Session 1: Introduction to R

Welcome!

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MMSS 211: Institutions, Rules, & Models in Social Science

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Goals

1. Become familiar with the "lay of the land" of R and R Studio.
2. Understand the basic data structures for statistical computing and how to translate this theory to practice in R.
3. Introduce techniques to organize code and to troubleshoot issues.

Overview of R Session Structure

- Before class, I will post, to Canvas, the following:
  - Slides (PDF)
  - Handout (PDF)
  - Code (R Script and R Markdown)
- *Slides* are these current slides in PDF format
- *Handouts* are the narration to the slides that provide more detail about each topic
- *Code* files are for you to use during class sessions. You can choose between the R Script or R Markdown format. Both contain the same information.

My Philosophy

- The best way to learn R is to apply what you learn to novel situations that interest you.
- Class will integrate lecture with hands on exercises that have a "choose your adventure" component so you can pick topics of interest to apply the code.
- Learning R is collaborative so section will be rather interactive in nature.

What is R?

R

```
R version 4.1.1 (2021-08-10) -- "Kick Things"
Copyright (C) 2021 The R Foundation for Statistical Computing
Platform: x86_64-apple-darwin17.0 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

  Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
```

R is...

- free software and comes with ABSOLUTELY NO WARRANTY.
- a collaborative project with many contributors.

Difference between R and R Studio

You need to write a paper for a class. There are many ways to do it.

- Microsoft Word
- Pages
- Google Docs

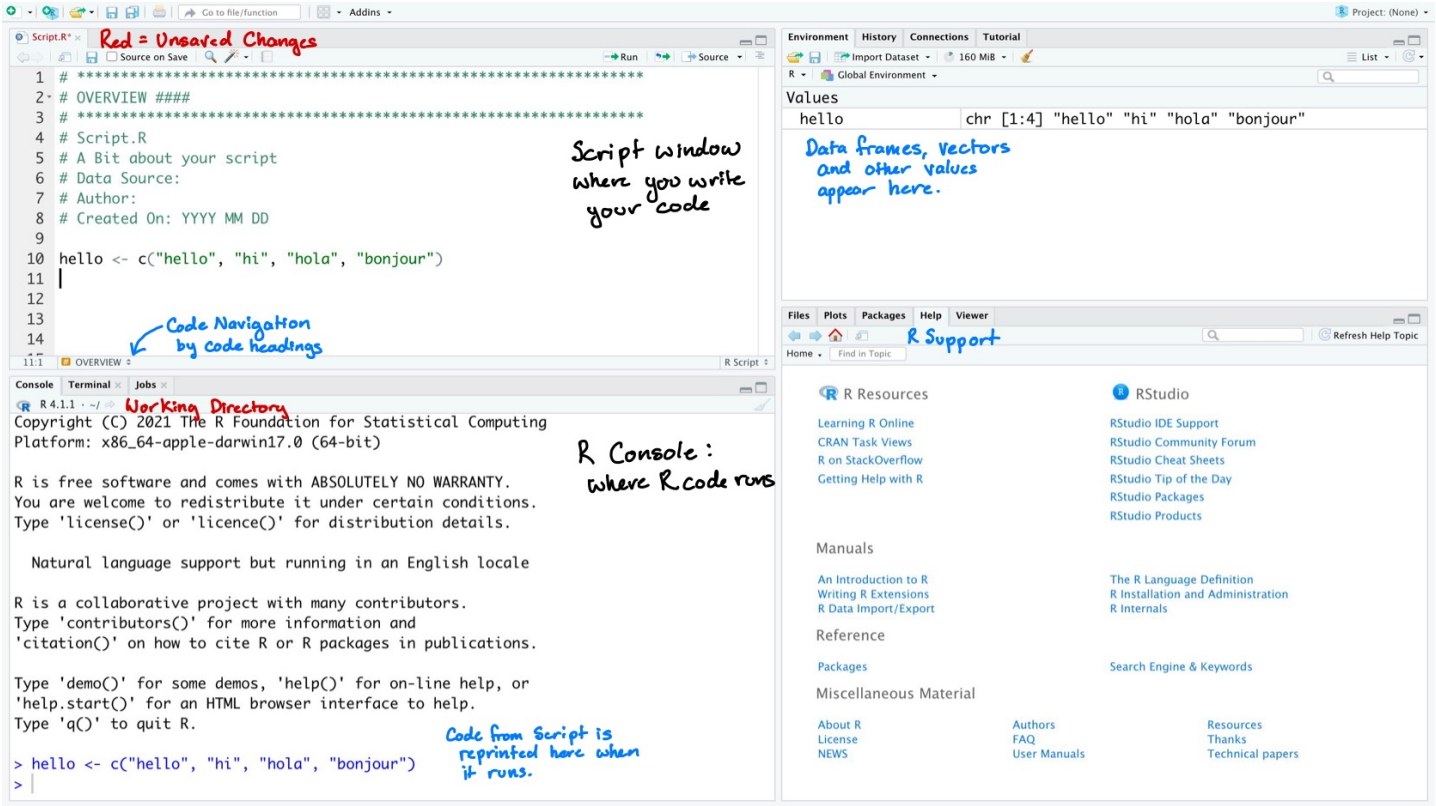
All access the same underlying software structure (your computer) to generate a document with words on virtual paper.

R and R Studio operate similarly

Difference between R and R Studio

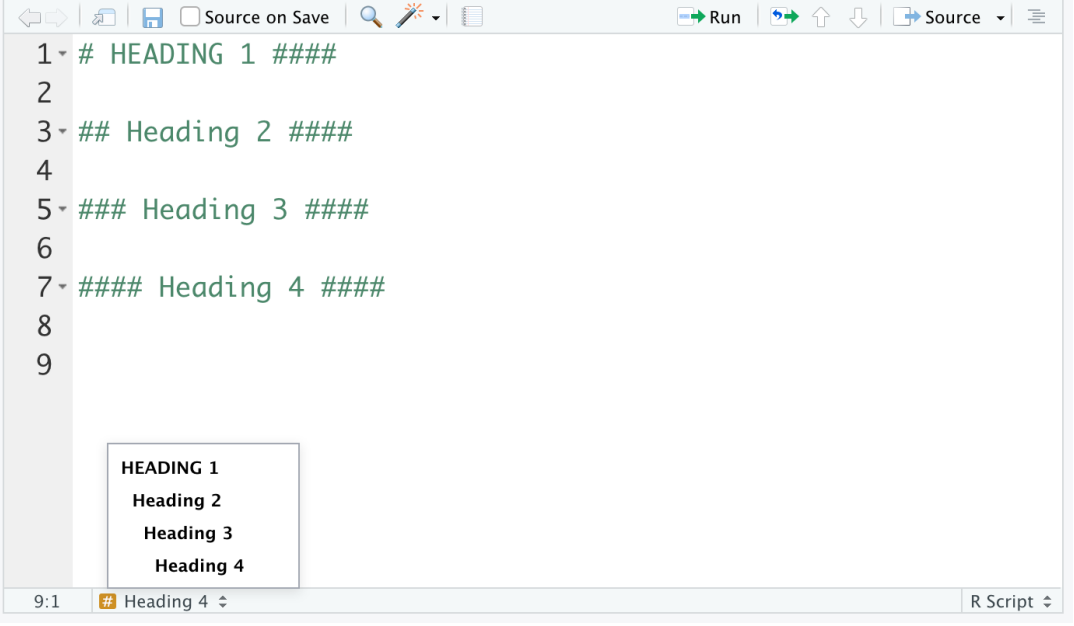
- R is the software for statistical computing
- R Studio is the means for you to do it -- it is the "Microsoft Word" interface for code writing
  - There are Pages/Google Docs equivalents for writing R code
  - But I do not recommend looking into these unless you are super comfortable in R Studio

Layout of R Studio



Using R Scripts

- Insert comments using a # sign -- Tells R to ignore the text that follows this
- Anything not preceded by a # will be treated as code
- Section R scripts using multiple #'s after the heading.



A Note About Writing Code

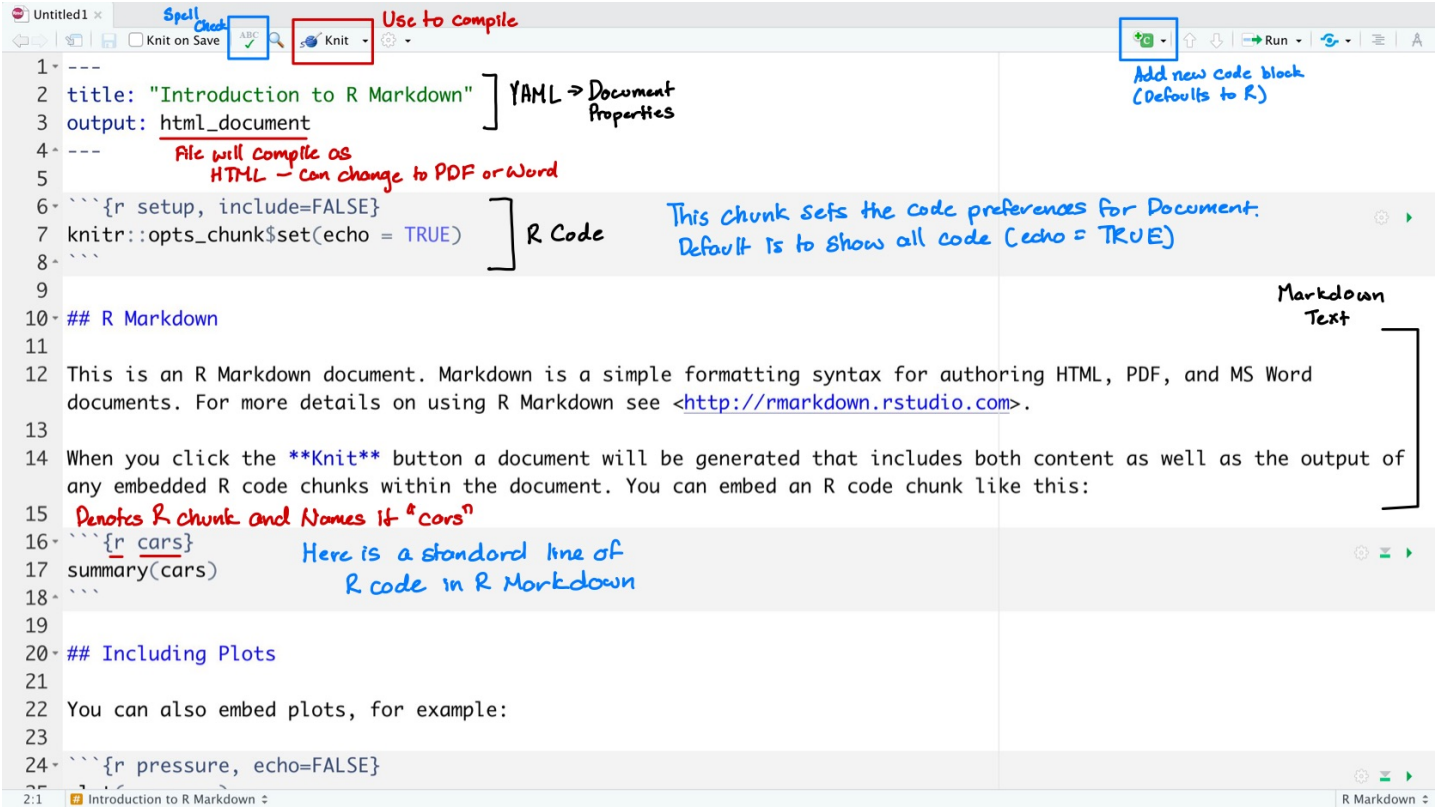
1. ALWAYS comment your code
2. Develop a taste for good code structure and adopt it for your code going forward

Good Code Structure Examples

- Proper indentation of code
- Limit the length of each line
- Create sections on your code

Your future self will thank you for a clean code script!

Introduction to Markdown



What is Markdown?

- Plain text -- text formats through markings rather than by clicking things on a toolbar
- Markup language -- Include markings next to text to denote what is bold, italic, and so on

Markdown Syntax

Headings

You can specify headings and subheadings in your document using the # before text that is meant to be a heading.

```
# Heading 1

## Heading 2

### Heading 3
```

Markdown Syntax

Bold, Italic, Code Text

You can **BOLD** text by inserting two asterisks before and after
`**text that should be bolded**`

You can *italicize* text by inserting one asterisk before and after
`*text that should be italicized*`

Markdown Syntax

Math Equations

We can also render math in markdown using LaTeX syntax. Inline math equations need to be enclosed in dollar signs such that $ax^2 + bx + c = 0$ is typed as `$ax^2 + bx + c = 0$` and

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

as

```
$$
x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
$$
```

Oh and back ticks give us verbatim text.

R Markdown

- Serves as a place to write R code and description text
- Can be rendered as a PDF, HTML or Word document (You will need LaTeX installed to do PDF compiles)
- Compiles with "Knit" button on top of screen -- Careful! This runs all of the code that you write each time!

R Markdown Code Chunks

- Runs R code like the R Scripts

```
```{r, warning=FALSE, message=FALSE}
library(dplyr)
library(ggplot2)
library(tidyr)
```
```

- Code must be in the grey chunks and can be shown or hidden
  - `echo = TRUE` shows and evaluates code
  - `eval = TRUE` evaluates code, FALSE does not
  - `include = TRUE` includes the code in the output
  - `warning = FALSE` suppresses warnings
  - `message = FALSE` suppresses messages

Programming in R

The Mindset

- R is an **object oriented programming language**. This means that
  - Objects are the core of R
  - Everything in R is an object
- What are Objects?
  - Functions
  - Data sets
  - Packages
  - Anything you can point an arrow to
- Assign objects with the `<-`, which is the *assignment arrow*

The Grammar of R

In English: `Verb(Noun, Adjective)`

In Colloquial terms: `Do Something(To What, How So)`

Formally, `function(data, arguments)`

Example:

```
data <- c(1, 2, 3, 4, 5, 6)

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

Packages and Libraries

Earlier, we discussed how `"R is a collaborative project with many contributors."`

What is a Package?

It is an app for your statistics needs

On Smartphone	In R
Download app	`install.packages("app_name")`
Open app	`library(app_name)`

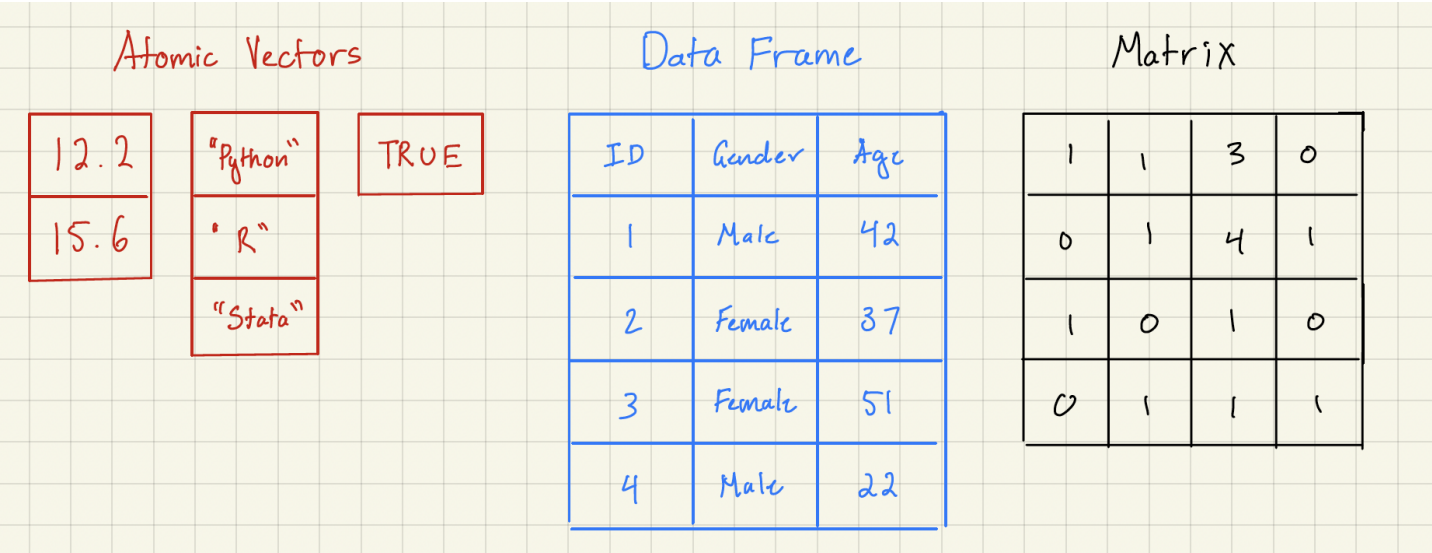
R's package library is the **Comprehensive R Archive Network (CRAN)**, which houses most packages.

Data Structures

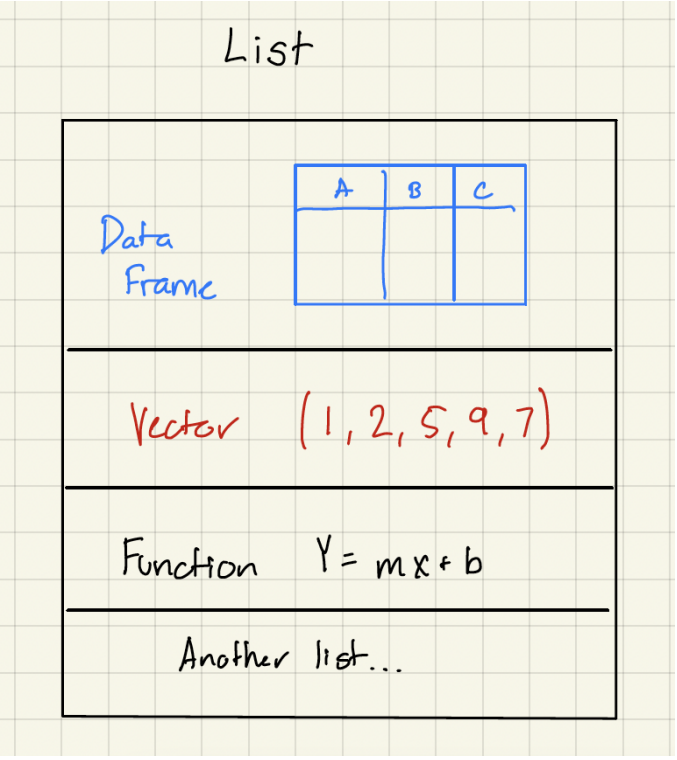
Types of Data

Type	Example
Character	`"dog", "cat", "fish"`
Double/Numeric	`-1, 2.8, 3, 4.5, 5, 6.4`
Integer	`1, 2, 3, -4, 5`
Logical	`TRUE, FALSE`
Complex	`1+4i`

Simple Data Formats



(A Bit More) Complex Data Formats



- Lists include all sorts of basic data structures
- They can be useful but also a hassle to work with

Vectors

Make a Vector

- Vectors are a collection of values that are tied to an index that starts with 1.
- The function `c()` (concatenate) makes vectors for you. Put all vector elements within `c()`
- Access index by appending `[]` to vector name

```
stats_programs <- c("Python", "R", "Stata", "SPSS", "SAS")

stats_programs[2]
```

```
## [1] "R"
```

Vectors

Extracting Values

```
fibonacci <- c(
  1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144)
```

- Let's get the first 10 numbers of the Fibonacci Sequence

```
fibonacci[1:10]
```

```
##  [1]  1  1  2  3  5  8 13 21 34 55
```

- Let's get the first, third, and tenth number in the Sequence

```
fibonacci[c(1, 3, 10)]
```

```
## [1]  1  2 55
```

Vectors

Editing Values

- Whatever math we do to the vector is applied to each element

```
fibonacci + 1
```

```
##  [1]   2   2   3   4   6   9  14  22  35  56  90 145
```

```
fibonacci * 4
```

```
##  [1]   4   4   8  12  20  32  52  84 136 220 356 576
```

Vectors

Editing Values

- You can edit a value using the index of a vector
- CAUTION: NEVER Write over the original data -- actions cannot be undone

```
new_fibonacci <- fibonacci
new_fibonacci[2] <- 100

fibonacci
```

```
##  [1]   1   1   2   3   5   8  13  21  34  55  89 144
```

```
new_fibonacci
```

```
##  [1]   1 100   2   3   5   8  13  21  34  55  89 144
```

Data Frames

Base R

```
state_abbv <- c("AL", "AK", "AZ", "AR", "CA")
state_fips <- c(1, 2, 4, 5, 6)
state_names <- c("Alabama", "Alaska", "Arizona", "Arkansas", "Cal
```

```
states <- data.frame(
  state_abbv,
  state_fips,
  state_names
)
```

Data Frames

Tidyverse

```
library(dplyr)

state_data <- tibble(
  state_abbv,
  state_fips,
  state_names
)
```

state_abbv	state_fips	state_names
AL	1	Alabama
AK	2	Alaska
AZ	4	Arizona
AR	5	Arkansas
CA	6	California

Data from packages

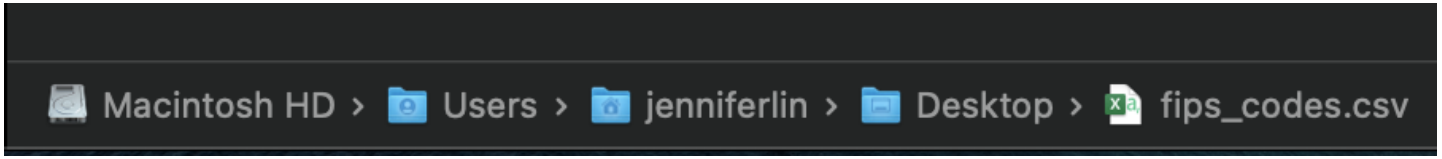
```r
library(tidycensus)

data(fips_codes)
```

state	state_code	state_name	county_code	county
AL	01	Alabama	001	Autauga County
AL	01	Alabama	003	Baldwin County
AL	01	Alabama	005	Barbour County
AL	01	Alabama	007	Bibb County
AL	01	Alabama	009	Blount County
AL	01	Alabama	011	Bullock County

Loading External Data

A Note on File Paths

- File paths are a string containing folder names and end with the name of the particular file of interest.
- You can find them in your documents folder.



- Being able to locate your file path is important for locating files
- If you put an R script and a data file in the same folder and open R from that script, you should be able to skip this step. Otherwise, you need to tell R where your data file is.

Loading External Data

Reading Different File Types -- CSV

```
fips_csv <- read.csv("fips_codes.csv")
```

X	state	state_code	state_name	county_code	county
1	AL	1	Alabama	1	Autauga County
2	AL	1	Alabama	3	Baldwin County
3	AL	1	Alabama	5	Barbour County
4	AL	1	Alabama	7	Bibb County
5	AL	1	Alabama	9	Blount County
6	AL	1	Alabama	11	Bullock County

Loading External Data

Reading Different File Types -- CSV (`readr`)

```
library(readr)
fips_csv <- read_csv("fips_codes.csv")
```

...1	state	state_code	state_name	county_code	county
1	AL	01	Alabama	001	Autauga County
2	AL	01	Alabama	003	Baldwin County
3	AL	01	Alabama	005	Barbour County
4	AL	01	Alabama	007	Bibb County
5	AL	01	Alabama	009	Blount County
6	AL	01	Alabama	011	Bullock County

Loading External Data

Reading Different File Types -- R Data

```
load("fips_codes.RData")
```

state	state_code	state_name	county_code	county
AL	01	Alabama	001	Autauga County
AL	01	Alabama	003	Baldwin County
AL	01	Alabama	005	Barbour County
AL	01	Alabama	007	Bibb County
AL	01	Alabama	009	Blount County
AL	01	Alabama	011	Bullock County

Loading External Data

Reading Different File Types -- JSON

```
library(rjson)

fips_json <- fromJSON(file = "fips_codes.json") %>%
  as.data.frame()
```

state	state_code	state_name	county_code	county
AL	01	Alabama	001	Autauga County
AL	01	Alabama	003	Baldwin County
AL	01	Alabama	005	Barbour County
AL	01	Alabama	007	Bibb County
AL	01	Alabama	009	Blount County
AL	01	Alabama	011	Bullock County

Loading External Data

Reading Different File Types -- Stata

```r
library(haven)

fips_stata <- read_dta("fips_codes.dta")
```

state	state_code	state_name	county_code	county
AL	01	Alabama	001	Autauga County
AL	01	Alabama	003	Baldwin County
AL	01	Alabama	005	Barbour County
AL	01	Alabama	007	Bibb County
AL	01	Alabama	009	Blount County
AL	01	Alabama	011	Bullock County

Accessing Variables

- You can access variables in a data frame using the $
- $ means "at"

```
fips_codes[1:3,1:5]
```

```
##   state state_code state_name county_code
## 1    AL         01    Alabama         001
## 2    AL         01    Alabama         003
## 3    AL         01    Alabama         005
##           county
## 1 Autauga County
## 2 Baldwin County
## 3 Barbour County
```

```
head(fips_codes$county)
```

```
## [1] "Autauga County" "Baldwin County" "Barbour County"
## [4] "Bibb County"    "Blount County"  "Bullock County"
```

Troubleshooting R Code

Step 1: Check Your Code

Check your code for

- Typos in object references or function names
- Missing open or close parentheses
- Missing `+` or `%>%`
- Upper or lower case -- R is case sensitive!

Step 2: Look at the R Help Page

Use `?package::function()` to load the R help page

Read the argument descriptions and examples

Step 3: Google!

1. Draw (on paper) your desired end result and find words around that
2. Use these words to craft a Google search
3. See what Stack Overflow has to say
4. If nothing useful comes up, take advantage of related searches

Step 4: Schedule a Meeting with Me

I am always happy to help!

Email me at jenniferlin2025@u.northwestern.edu with questions.