Lesson 2: Data and File Management

Adapted from parts of Mine Çetinkaya-Rundel's tidyverse course

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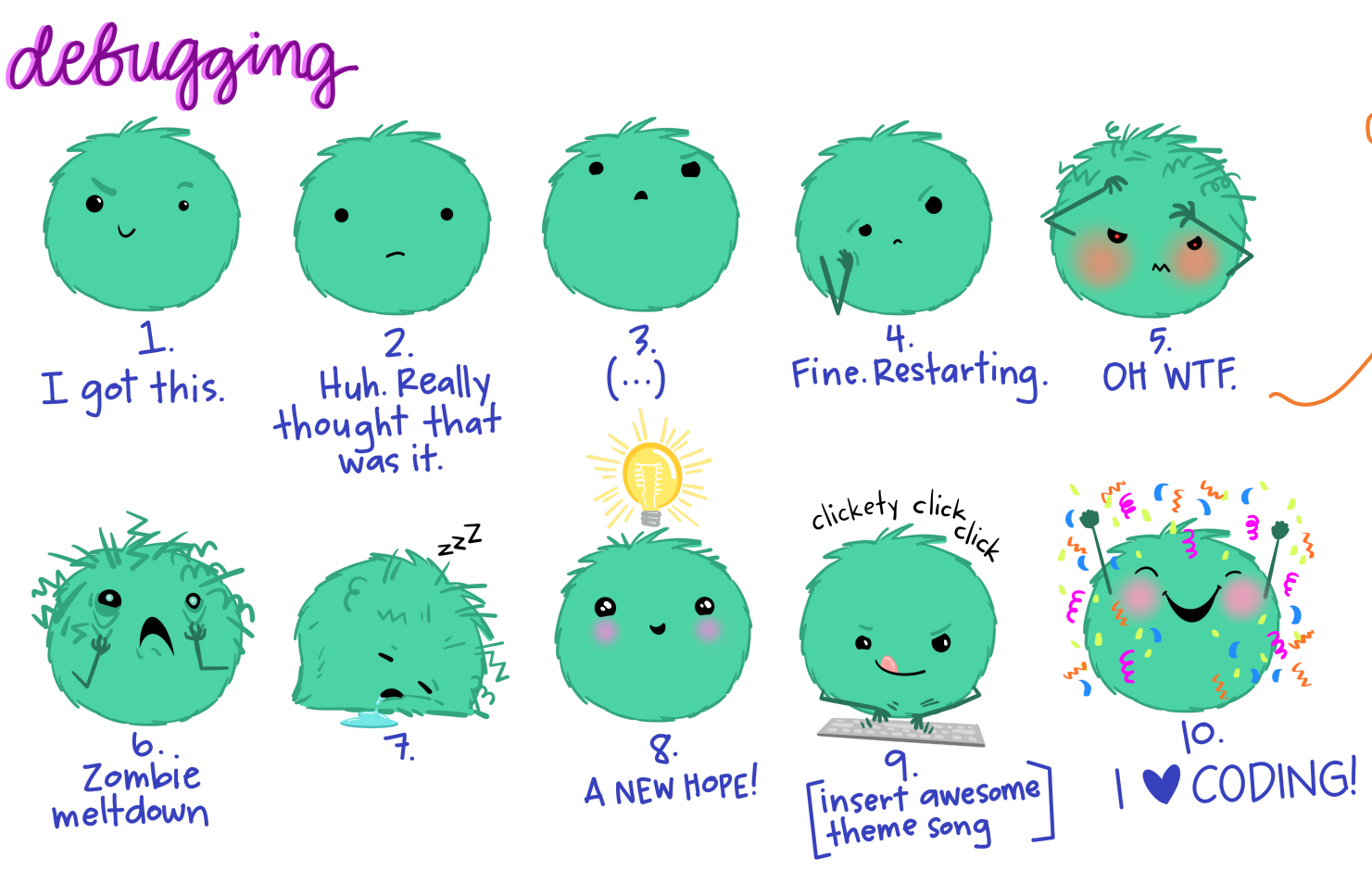
What we will cover

1. Introduction to `tidyverse`
2. `ggplot2` revisited
3. Functions for data management
4. Functions for data summarization
5. Folder organization
6. `here` package and importing data

- Not covered: basic Quarto set up. Please see R recordings in OneDrive and my EPI 525 site for videos and slides.



Artwork by @allison_horst

Introduction to the `tidyverse`

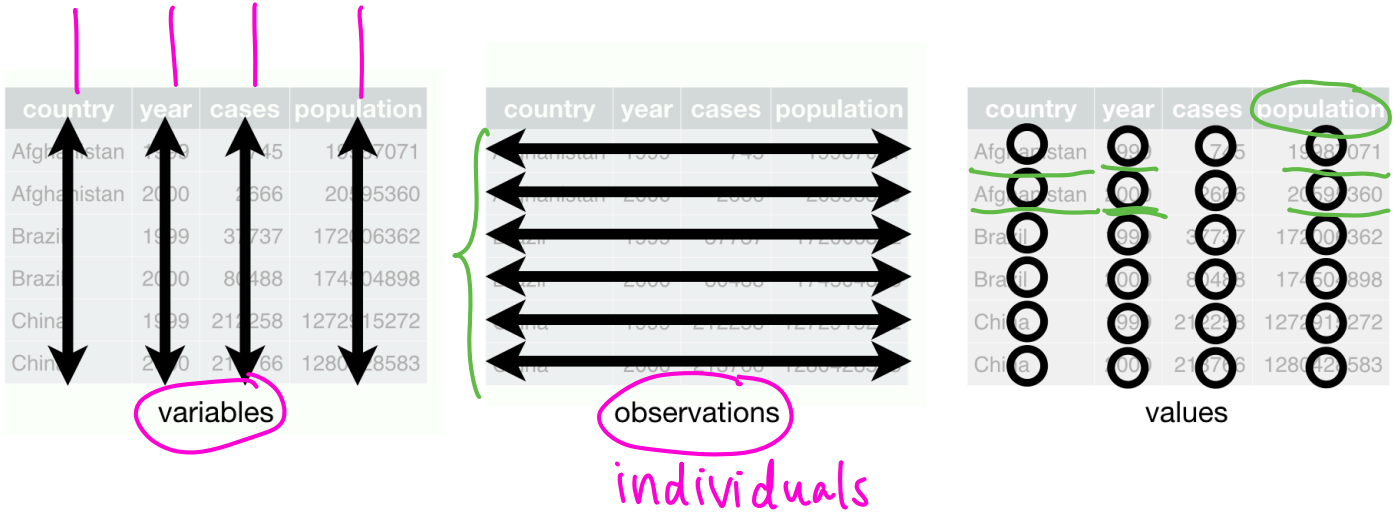

SPIDER-MAN
INTO THE SPIDER-VERSE

What is the tidyverse?

The **tidyverse** is a collection of R packages designed for data science. All packages share an underlying design philosophy, grammar, and data structures.

- **ggplot2** - data visualisation
- **dplyr** - data manipulation
- **tidyr** - tidy data
- **readr** - read rectangular data
- **purrr** - functional programming
- **tibble** - modern data frames
- **stringr** - string manipulation
- **forcats** - factors
- and many more …

Tidy data[1]



1. Each variable must have its own column.
2. Each observation must have its own row.
3. Each value must have its own cell.

Pipe operator (`magrittr`)

- The pipe operator (`%>%`) allows us to step through sequential functions in the same way we follow if-then statements or steps from instructions

I want to find my keys, then start my car, then drive to work, then park my car.

Nested

```
park(drive(start_car(find("keys")),
           to = "work"))
```

Piped

```
find("keys") %>%
  start_car() %>%
  drive(to = "work") %>%
  park()
```

Recoding a binary variable with pipe operator

Let's say I want a variable `transmission` to show the category names that are assigned to numeric values in the code. I want `0` to be coded as `automatic` and `1` to be coded as `manual`.

Base R:

```
1  mtcars$transmission <-
2    ifelse(
3      mtcars$am == 0,
4      "automatic",
5      "manual"
6    )
```

Tidyverse:

```
1  mtcars <- mtcars %>%
2    mutate(
3      transmission = case_when(
4        am == 0 ~ "automatic",
5        am == 1 ~ "manual"
6      )
7    )
```

`mutate()` creates new columns that are functions of existing variables

Recoding a multi-level variable

Ref

Let's say I want a variable `gear` to show the category names that are assigned to numeric values in the code. I want `3` to be coded as gear `three`, `4` to be coded as gear `four`, `5` to be coded as gear `five`.

Base R:

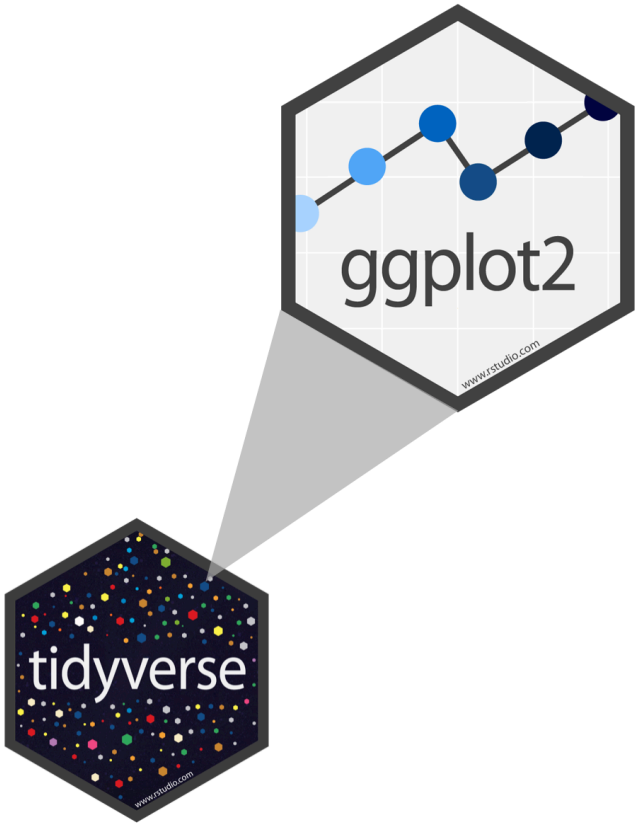
```r
mtcars$gear_char <-
  ifelse(
    mtcars$gear == 3,
    "three",
    ifelse(
      mtcars$gear == 4,
      "four",
      "five"
    )
  )
```

Tidyverse:

```r
mtcars <- mtcars %>%
  mutate(
    gear_char = case_when(
      gear == 3 ~ "three",
      gear == 4 ~ "four",
      gear == 5 ~ "five"
    )
  )
```

`ggplot2` revisited

ggplot2 in tidyverse



- We talked about this in our review notes
  - I want to revisit it: always helps to have more examples!
  - This example is closer to the multivariable work we'll do in this class!

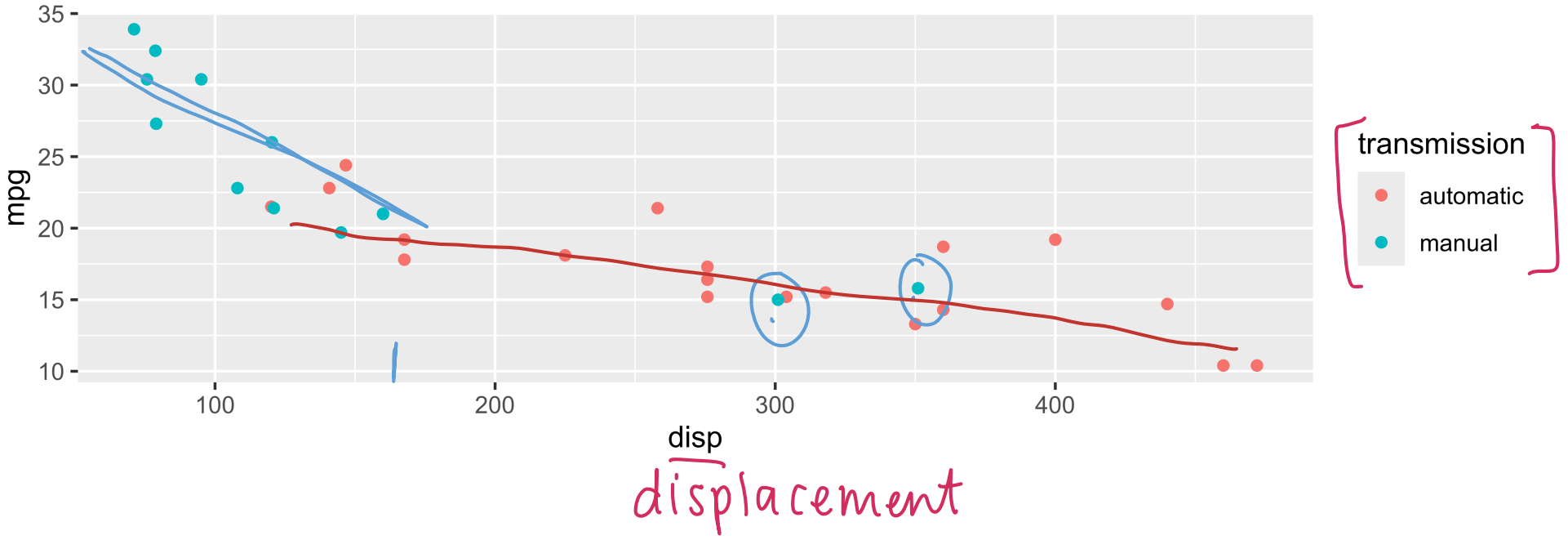
- **ggplot2** is tidyverse's data visualization package

- The gg in "ggplot2" stands for Grammar of Graphics

- It is inspired by the book **Grammar of Graphics** by Leland Wilkinson

Tidyverse: Visualizing multiple variables

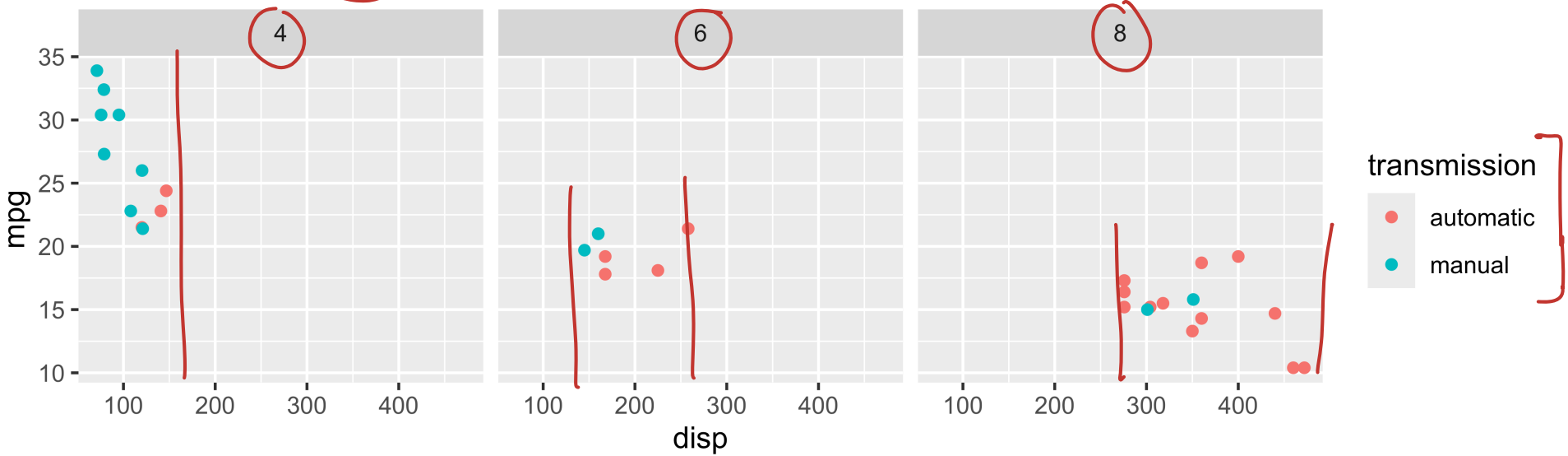
```
1 ggplot(
2   mtcars,
3   aes(x = disp, y = mpg, color = transmission)) +
4   geom_point()
```



displacement

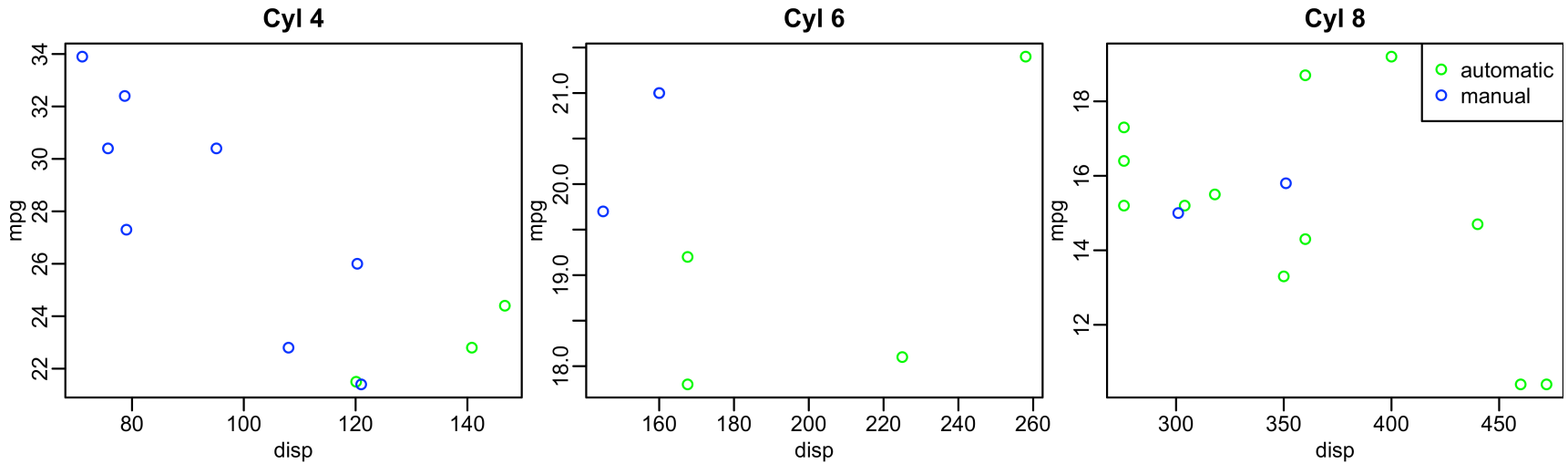
Tidyverse: Visualizing even more variables

```
1 ggplot(
2   mtcars,
3   aes(x = disp, y = mpg, color = transmission)) +
4   geom_point() +
5   facet_wrap(~ cyl)
```



Base R: Visualizing even more variables

```r
mtcars$trans_color <- ifelse(mtcars$transmission == "automatic", "green", "blue")
mtcars_cyl4 = mtcars[mtcars$cyl == 4, ]
mtcars_cyl6 = mtcars[mtcars$cyl == 6, ]
mtcars_cyl8 = mtcars[mtcars$cyl == 8, ]
par(mfrow = c(1, 3), mar = c(2.5, 2.5, 2, 0), mgp = c(1.5, 0.5, 0))
plot(mpg ~ disp, data = mtcars_cyl4, col = trans_color, main = "Cyl 4")
plot(mpg ~ disp, data = mtcars_cyl6, col = trans_color, main = "Cyl 6")
plot(mpg ~ disp, data = mtcars_cyl8, col = trans_color, main = "Cyl 8")
legend("topright", legend = c("automatic", "manual"), pch = 1, col = c("green", "bl
```



Functions for data management

Important functions for data management

Data manipulation

- `pivot_longer()` and `pivot_wider()` (not covered today)
- `rename()`
- `mutate()`
- `filter()`
- `select()`

Summarizing data

- `tbl_summary()`
- `group_by()`
- `summarize()`
- `across()`

Let's look back at the `dds.discr` dataset that I briefly used last class

- We will load the data (This is a special case! `dds.discr` is a built-in R dataset)

```
1 data("dds.discr")
```

- Now, let's take a glimpse at the dataset:

```
1 glimpse(dds.discr)
```

```
Rows: 1,000
Columns: 6
$ id           <int> 10210, 10409, 10486, 10538, 10568, 10690, 10711, 10778, 1…
$ age.cohort   <fct> 13-17, 22-50, 0-5, 18-21, 13-17, 13-17, 13-17, 13-17, 13-…
$ age          <int> 17, 37, 3, 19, 13, 15, 13, 17, 14, 13, 13, 14, 15, 17, 20…
$ gender       <fct> Female, Male, Male, Female, Male, Female, Female, Male, F…
$ expenditures <int> 2113, 41924, 1454, 6400, 4412, 4566, 3915, 3873, 5021, 28…
$ ethnicity    <fct> White not Hispanic, White not Hispanic, Hispanic, Hispani…
```

`rename()`: one of the first things I usually do

- I notice that two variables have values that don't necessarily match the variable name
  - Female and male are not genders
  - "White not Hispanic" combines race and ethnicity into one category

I want to rename gender to SAB (sex assigned at birth) and rename ethnicity to R_E (race and ethnicity)

```
1 dds.discr1 = dds.discr %>%
2   rename(SAB = gender,
3          R_E = ethnicity)
4
5 glimpse(dds.discr1)
```

```
Rows: 1,000
Columns: 6
$ id          <int> 10210, 10409, 10486, 10538, 10568, 10690, 10711, 10778, 1…
$ age.cohort  <fct> 13-17, 22-50, 0-5, 18-21, 13-17, 13-17, 13-17, 13-17, 13-…
$ age         <int> 17, 37, 3, 19, 13, 15, 13, 17, 14, 13, 13, 14, 15, 17, 20…
$ SAB         <fct> Female, Male, Male, Female, Male, Female, Female, Male, F…
$ expenditures <int> 2113, 41924, 1454, 6400, 4412, 4566, 3915, 3873, 5021, 28…
$ R_E         <fct> White not Hispanic, White not Hispanic, Hispanic, Hispani…
```

`mutate()`: constructing new variables from what you have

- We've seen a couple examples for `mutate()` so far (mostly because its used so often!)
- We haven't seen an example where we make a new variable from two variables

I want to make a variable that is the ratio of expenditures over age

```
1 dds.discr2 = dds.discr1 %>%
2   mutate(exp_to_age = expenditures/age)
3
4 glimpse(dds.discr2)
```

```
Rows: 1,000
Columns: 7
$ id           <int> 10210, 10409, 10486, 10538, 10568, 10690, 10711, 10778, 1…
$ age.cohort   <fct> 13-17, 22-50, 0-5, 18-21, 13-17, 13-17, 13-17, 13-17, 13-…
$ age          <int> 17, 37, 3, 19, 13, 15, 13, 17, 14, 13, 13, 14, 15, 17, 20…
$ SAB          <fct> Female, Male, Male, Female, Male, Female, Female, Male, F…
$ expenditures <int> 2113, 41924, 1454, 6400, 4412, 4566, 3915, 3873, 5021, 28…
$ R_E          <fct> White not Hispanic, White not Hispanic, Hispanic, Hispani…
$ exp_to_age   <dbl> 124.2941, 1133.0811, 484.6667, 336.8421, 339.3846, 304.40…
```

mutate(): other examples

```
 1 dds.discr3 = dds.discr1 %>%
 2   mutate(expend_20perc = expenditures * 0.2,
 3          expend_sq = expenditures^2,
 4          expend_over_5000 = case_when(
 5            expenditures > 5000 ~ "Yes",
 6            expenditures <= 5000 ~ "No"
 7          ),
 8          expend_log = log(expenditures)
 9   )
10 glimpse(dds.discr3)
```

```
Rows: 1,000
Columns: 10
$ id              <int> 10210, 10409, 10486, 10538, 10568, 10690, 10711, 1077…
$ age.cohort      <fct> 13-17, 22-50, 0-5, 18-21, 13-17, 13-17, 13-17, 13-17,…
$ age             <int> 17, 37, 3, 19, 13, 15, 13, 17, 14, 13, 13, 14, 15, 17…
$ SAB             <fct> Female, Male, Male, Female, Male, Female, Female, Mal…
$ expenditures    <int> 2113, 41924, 1454, 6400, 4412, 4566, 3915, 3873, 5021…
$ R_E             <fct> White not Hispanic, White not Hispanic, Hispanic, His…
$ expend_20perc   <dbl> 422.6, 8384.8, 290.8, 1280.0, 882.4, 913.2, 783.0, 77…
$ expend_sq       <dbl> 4464769, 1757621776, 2114116, 40960000, 19465744, 208…
$ expend_over_5000 <chr> "No", "Yes", "No", "Yes", "No", "No", "No", "No", "Ye…
$ expend_log      <dbl> 7.655864, 10.643614, 7.282074, 8.764053, 8.392083, 8.…
```

`filter()`: keep rows that match a condition

for ROWS!

- What if I want to subset the data frame? (keep certain rows of observations)

I want to look at the data for people who between 50 and 60 years old

```
1 dds.discr3 = dds.discr2 %>%
2   filter(age >= 50 & age <= 60)
3
4 glimpse(dds.discr3)
```

meet both

x >= 50 & <= 60

"|"

meet either req.

```
Rows: 23
Columns: 7
$ id           <int> 15970, 19412, 29506, 31658, 36123, 39287, 39672, 43455, 4…
$ age.cohort   <fct> 51+, 51+, 51+, 51+, 51+, 51+, 51+, 51+, 51+, 51+, 51+, 51…
$ age          <int> 51, 60, 56, 60, 59, 59, 54, 57, 52, 57, 55, 52, 59, 54, 5…
$ SAB          <fct> Female, Female, Female, Female, Male, Female, Female, Mal…
$ expenditures <int> 54267, 57702, 48215, 46873, 42739, 44734, 52833, 48363, 5…
$ R_E          <fct> White not Hispanic, White not Hispanic, White not Hispani…
$ exp_to_age   <dbl> 1064.0588, 961.7000, 860.9821, 781.2167, 724.3898, 758.20…
```

`select()`: keep or drop columns using their names and types

for COL's!!

- What if I want to remove or keep certain variables?

I want to only have age and expenditure in my data frame

```
1 dds.discr4 = dds.discr2 %>%
2   select(age, expenditures)
3
4 glimpse(dds.discr4)
```

```
Rows: 1,000
Columns: 2
$ age          <int> 17, 37, 3, 19, 13, 15, 13, 17, 14, 13, 13, 14, 15, 17, 20…
$ expenditures <int> 2113, 41924, 1454, 6400, 4412, 4566, 3915, 3873, 5021, 28…
```

Summarizing Data

`tbl_summary()` : table summary (1/2)

- What if I want one of those fancy summary tables that are at the top of most research articles? (lovingly called "Table 1")

```
1 library(gtsummary)
2 tbl_summary(dds.discr2)
```

Characteristic	N = 1,000[1]
id	55,385 (31,759, 76,205)
age.cohort	
0-5	82 (8.2%)
6-12	175 (18%)
13-17	212 (21%)
18-21	199 (20%)
22-50	226 (23%)
51+	106 (11%)
age	18 (12, 26)
SAB	
Female	503 (50%)
Male	497 (50%)
expenditures	7,026 (2,898, 37,718)
R_E	
American Indian	4 (0.4%)
Asian	129 (13%)
Black	59 (5.9%)
Hispanic	376 (38%)
Multi Race	26 (2.6%)
Native Hawaiian	3 (0.3%)
Other	2 (0.2%)
White not Hispanic	401 (40%)
exp_to_age	462 (273, 938)

[1] Median (Q1, Q3); n (%)

`tbl_summary()` : table summary (2/2)

- Let's make this more presentable

```
1  dds.discr2 %>%
2    select(-id, -age.cohort, -exp_to_age) %>%
3   tbl_summary(label = c(age ~ "Age",
4                         R_E ~ "Race/Ethnicity",
5                         SAB ~ "Sex Assigned at Birth",
6                         expenditures ~ "Expenditures") ,
7               statistic = list(all_continuous() ~ "{mean
```

Characteristic	N = 1,000[1]
Age	23 (18)
Sex Assigned at Birth	
Female	503 (50%)
Male	497 (50%)
Expenditures	18,066 (19,543)
Race/Ethnicity	
American Indian	4 (0.4%)
Asian	129 (13%)
Black	59 (5.9%)
Hispanic	376 (38%)
Multi Race	26 (2.6%)
Native Hawaiian	3 (0.3%)
Other	2 (0.2%)
White not Hispanic	401 (40%)

[1] Mean (SD); n (%)

`group_by()`: group by one or more variables

- What if I want to quickly look at group differences?
- It will not change how the data look, but changes the actions of following functions

> I want to group my data by sex assigned at birth.

```
1 dds.discr5 = dds.discr2 %>%
2   group_by(SAB)
3 glimpse(dds.discr5)
```

```
Rows: 1,000
Columns: 7
Groups: SAB [2]
$ id           <int> 10210, 10409, 10486, 10538, 10568, 10690, 10711, 10778, 1…
$ age.cohort   <fct> 13-17, 22-50, 0-5, 18-21, 13-17, 13-17, 13-17, 13-17, 13-…
$ age          <int> 17, 37, 3, 19, 13, 15, 13, 17, 14, 13, 13, 14, 15, 17, 20…
$ SAB          <fct> Female, Male, Male, Female, Male, Female, Female, Male, F…
$ expenditures <int> 2113, 41924, 1454, 6400, 4412, 4566, 3915, 3873, 5021, 28…
$ R_E          <fct> White not Hispanic, White not Hispanic, Hispanic, Hispani…
$ exp_to_age   <dbl> 124.2941, 1133.0811, 484.6667, 336.8421, 339.3846, 304.40…
```

- Let's see how the groups change something like the `summarize()` function in the next slide

`summarize()`: summarize your data or grouped data into one row

- What if I want to calculate specific descriptive statistics for my variables?
- This function is often best used with `group_by()`
- If only presenting the summaries, functions like `tbl_summary()` is better
- `summarize()` creates a new data frame, which means you can plot and manipulate the summarized data

Over whole sample:

```
dds.discr2 %>%
  summarize(
    ave = mean(expenditures),
    SD = sd(expenditures),
    med = median(expenditures))
```

```
# A tibble: 1 × 3
     ave     SD   med
   <dbl>  <dbl> <dbl>
1 18066. 19543.  7026
```

Grouped by sex assigned at birth:

```
dds.discr2 %>%
  group_by(SAB) %>%
  summarize(
    ave = mean(expenditures),
    SD = sd(expenditures),
    med = median(expenditures))
```

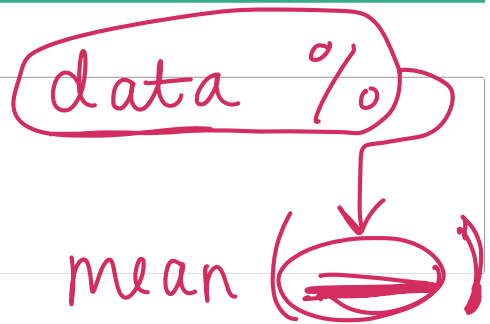
```
# A tibble: 2 × 4
  SAB       ave     SD   med
  <fct>   <dbl>  <dbl> <int>
1 Female 18130. 20020.  6400
2 Male   18001. 19068.  7219
```

`across()`: apply a function across multiple columns

- Like `group_by()`, this function is often paired with another transformation function

I want all my integer values to have two significant figures.

```
1 dds.discr6 = dds.discr2 %>%
2   mutate(across(where(is.integer), signif, digits = 2))
3
4 glimpse(dds.discr6)
```



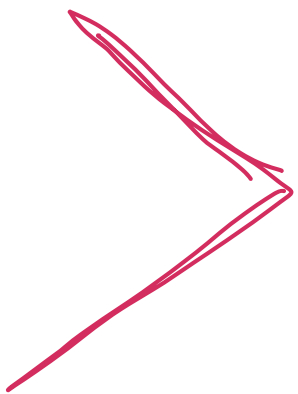

```
Rows: 1,000
Columns: 7
$ id           <dbl> 10000, 10000, 10000, 11000, 11000, 11000, 11000, 11000, 1…
$ age.cohort   <fct> 13-17, 22-50, 0-5, 18-21, 13-17, 13-17, 13-17, 13-17, 13-…
$ age          <dbl> 17, 37, 3, 19, 13, 15, 13, 17, 14, 13, 13, 14, 15, 17, 20…
$ SAB          <fct> Female, Male, Male, Female, Male, Female, Female, Male, F…
$ expenditures <dbl> 2100, 42000, 1500, 6400, 4400, 4600, 3900, 3900, 5000, 29…
$ R_E          <fct> White not Hispanic, White not Hispanic, Hispanic, Hispani…
$ exp_to_age   <dbl> 124.2941, 1133.0811, 484.6667, 336.8421, 339.3846, 304.40…
```

Folder organization

Folder organization

- Make a folder for our class!
  - I suggest naming it something like `BSTA_512_W25` to indicate the class and the term
- Make these folders in your computer (or in OneDrive if you prefer)
  - Only make them in OneDrive **if** you have a desktop connection

- For a project, I have the following folders
  - Background
  - Code
  - Data_Raw
  - Data_Processed
  - Dissemination
  - Reports
  - Meetings



- For our class, I suggest making one folder for the course with the following folders in it:
  - Data
  - Homework
  - Project (with above subfolders)
  - Lessons
  - And other folders if you want

Aside: folder and file naming

There are a few good practices for naming files and folders for easy tracking:

1. Keep the name short and relevant
2. Use leading numbers to help organize sequential items
   - I can show you my lessons folders as an example
3. Use dates in the format "YYYY-MM-DD" so that files are in chronological order
4. You can label different versions if you would like to
5. Use "_" to separate sections of the name
   - I also use this to separate words, but some people say you should use "-" to separate words

02_Data-management

Data_management

Creating project in RStudio ".Rproj"

- Way to designate a working directory: basically your home base when working in R
  - We have to tell R exactly where we are in our folders and where to find other things
  - A project makes it easier to tell R where we are
- Basic steps to create a project
  - Go into RStudio
  - Create new project for this class (under `File` or top right corner)
    - I would chose “Existing Directory” since we have already set up our folders
    - Make the new project in the `BSTA_512_W25` folder
- Once we have projects, we can open one and R will automatically know that its location is the start of our working directory
- Only make one project for now!!

The nice thing about R projects

- 5 minute video explaining some of the nice features of R projects

https://rfortherestofus.com/2022/10/rstudio-projects

Reproducibility

- Research data and code can reach the same results regardless of who is running the code
  - This can also refer to future or past you!

- We want to set up our work so the entire folder can be moved around and work in its new location

- Projects work well in combination with the `here` package

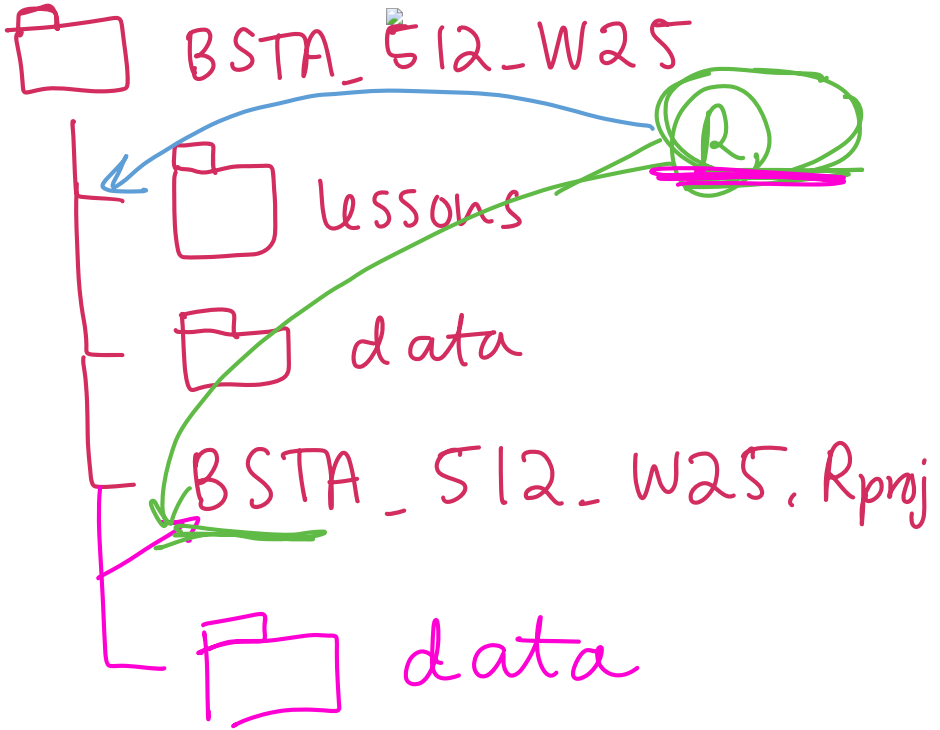
`here` package and importing data

here package

Illustration by Allison Horst

here package

- Good source for the here package
  - Just substitute .Rmd with .qmd
- Basically, a .qmd file and .R file work differently
  - We haven't worked much with .R files
- For .qmd files, the automatic directory is the folder it is in
  - But we want it to be the main project folder
- here can help with that



- **Very important for reproducibility!!**

"../data/____.csv"

here("data/____.csv")

Using here package

- Within your console, type `here()` and enter
  - Try this with `getwd()` as well

```
1 library(here)
2 here()
```

```
[1] "/Users/wakim/Library/CloudStorage/OneDrive-
OregonHealth&ScienceUniversity/Teaching/Classes/W25_BSTA_512_612/BSTA_512_W25_site"
```

```
1 getwd()
```

```
[1] "/Users/wakim/Library/CloudStorage/OneDrive-
OregonHealth&ScienceUniversity/Teaching/Classes/W25_BSTA_512_612/BSTA_512_W25_site"
```

- `here` can be used whenever we need to access a file path in **R code**
  - Importing data
  - Saving output
  - Accessing files

Importing data

Using `here()` to load data

- The `here()` function will start at the working directory (where your `.Rproj` file is) and let you write out a file path for anything
- To load the dataset in our `.qmd` file, we will use:

```
1 library(readxl)
2 data = read_excel(here("./data/BodyTemperatures.xlsx"))
3 data = read_excel(here("data", "BodyTemperatures.xlsx"))
```

Common functions to load data

Function	Data file type	Package needed
`read_excel()`	`.xls`, `.xlsx`	`readxl`
`read.csv()`	`.csv`	Built in
`load()`	`.Rdata`	Built in
`read_sas()`	`.sas7bdat`	`haven`

Resources

`dplyr` resources

- More `dpylr` functions to reference!

Additional details and examples are available in the vignettes:

- column-wise operations vignette
- row-wise operations vignette

and the dplyr 1.0.0 release blog posts:

- working across columns
- working within rows

R programming class at OHSU!

You can check out Dr. Jessica Minnier's R class page if you want more notes, videos, etc.

The larger tidy ecosystem

Just to name a few…

- janitor
- kableExtra
- patchwork
- gghighlight
- tidybayes

Credit to Mine Çetinkaya-Rundel

- These notes were built from Mine's notes
  - Most pages and code were left as she made them
  - I changed a few things to match our class
- Please see her Github repository for the original notes