of a log-transformed x-axis, make a square-root transformed x-axis.
4. Doing part 3 squishes the labels on the x-axis. Using the `breaks =` argument that all the `scale_x_()` functions have, make labels at 1000, 10000, 25000, and

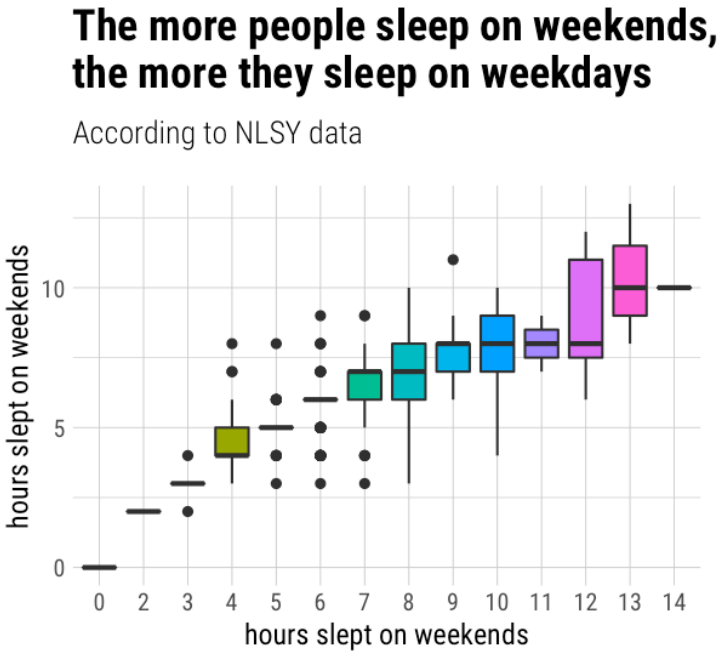
Finally, themes

You probably recognize the ggplot theme. But did you know you can trick people into thinking you made your figures in Stata?





```
ggplot(data = nlsy) +
  geom_boxplot(aes(x = factor(sleep_w
                   y = sleep_wkdy,
                   fill = factor(slee
  scale_fill_discrete(guide = FALSE)
  labs(x = "hours slept on weekends",
       y = "hours slept on weekends",
       title = "The more people sleep
the more they sleep on weekdays",
       subtitle = "According to NLSY
  louisahstuff::my_theme()
```



Here is a good list of themes and instructions to make your own: https://www.datanovia.com/en/blog/ggplot-themes-gallery/

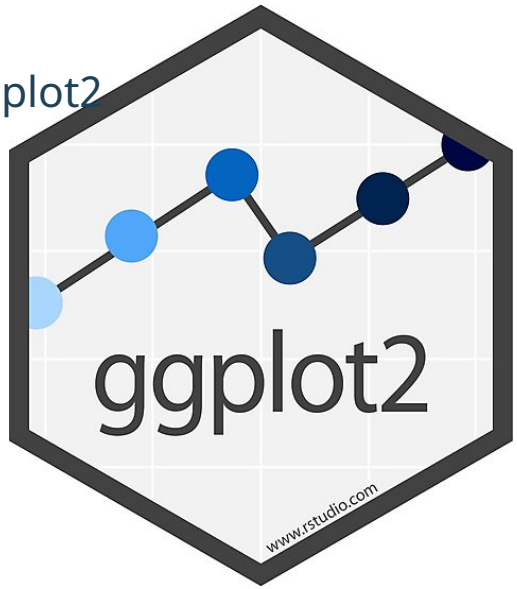
Finally, save it!

If your data changes, you can easily run the whole script again

```
library(tidyverse)
dataset <- read_csv("dataset.csv")
ggplot(dataset) +
  geom_point(aes(x = xvar, y = yvar))
ggsave(filename = "scatterplot.pdf")
```

More resources

- Cheat sheet: https://www.rstudio.com/resources/cheatsheets/#ggplot2
- Catalog: http://shiny.stat.ubc.ca/r-graph-catalog/
- Cookbook: http://www.cookbook-r.com/Graphs/
- Official package reference: https://ggplot2.tidyverse.org/index.html



Final challenge

Recreate this plot using the NLSY data!