

INTRODUCTION TO DATA ANALYSIS IN R - DAY 1

Randi L. Garcia, PhD

DATIC Introduction to R Workshop

Session 1: June 7th and 8th

Session 2: June 21st and 22nd



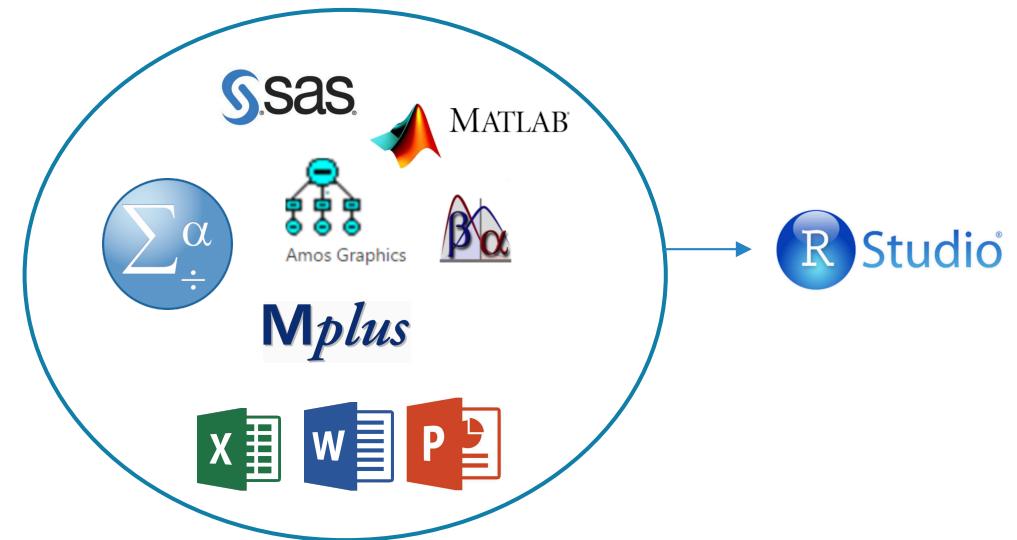
Introductions

- Me
 - Randi L. Garcia
 - Assistant Professor in Psychology and Statistical & Data Sciences at Smith College
 - Research interests
 - Data analysis software experiences
- You...
 - Who are you, where are you coming from?
 - What brings you here? What do you hope to get out of this workshop?



Why Learn to use R?

- Many of the reasons you mentioned...
 - High cost of SPSS, especially for students
 - Reproducibility
- My personal reasons:
 - It can do everything in one program
 - The R programming language versus SPSS syntax
 - Ability to create fully reproducible results, including automating results in manuscripts
 - Many teaching reasons



Schedule

DAY 1

- RStudio environment, packages, and R Markdown
- Making figures
- Data cleaning
- Descriptive stats, correlations, reliability, creating scale scores

DAY 2

- T-test, ANOVA, and regression
- Preparing APA style manuscripts
- Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA)
- Path Analysis and Structural Equation Modeling (SEM)

DAY 1

- RStudio environment, packages, and R Markdown
- Making figures
- Data cleaning
- Descriptive stats, correlations, reliability, creating scale scores

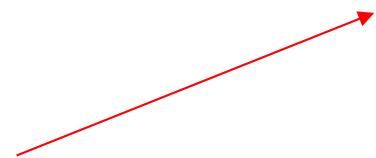
R and RStudio



The screenshot shows the R Console window with the following text:

```
R version 3.4.3 (2017-11-30) -- "Kite-Eating Tree"  
Copyright (C) 2017 The R Foundation for Statistical Computing  
Platform: x86_64-apple-darwin15.6.0 (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.app GUI 1.70 (7463) x86_64-apple-darwin15.6.0]  
  
[Workspace restored from /Users/rgarcia/.RData]  
[History restored from /Users/rgarcia/.Rapp.history]  
  
> |
```

R and RStudio



The screenshot shows the RStudio interface with the following components:

- Code Editor:** Displays an R Markdown file named "My Analysis.Rmd". The code includes a title block, a reliability test section, and a call to the `alpha` function.
- Console:** Shows the output of the `alpha` function call, displaying reliability statistics for the selected items.
- Environment:** Shows the `bfi` dataset in the Global Environment, which contains 2800 observations and 28 variables.
- Help:** The `bfi` dataset is highlighted in the Help pane, showing its documentation. It describes 25 personality items representing 5 factors, with details on usage, format, and a data frame structure.

```
1 ---  
2 title: "My Analysis"  
3 author: "Randi L. Garcia"  
4 ---  
5  
6 # Reliability Test  
7  
8 This how to compute Cronbach's alpha for the agreeableness items.  
9  
10 `r`  
11 library(dplyr)  
12 library(psych)  
13  
14 alpha(select(bfi, A2:A5))  
15  
  
Reliability analysis  
Call: alpha(x = select(bfi, A2:A5))  
  
 raw_alpha std.alpha G6(smc) average_r S/N    ase mean     sd  
      0.72      0.73      0.67      0.4 2.6 0.0087  4.7 0.96
```

Help Documentation for bfi (psych)

25 Personality items representing 5 factors

Description

25 personality self report items taken from the International Personality Item Pool (ipip.ori.org) were included as part of the Synthetic Aperture Personality Assessment (SAPA) web based personality assessment project. The data from 2800 subjects are included here as a demonstration set for scale construction, factor analysis, and item Response Theory analysis. Three additional demographic variables (sex, education, and age) are also included.

Usage

```
data(bfi)
data(bfi.dictionary)
```

Format

A data frame with 2800 observations on the following 28 variables. (The q numbers are the SAPA item numbers).

A1
Am indifferent to the feelings of others. (q_146)

A2
Inquire about others' well-being. (q_1162)

OPEN R STUDIO

Let's Use R Studio!

➤ Bookmark this website:

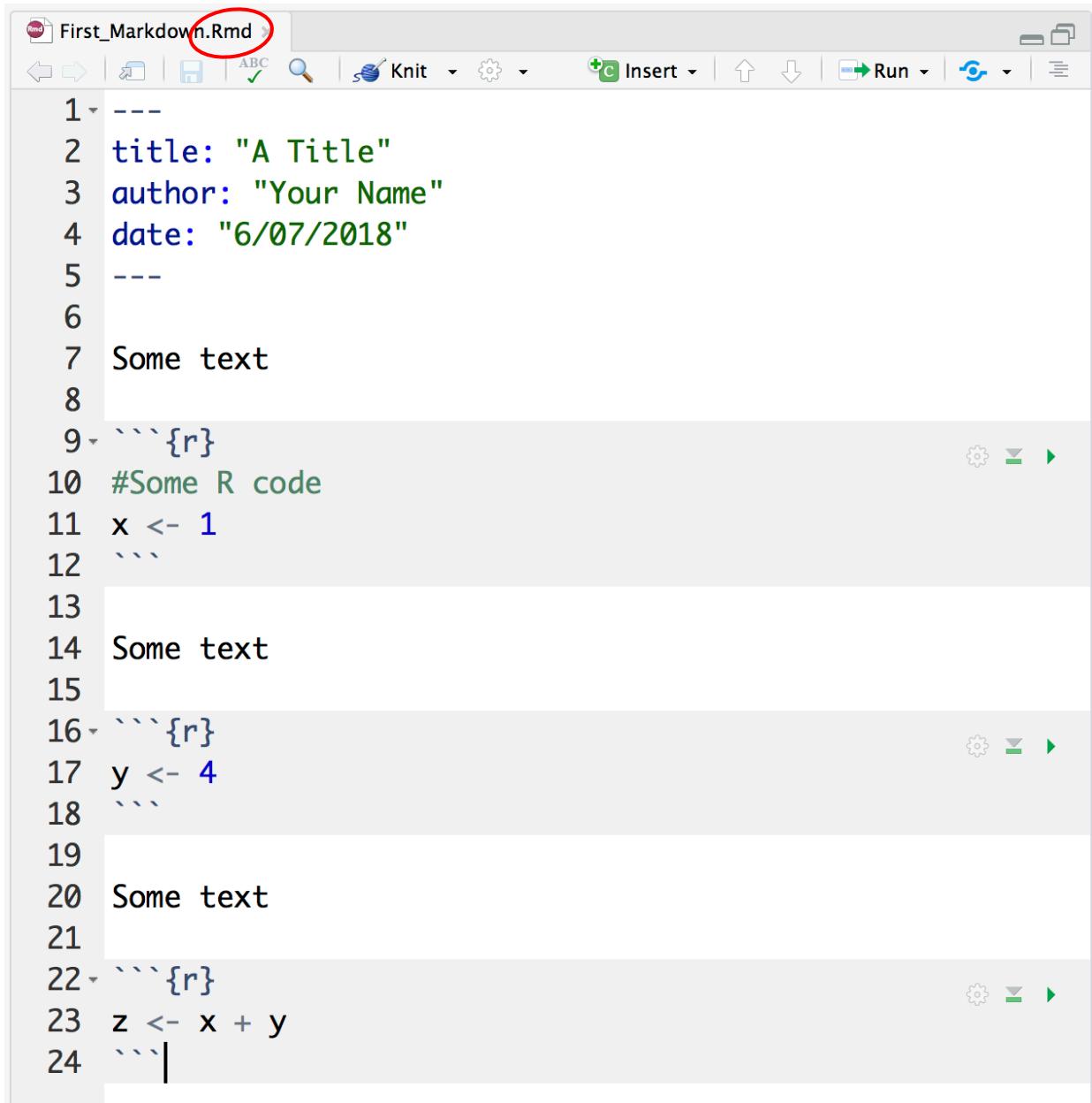
bit.ly/intro-r-website

➤ Download ALL materials, including R-code, here:

bit.ly/intro-r-materials

R Markdown is where your analyses live!

- A file of type ".Rmd"

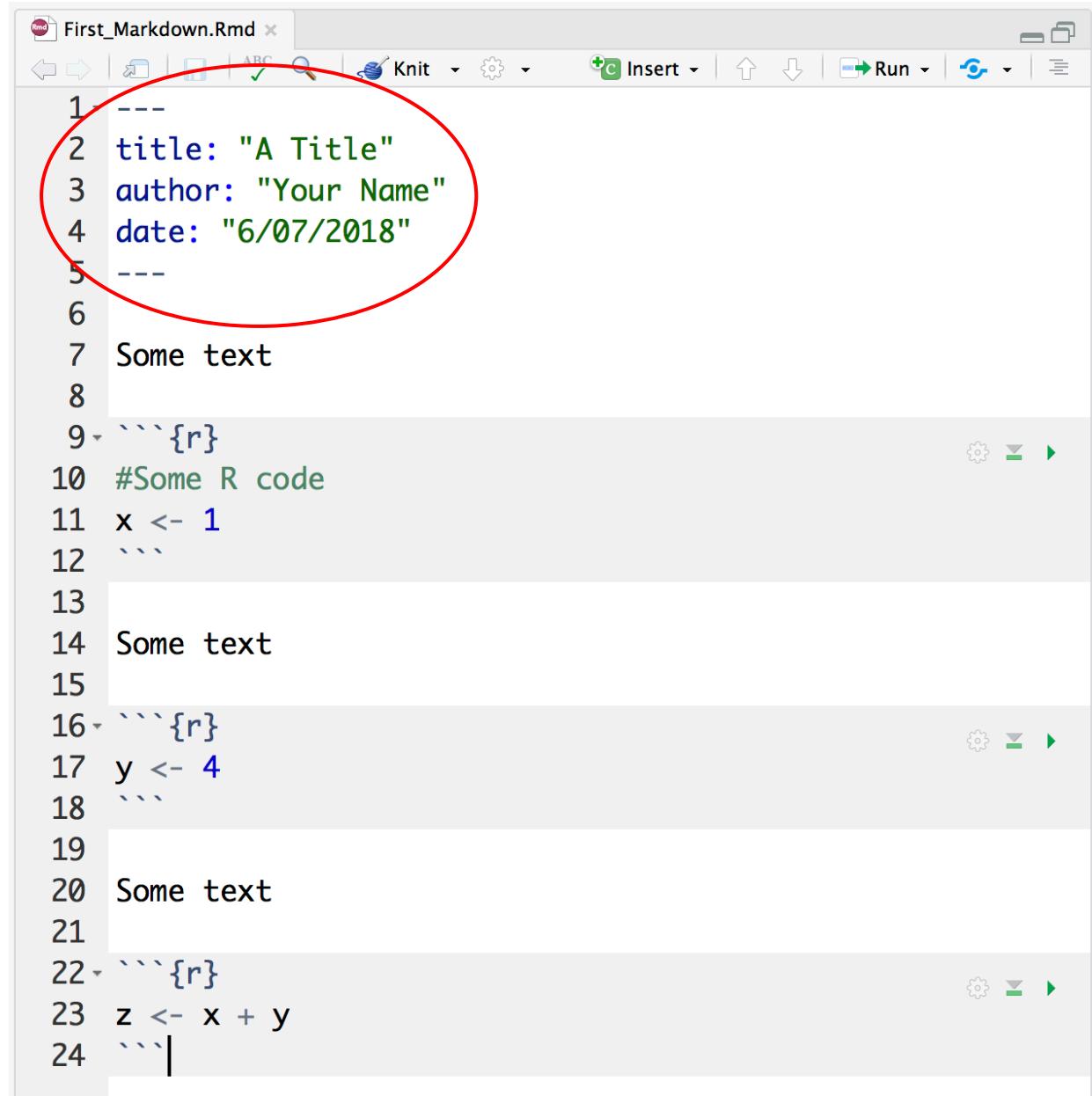


The screenshot shows the RStudio interface with the title bar "First_Markdown.Rmd" circled in red. The main pane displays the following R Markdown code:

```
1 ---  
2 title: "A Title"  
3 author: "Your Name"  
4 date: "6/07/2018"  
5 ---  
6  
7 Some text  
8  
9 `r`  
10 #Some R code  
11 x <- 1  
12 `r`  
13  
14 Some text  
15  
16 `r`  
17 y <- 4  
18 `r`  
19  
20 Some text  
21  
22 `r`  
23 z <- x + y  
24 `r`
```

R Markdown is where your analyses live!

- A file of type “.Rmd”
- Starts with some basic information in the “YAML header”



```
1 ---  
2 title: "A Title"  
3 author: "Your Name"  
4 date: "6/07/2018"  
5 ---  
6  
7 Some text  
8  
9 `r`  
10 #Some R code  
11 x <- 1  
12 `r`  
13  
14 Some text  
15  
16 `r`  
17 y <- 4  
18 `r`  
19  
20 Some text  
21  
22 `r`  
23 z <- x + y  
24 `r`
```

R Markdown is where your analyses live!

- A file of type “.Rmd”
- Starts with some basic information in the “YAML header”
- A series of text and “code chunks”:



- We will need to install some stuff...

Anatomy of a Code Chunk

"Bookends" to signify code is starting and ending

Giving your chunk a name helps find it later

```
50 Write some text, any text, outside of the chunk.  
51  
52 `r t-test}  
53 #Comment your code inside of the chunk  
54 t.test(y ~ x, data = MyDatasetName)  
55 ...  
56
```

The R code goes between the bookends

Chunk options (more on that later)

Run all of the code in this chunk

Run all of code in the chunks above

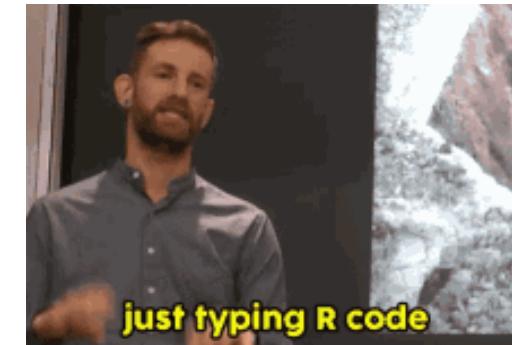
R STUDIO



[Intro_to_R.Rmd](#)
[packages_descriptive_stats.Rmd](#)

Which R?

- There are >10,000 packages in R
- This can feel overwhelming for new users
 - To make matters worse, “R people” are opinionated about which packages are “best”
 - There is NO consensus! Eventually you’ll be able to decide for yourself, for now, I’ll decide for you...
- We are going to learn *some* of the **tidyverse** packages in this workshop
 - Hadley Wickham





Making Figures with ggplot2

- As with everything else, there are lots of ways to make figures in R
 - Base R
 - Lattice graphics
 - The `ggplot2` package
- We'll be learning the `ggplot2` package.
 - It makes beautiful visualizations
 - It's popular so there is a lot of help on the internet and companion packages
 - It works well with all of the `tidyverse` packages

```
```{r}  
library(ggplot2)
```
```



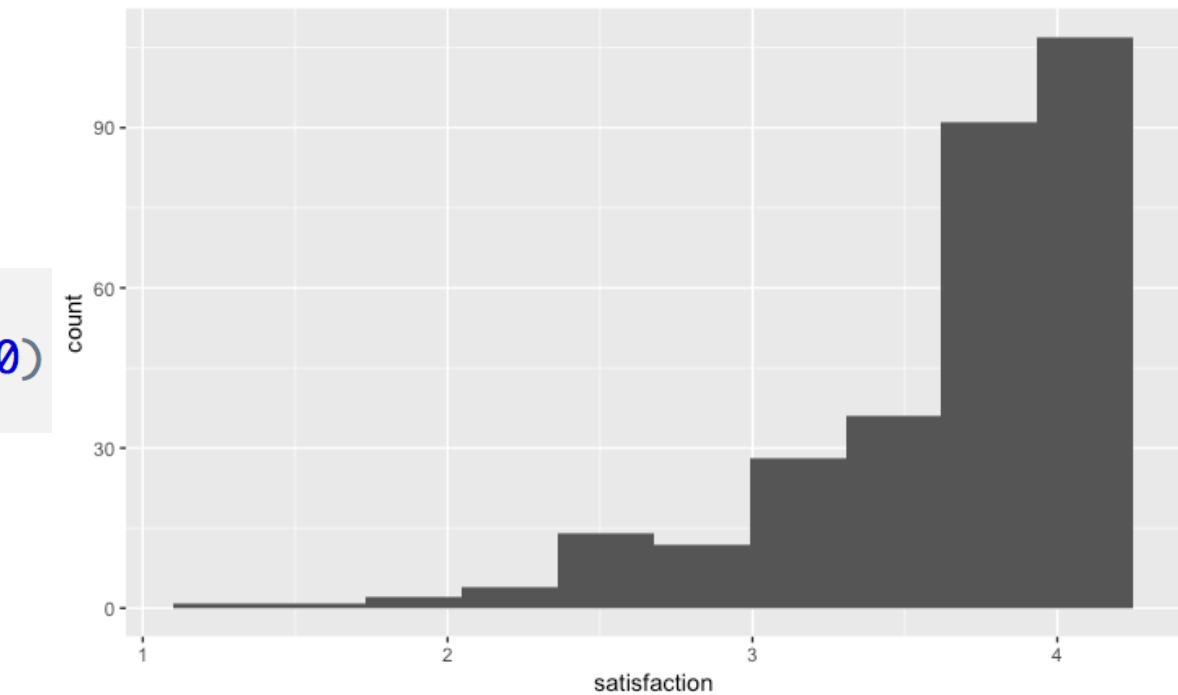
Making Figures with ggplot2

- The easiest figures are made with the `qplot()` function
 - The q stands for quick!

Guesses which kind of figure you want based on the variable(s) type

```
```{r}  
qplot(satisfaction, data = acitelli, bins = 10)
```
```

It needs to know the data, but no dollar signs!

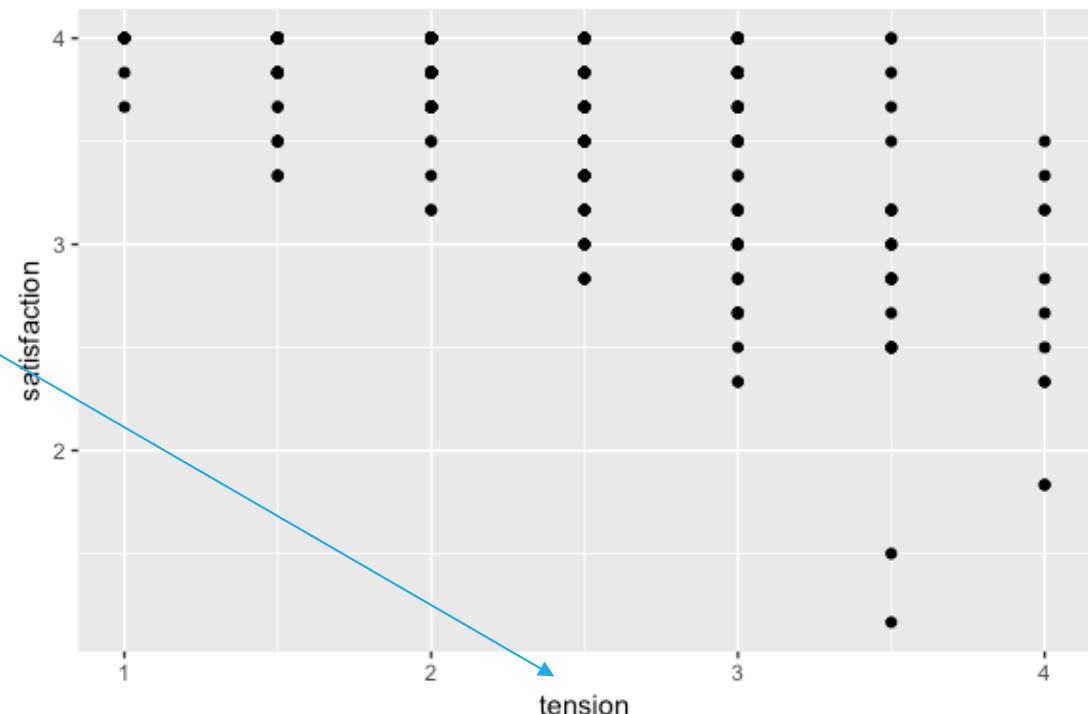




Making Figures with ggplot2

```
```{r}  
qplot(x = tension, y = satisfaction, data = acitelli)
```
```

- qplot: “Two numerical variables? Oh, you probably want a scatter plot...”





Making Figures with ggplot2

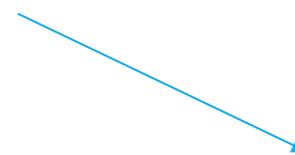
- The `qplot()` function is good for quick visualizations
 - Good for probably 80% of what you'd want to do while analyzing data
- But, you'll use the `ggplot()` function for anything more involved, like for making figures for publication
- The `ggplot2` package uses the “grammar of graphics”



Making Figures with ggplot2

- We independently specify pieces of the graph using the “grammar of graphics”
- Building blocks:
 - **Data**
 - **Geometric objects** (the actual things we'll draw: points, lines, boxplot, histograms, etc.)
 - **Aesthetic mappings** (what and where we'll draw: x-axis, y-axis, color, fill, shape, size, linetype, etc.)
 - **Statistics** (implied or specified computing to be done)
 - **Scales** (range of values, colors, or shapes)
 - **Facets** (the panes—there can be more than 1)
 - **Guides** (legends—what the humans see)

```
```{r}  
ggplot()
```
```

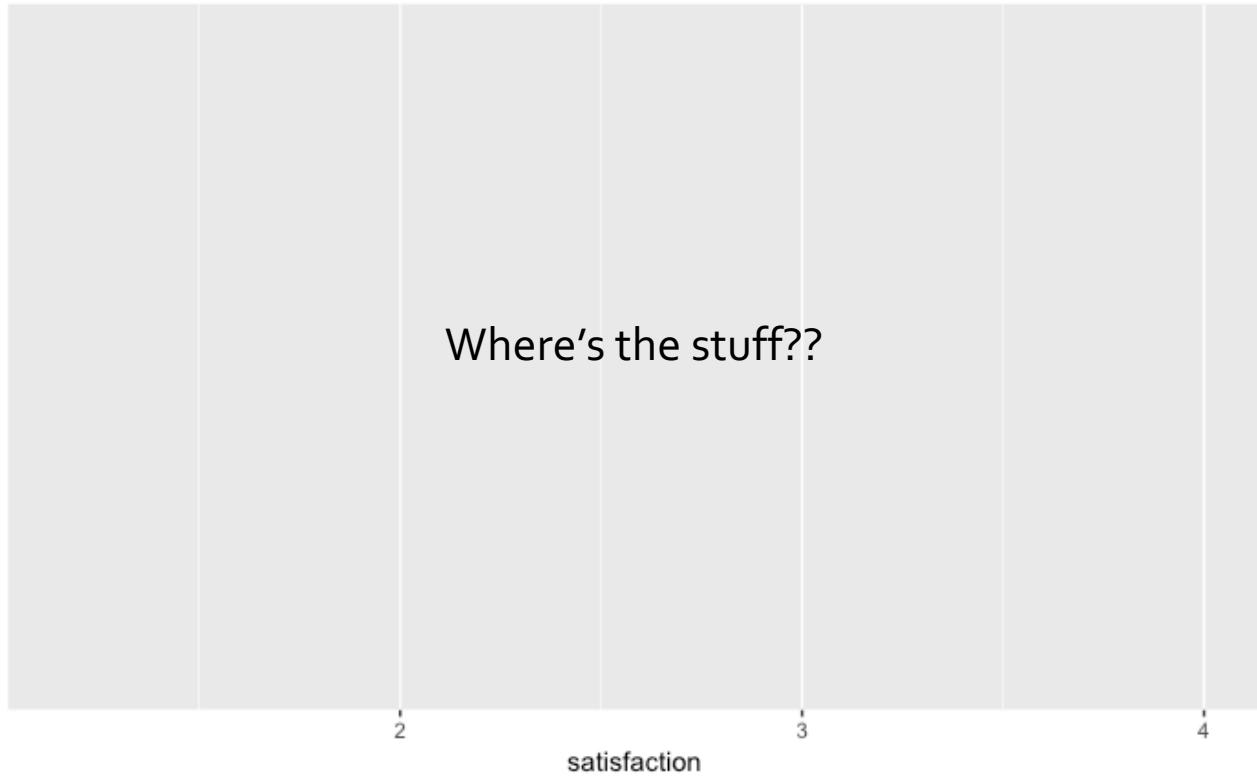




```
```{r}  
ggplot(acitelli, aes(x = satisfaction))
```
```

The data comes first

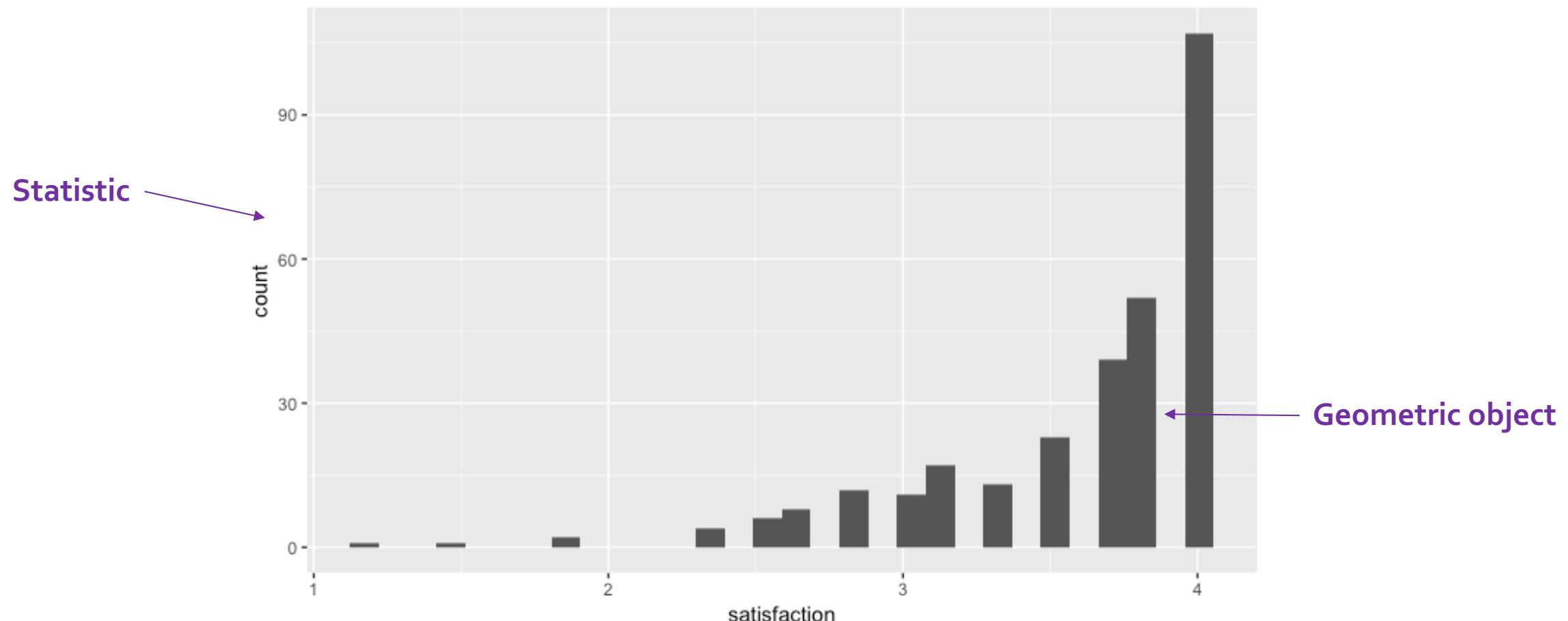
Specify “aesthetic mappings”
with the `aes()` function



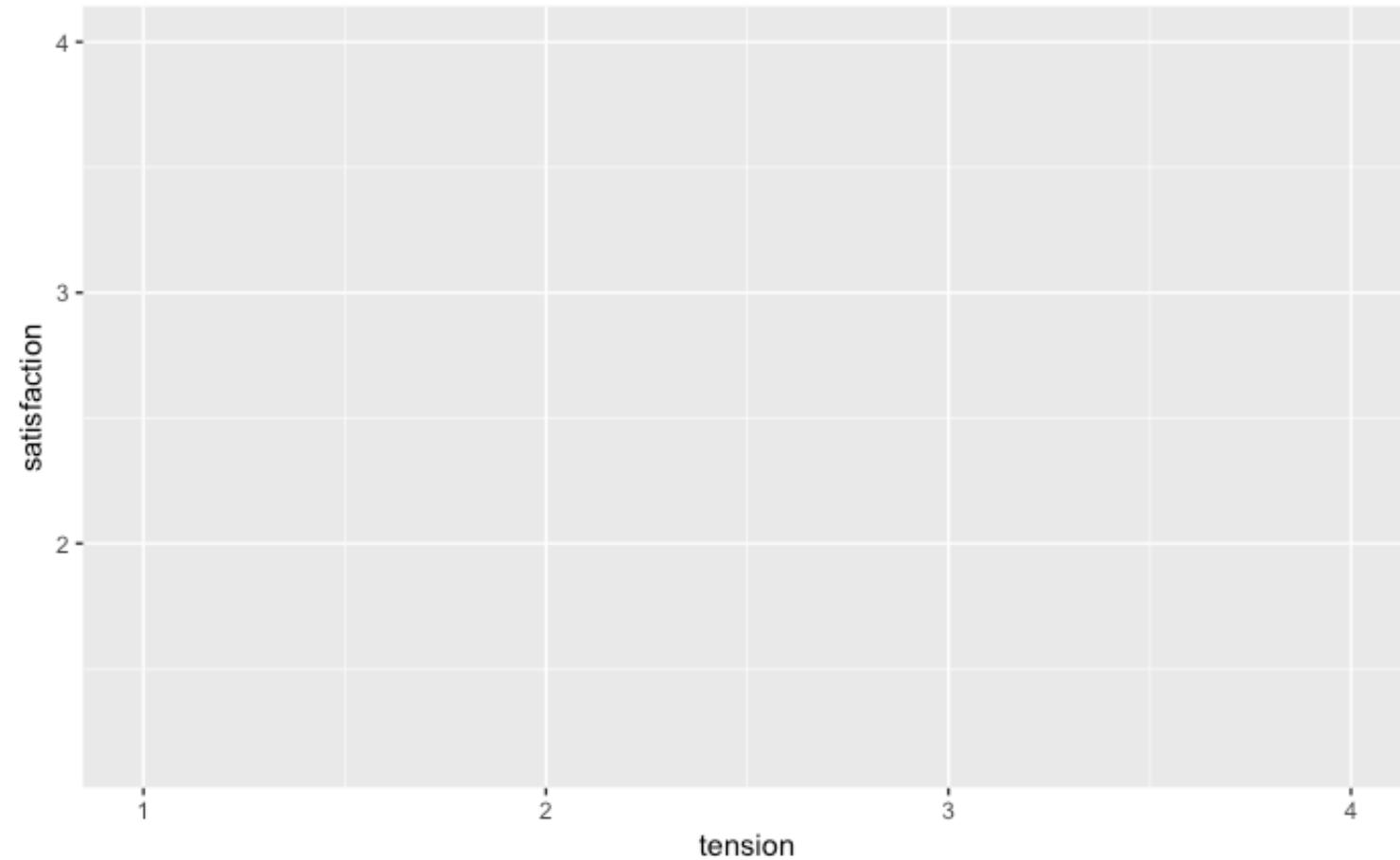
```
```{r}  
ggplot(acitelli, aes(x = satisfaction)) +
 geom_histogram()
```
```



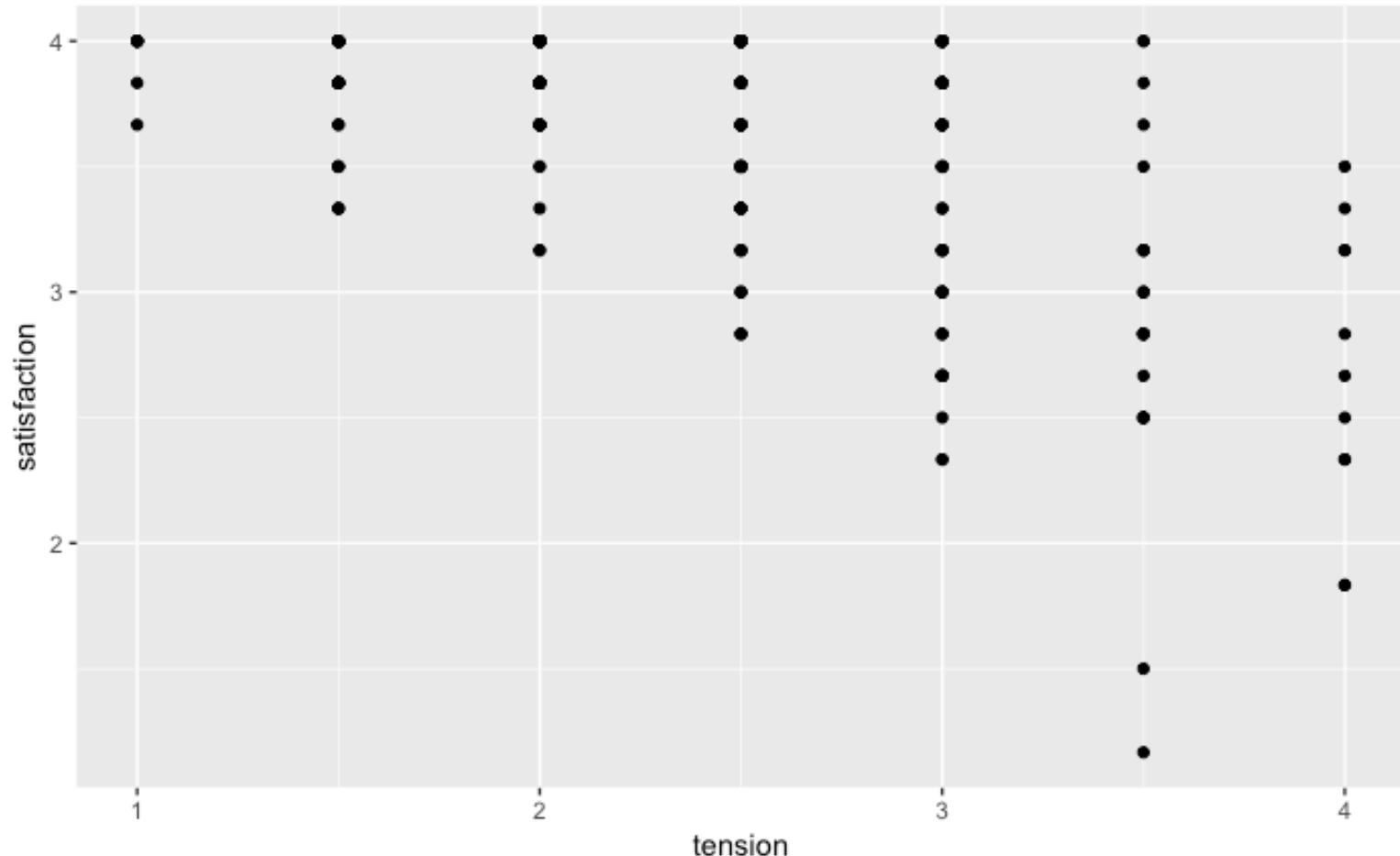
Gotta add some geom's



```
```{r}
ggplot(acitelli, aes(x = tension, y = satisfaction))
```
```



```
```{r}
ggplot(acitelli, aes(x = tension, y = satisfaction)) +
 geom_point()
```
```

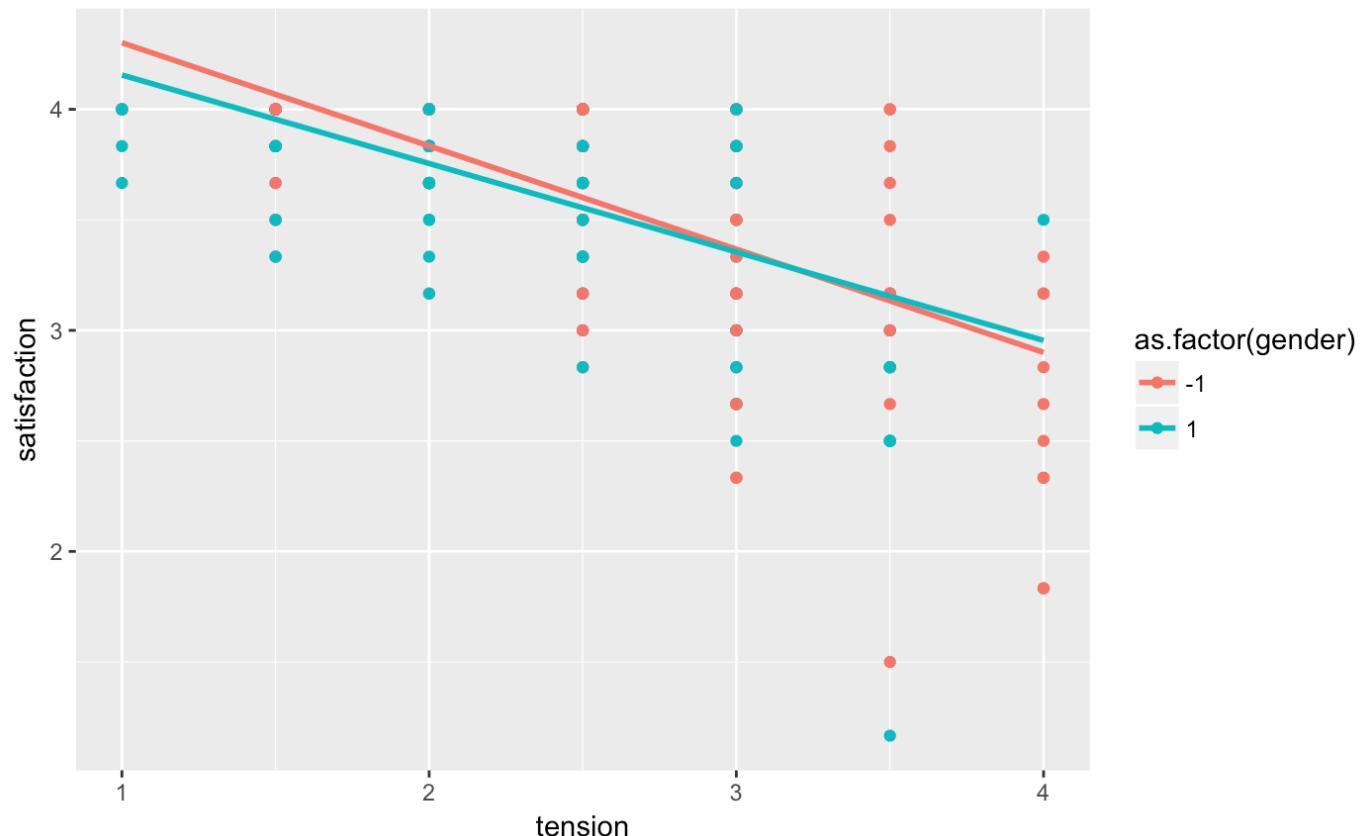




```
```{r}
ggplot(acitelli, aes(x = tension,
 y = satisfaction,
 color = as.factor(gender))) +
 geom_point() +
 geom_smooth(method = "lm", se = 0)
```
```

Layer on those geoms!

Map to color!



- What do you think would happen if we mapped color to self_pos, a numerical variable?

R MARKDOWN

Intro_to_ggplot2.Rmd



Data Cleaning

- The package we'll use for data cleaning is called **dplyr**, which is part of the **tidyverse**, also written by Hadley Wickham
- Find all the cheatsheets here: <https://www.rstudio.com/resources/cheatsheets/>

Data Transformation with dplyr :: CHEAT SHEET

dplyr functions work with pipes and expect **tidy data**. In tidy data:

Each variable is in its own column & Each observation, or case, is in its own row becomes `f(x, y)`

Summarise Cases

These apply **summary** functions to columns to create a new table of summary statistics. Summary functions take vectors as input and return one value (see back).

summary function →

- `summarise(data, ...)` Compute table of summaries. `summarise(mtcars, avg = mean(mpg))`
- `count(x, ..., wt = NULL, sort = FALSE)` Count number of rows in each group defined by the variables in ... Also `tally()`. `count(iris, Species)`

VARIATIONS

→

Manipulate Cases

EXTRACT CASES

Row functions return a subset of rows as a new table.

- `filter(data, ...)` Extract rows that meet logical criteria. `filter(iris, Sepal.Length > 7)`
- `distinct(data, ..., keep_all = FALSE)` Remove rows with duplicate values. `distinct(iris, Species)`
- `sample_frac(tbl, size = 1, replace = FALSE, weight = NULL, .env = parent.frame())` Randomly select fraction of rows. `sample_frac(iris, 0.5, replace = TRUE)`
- `sample_n(tbl, size, replace = FALSE, weight = NULL, .env = parent.frame())` Randomly select size rows. `sample_n(iris, 10, replace = TRUE)`
- `slice(data, ...)` Select rows by position. `slice(iris, 10:15)`
- `top_n(x, n, wt)` Select and order top n entries (by group if grouped data). `top_n(iris, 5, Sepal.Width)`

Manipulate Variables

EXTRACT VARIABLES

Column functions return a set of columns as a new vector or table.

- `pull(data, var = -1)` Extract column values as a vector. Choose by name or index. `pull(iris, Sepal.Length)`
- `select(data, ...)` Extract columns as a table. Also `select_if()`. `select(iris, Sepal.Length, Species)`

Use these helpers with `select()`,
e.g. `select(iris, starts_with("Sepal"))`

| | |
|-------------------------------|---|
| <code>contains(match)</code> | <code>num_range(prefix, range)</code> ; e.g. <code>mpg:cyl</code> |
| <code>ends_with(match)</code> | <code>one_of(...)</code> ; e.g. <code>-Species</code> |
| <code>matches(match)</code> | <code>starts_with(match)</code> |

MAKE NEW VARIABLES

These apply **vectorized functions** to columns. Vectorized funs take vectors as input and return vectors of the same length as output (see back).

vectorized function →



Data Cleaning

- The five data verbs
 - `filter()`
 - `mutate()`
 - `arrange()`
 - `select()`
 - `summarize()`
- And also...
 - `group_by()`
 - `rename()`
 - `full_join()`,
`right_join()`,
`left_join()`,
`inner_join()`
 - `gather()`
 - `spread()`



Data Cleaning

- Each verb performs familiar operations on a dataset
 - Each function takes a dataset and returns a dataset

| Verb | What it does | ...in SPSS |
|-------------|--|---------------------------------|
| mutate() | Creates new variables | COMPUTE (or transform in menu) |
| filter() | Filters for specific cases | FILTER (or select data in menu) |
| arrange() | Sorts using some logic | SORT |
| select() | Subsets for only certain variables | DROP |
| summarize() | Create a summary table | Descriptive statistics |
| group_by() | Groups dataset by a categorical variable | Like split file in menu |

Data Cleaning



- We will use the pipe operator to combine verbs!

%>%



Data Cleaning



```
```{r}
function(dataset, args)
```
```

...is the same as:

```
```{r}
dataset %>% function(args)
```
```

Data Cleaning



```
```{r}
filter(dataset, age >= 18)
```
```

...is the same as:

```
```{r}
dataset %>% filter(age >= 18)
```
```



Data Cleaning

- Why the pipe!?!?
- Let's say we want to
 1. Create a scale score, a depression index (bdi), then
 2. Filter for only people 18 or older, then finally
 3. Keep only a smaller dataset with just bdi and say, social support

```
mutate(dataset, bdi = bdi1 + bdi2 + bdi3)
```



Data Cleaning

- Why the pipe!?!?
- Let's say we want to
 1. Create a scale score, a depression index (bdi), then
 2. Filter for only people 18 or older, then finally
 3. Keep only a smaller dataset with just bdi and say, social support

```
filter(mutate(dataset, bdi = bdi1 + bdi2 + bdi3), age >= 18)
```



Data Cleaning

- Why the pipe!?!?
- Let's say we want to
 1. Create a scale score, a depression index (bdi), then
 2. Filter for only people 18 or older, then finally
 3. Keep only a smaller dataset with just bdi and say, social support

```
select(filter(mutate(dataset, bdi = bdi1 + bdi2 + bdi3), age >= 18) bdi, soc_sprt)
```



Data Cleaning

- Instead of reading/writing:

```
```{r}
select(filter(mutate(dataset, bdi = bdi1 + bdi2 + bdi3), age >= 18) bdi, soc_sprt)
```
```

- We can write:

```
```{r}
dataset %>%
 mutate(bdi = bdi1 + bdi2 + bdi3) %>%
 filter(age >= 18) %>%
 select(bdi, soc_sprt)
```
```



Data Cleaning

- Save to a new object:

```
```{r}
dataset_small <- dataset %>%
 mutate(bdi = bdi1 + bdi2 + bdi3) %>%
 filter(age >= 18) %>%
 select(bdi, soc_sppt)
...````
```

- Or the same object

```
```{r}
dataset <- dataset %>%
  mutate(bdi = bdi1 + bdi2 + bdi3) %>%
  filter(age >= 18) %>%
  select(bdi, soc_sppt)
...````
```

Little Bunny Foo Foo

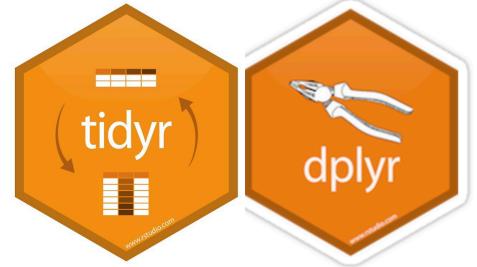
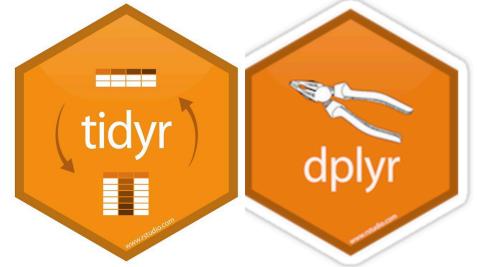
```
bop(scoop(hop(foo_foo, through = forest), up = field_mice), on = head)
```

```
foo_foo %>%
  hop(through = forest) %>%
  scoop(up = field_mouse) %>%
  bop(on = head)
```



"Little Bunny Foo Foo,
I don't want to see you"

More Data Cleaning (Day 2)



- There are also verbs for **joining two tables** (in `dplyr`)
 - Adding cases from another dataset
 - `bind_rows()`
 - Adding variables from another dataset
 - `inner_join()`, `right_join()`,
`left_join()`, `full_join()`
 - `bind_cols()`
 - And verbs for **transforming data** from (in `tidyr` package)
 - Wide-to-long
 - `gather()`
 - Long-to-wide
 - `spread()`

R MARKDOWN FILE

intro_to_dplyr.Rmd



Categorical Variables

- Some stuff you'll need from the `forcats` package:

`fct_recode()`

`fct_collapse()`

- Categorical variables are called factors in R. The package name, `forcats` is an anagram for factors!
- There's tons of other stuff you can do with factors using this package—read the R for Data Science book for more detail.



Categorical Variables

- Recall that we made a categorical variable out of our years married variable.

```
```{r}
acitelli <- acitelli %>%
 mutate(married = case_when(Yearsmar < -7 ~ "newlywed",
 Yearsmar > -7 & Yearsmar < 0 ~ "early marriage",
 Yearsmar >= 0 ~ "mature marriage"))

...```

```

- We can use **fct\_recode("new" = "old")** to change levels of existing factors

```
```{r}
acitelli %>%
  mutate(married_new = fct_recode(married,
                                   "honeymoon phase" = "newlywed",
                                   "honeymoon phase" = "early marriage",
                                   "old marriage" = "mature marriage"))

...```

```

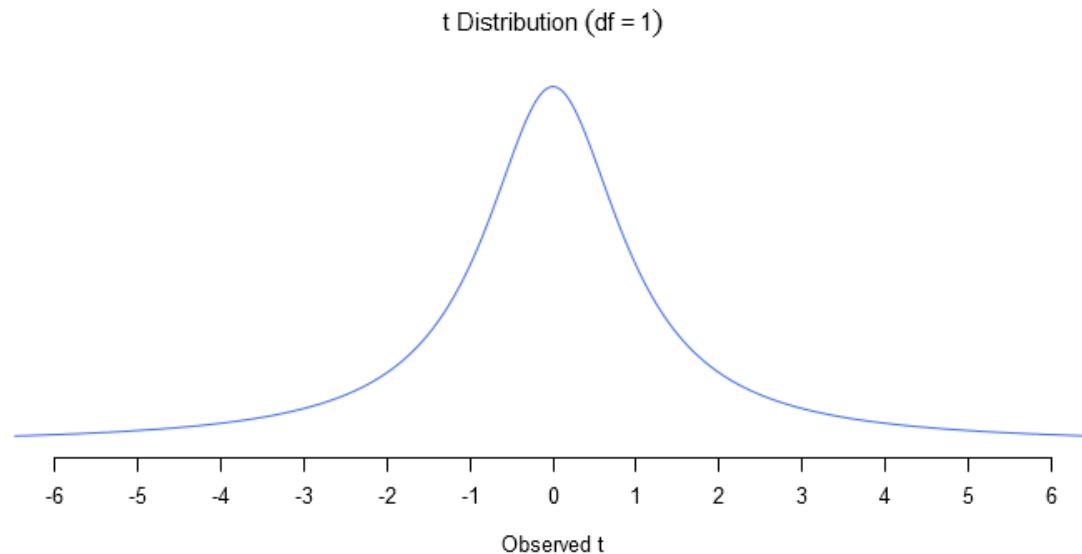


Categorical Variables

- We can use `fct_collapse()` to be even more slick

Correlation Matrices, Reliability, and t-Tests

- For correlation matrices and Cronbach's alpha we'll use the package called **psych**
- For t-Tests I recommend you use **mosaic** because it has the formula, then data, syntax (without needing dollar signs)



Correlation Matrices and Reliability

- Correlation Matrix
 - `corr.test()`
 - I like to use this with `select()`:

```
```{r}
corr.test(select(bfi, A1.r, A2, A3, A4, A5))
```
```

vars for matrix

- Reliability
 - `alpha()`
 - Also handy with `select()`:

```
```{r}
alpha(select(bfi, A1.r, A2, A3, A4, A5))
```
```

items for alpha

Creating Scale Scores

- It's best to use the `rowMeans()` function from Base R.
 - Doesn't quite have the same syntax, the data will need to be in the `select()` function.

```
bfi <- bfi %>%  
  mutate(agreeable = rowMeans(select(bfi, A1.r, A2, A3, A4, A5), na.rm = TRUE))
```

Student's t-Tests (in mosaic)

- One-sample

```
```{r}
t.test(~self_pos, data = acitelli)
```
```

- independent samples

```
```{r}
t.test(satisfaction ~ gender, data = acitelli)
```
```

- paired samples

```
```{r}
t.test(~(self_pos-other_pos), data = acitelli)
```
```

Function Masking

- R is open source and anyone is welcome to contribute a package!
- The package author decides on the names of their functions and there are bound to be redundant function names
- Sometimes it's by design
 - `t.test()` is a function in Base R
 - `t.test()` is a function in `mosaic`
- Sometimes is an unfortunate coincidence
 - `alpha()` is a function in `ggplot2`
 - `alpha()` is a function in `psych`

Function Masking

- Solution 1: Always load psych *after* dplyr and ggplot2

```
```{r}
library(forcats)
library(dplyr)
library(tidyr)
library(ggplot2)
library(psych)

acitelli <- read.csv("acitelli.csv")
```
```

- Solution 2: Do what you want, but if you get errors, be explicit about which package you want

```
```{r}
psych::alpha(select(bfi, A1.r, A2, A3, A4, A5))
````
```

R MARKDOWN FILE

cor_reliability_ttest.Rmd