Getting Help with R

After this workshop

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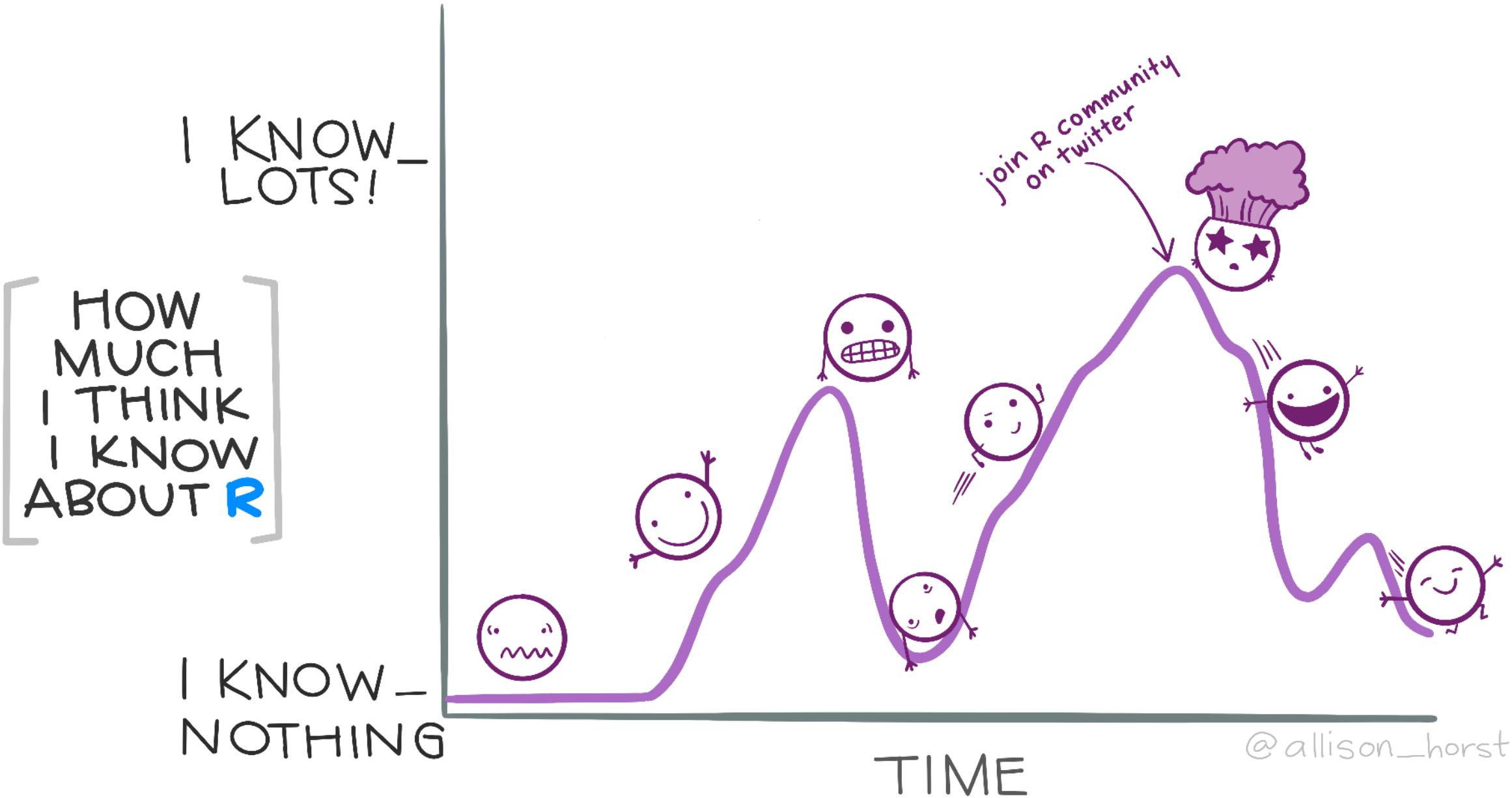
Analysis and Data Tools for Science

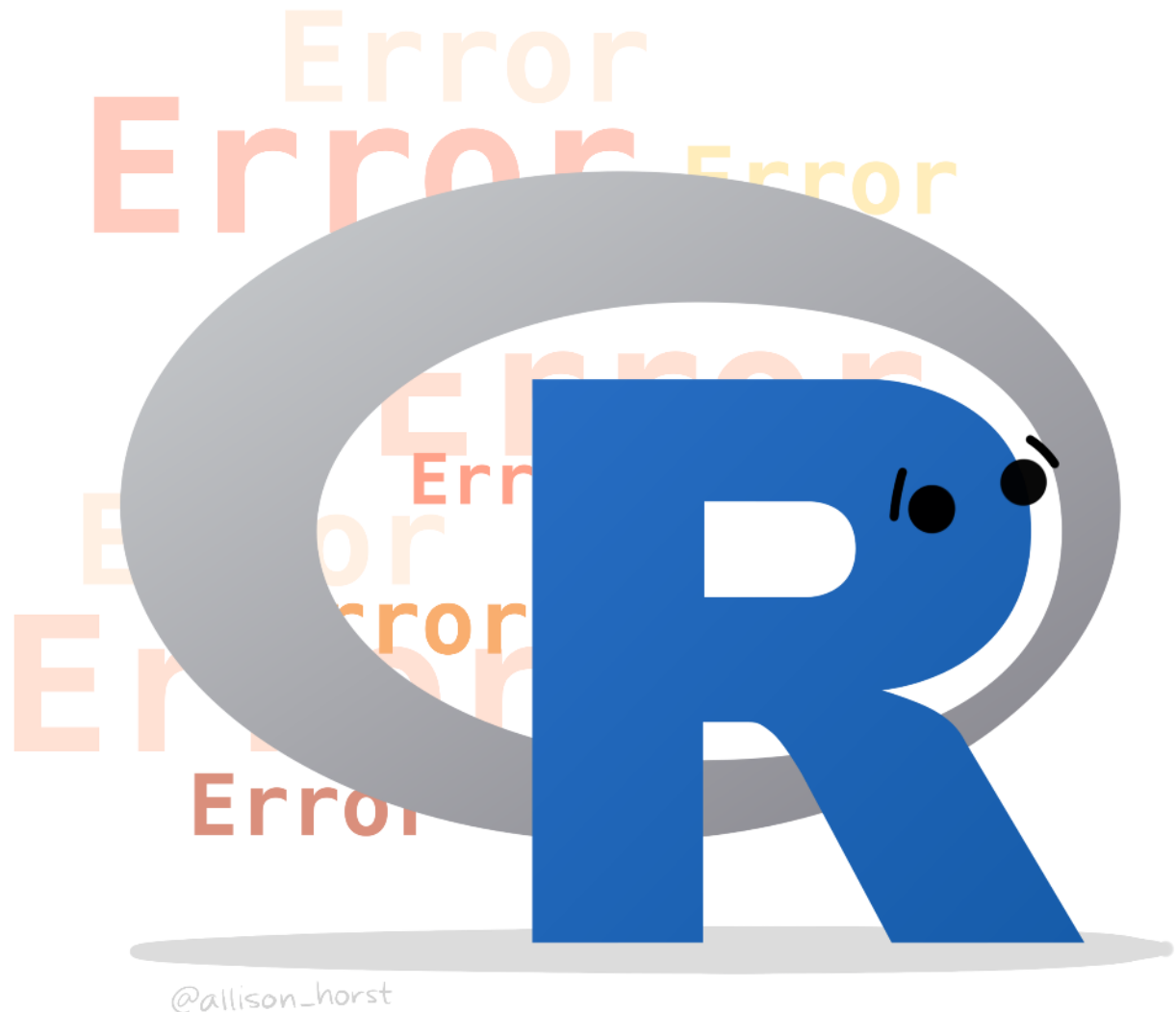
First things first

Save previous script
Consider taking notes during this section



Artwork by @allison_horst

Troubleshooting



Artwork by @allison_horst

Bit by bit

Line by line

- R is sequential
- If you skip lines, you're not running that part (and R has no idea)

```
#a <- 1
b <- 2
a + b
```

```
Error:
! object 'a' not found
```

Bit by bit

Line by line

- R is sequential
- If you skip lines, you're not running that part (and R has no idea)

```
#a <- 1
b <- 2
a + b
```

```
Error:
! object 'a' not found
```

- Error? Start at the beginning and go line by line

```
a <- 1
b <- 2
a + b
```

```
[1] 3
```

Bit by bit

Line by line

```
library(tidyverse)

# Load Data
size <- read_csv("./data/grain_size2.csv")

# First modification
size <- mutate(size,
               total_sand = coarse_sand + medium_sand + fine_sand,
               total_silt = coarse_silt + medium_silt + fine_silt)

# Second modification
size <- size |>
  group_by(plot) |>
  summarize(n = n(),
            total_sand = sum(total_sand),
            mean_sand = mean(total_sand),
            sd_sand = sd(total_sand),
            se_sand = sd_sand / sqrt(n))
```

Bit by bit

Line by line

Especially important if loading and modifying data

```
1  library(tidyverse)
2
3  # Load Data
4  size <- read_csv("./data/grain_size2.csv")
5
6  # First modification
7  size <- mutate(size,
8                 total_sand = coarse_sand + medium_sand + fine_sand,
9                 total_silt = coarse_silt + medium_silt + fine_silt)
10
11 # Second modification
12 size <- size |>
13   group_by(plot) |>
14   summarize(n = n(),
15             total_sand = sum(total_sand),
16             mean_sand = mean(total_sand),
17             sd_sand = sd(total_sand),
18             se_sand = sd_sand / sqrt(n))
```

Bit by bit

Line by line

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1  library(tidyverse)
2
3  # Load Data
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11 # Second modification
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14   summarize(n = n(),
15             total_sand = sum(total_sand),
16             mean_sand = mean(total_sand),
17             sd_sand = sd(total_sand),
18             se_sand = sd_sand / sqrt(n))
```

Especially important if loading and modifying data

Can't run 1st modification after 2nd modification

Bit by bit

Section by section

```
 1 library(tidyverse)
 2
 3 size <- read_csv("./data/grain_size2.csv") |>
 4   mutate(total_sand = coarse_sand + medium_sand + fine_sand,
 5          total_silt = coarse_silt + medium_silt + fine_silt) |>
 6   group_by(plot) |>
 7   summarize(n = n(),
 8             total_sand = sum(total_sand),
 9             mean_sand = mean(totall_sand),
10             sd_sand = sd(total_sand),
11             se_sand = sd_sand / sqrt(n))
```

```
Error in `summarize()`:
i In argument: `mean_sand = mean(totall_sand)`.
i In group 1: `plot = "CSP01"`.
Caused by error:
! object 'totall_sand' not found
```

Bit by bit

Section by section

```
1 library(tidyverse)
2
3 size <- read_csv("./data/grain_size2.csv")
```

No error

Bit by bit

Section by section

```
1 library(tidyverse)
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```

No error

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1 size <- read_csv("./data/grain_size2.csv") |>
2   mutate(total_sand = coarse_sand + medium_sand + fine_sand,
3          total_silt = coarse_silt + medium_silt + fine_silt)
```

No error

Bit by bit

Section by section

```
1 library(tidyverse)
2
3 size <- read_csv("./data/grain_size2.csv")
```

No error

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1 size <- read_csv("./data/grain_size2.csv") |>
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3          total_silt = coarse_silt + medium_silt + fine_silt)
```

No error

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1 size <- read_csv("./data/grain_size2.csv") |>
2   mutate(total_sand = coarse_sand + medium_sand + fine_sand,
3          total_silt = coarse_silt + medium_silt + fine_silt) |>
4   group_by(plot)
```

No error

Bit by bit

Section by section

```
size <- read_csv("./data/grain_size2.csv") |>
  mutate(total_sand = coarse_sand + medium_sand + fine_sand,
         total_silt = coarse_silt + medium_silt + fine_silt) |>
  group_by(plot) |>
  summarize(n = n(),
            total_sand = sum(total_sand),
            mean_sand = mean(totall_sand),
            sd_sand = sd(total_sand),
            se_sand = sd_sand / sqrt(n))
```

```
Error in `summarize()`:
i In argument: `mean_sand = mean(totall_sand)`.
i In group 1: `plot = "CSP01"`.
Caused by error:
! object 'totall_sand' not found
```

Ah ha!

Bit by bit

Applies to error messages too

- First, don’t panic!
- Look at the error bit by bit

```
Error: Problem with `summarise()` column `mean_sand`.
i `mean_sand = mean(totall_sand)`.
x object 'totall_sand' not found
i The error occurred in group 1: plot = "CSP01".
```

Bit by bit

Applies to error messages too

```
Error: Problem with 'summarise()' column 'mean_sand'`
```

Okay, we know the problem is in the `summarize()` part and then `mean_sand` part of that

Bit by bit

Applies to error messages too

```
Error: Problem with 'summarise()' column 'mean_sand'`
```

Okay, we know the problem is in the `summarize()` part and then `mean_sand` part of that

```
i 'mean_sand = mean(totall_sand)'
x object 'totall_sand' not found
```

Looks like this is the line with the problem.
And the problem is `object 'totall_sand' not found`.

Ooops! Typo!

Bit by bit

Applies to error messages too

```
Error: Problem with 'summarise()' column 'mean_sand'`
```

Okay, we know the problem is in the `summarize()` part and then `mean_sand` part of that

```
i 'mean_sand = mean(totall_sand)'
x object 'totall_sand' not found
```

Looks like this is the line with the problem.
And the problem is `object 'totall_sand' not found`.

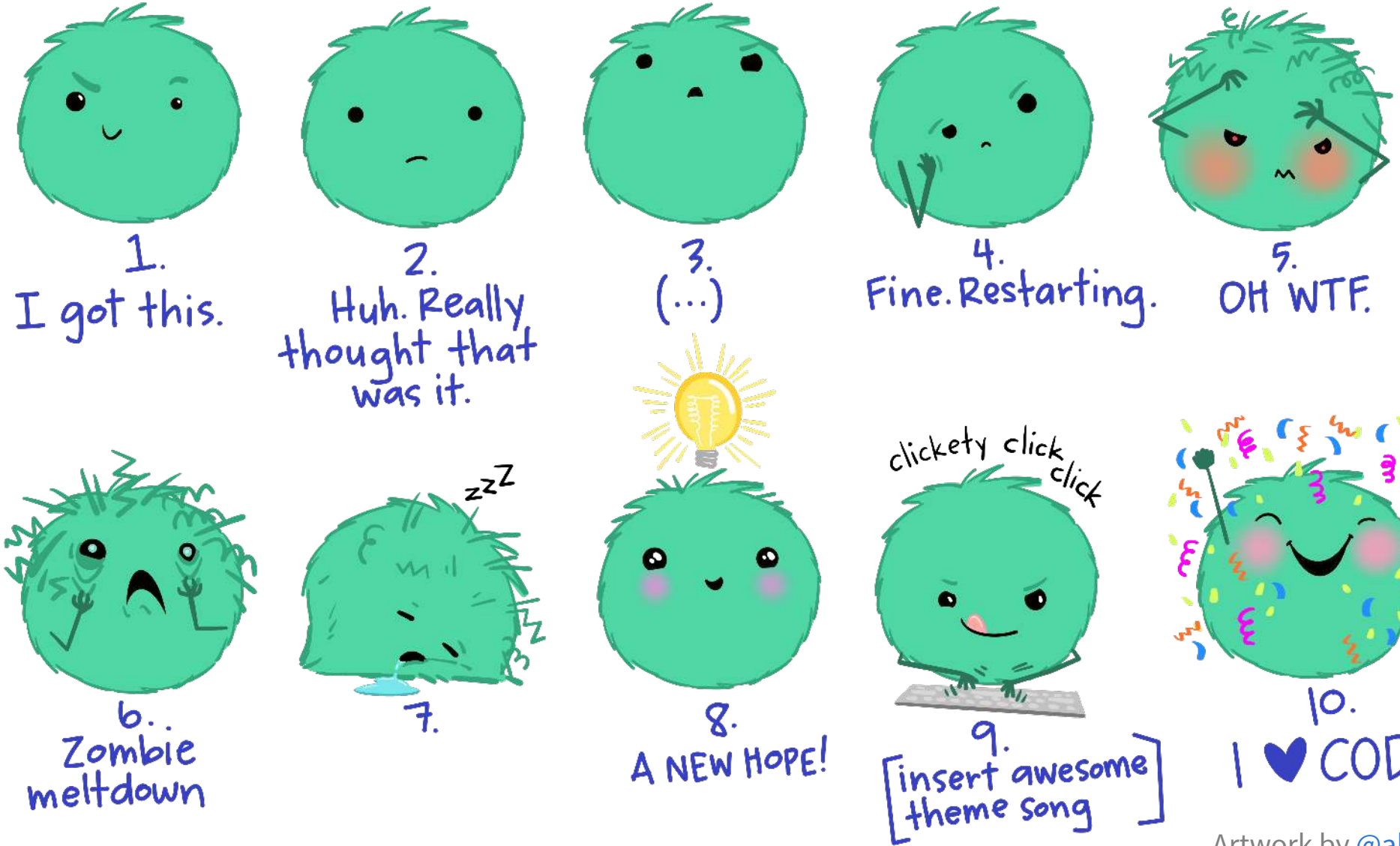
Ooops! Typo!

```
i The error occurred in group 1: plot = "CSP01".
```

Lastly, it's telling us that the problem was when working with this group of data.

(This can be useful when troubleshooting, because you can `filter()` your data and take a look)

debugging



Artwork by @allison_horst

@allison_horst

R is never wrong

R is never wrong

Just sometimes unhelpful!

Getting Help

Cheat Sheets

RStudio Menu

- Help
  - Cheatsheets

Take a look yourself

Data Visualization with ggplot2 : : **CHEAT SHEET**

Basics

ggplot2 is based on the **grammar of graphics**, the idea that you can build every graph from the same components: a **data** set, a **coordinate system**, and geoms—visual marks that represent data points.

To display values, map variables in the data to visual properties of the geom (**aesthetics**) like **size**, **color**, and **x** and **y** locations.

Complete the template below to build a graph.

required

```
ggplot (data = <DATA>) +
<GEOM_FUNCTION> (mapping = aes( <MAPPINGS> ),
stat = <STAT>, position = <POSITION> ) +
<COORDINATE_FUNCTION> +
<FACET_FUNCTION> +
<SCALE_FUNCTION> +
<THEME_FUNCTION>
```

Not required, sensible defaults supplied

ggplot(data = mpg, **aes**(x = cty, y = hwy)) Begins a plot that you finish by adding layers to. Add one geom function per layer.

aesthetic mappings | data | geom

qplot(x = cty, y = hwy, data = mpg, geom = "point") Creates a complete plot with given data, geom, and mappings. Supplies many useful defaults.

last_plot() Returns the last plot

ggsave("plot.png", width = 5, height = 5) Saves last plot as 5' x 5' file named "plot.png" in working directory. Matches file type to file extension.

Geoms

Use a geom function to represent data points, use the geom's aesthetic properties to represent variables. Each function returns a layer.

GRAPHICAL PRIMITIVES

a <- ggplot(economics, aes(date, unemploy))
b <- ggplot(seals, aes(x = long, y = lat))

a + geom_blank()
(Useful for expanding limits)

b + geom_curve(aes(yend = lat + 1, xend=long+1),curvature=1) - x, xend, y, yend, alpha, angle, color, curvature, linetype, size

a + geom_path(lineend="butt", linejoin="round", linemitre=1)
x, y, alpha, color, group, linetype, size

a + geom_polygon(aes(group = group)) x, y, alpha, color, fill, group, linetype, size

b + geom_rect(aes(xmin = long, ymin=lat, xmax= long + 1, ymax = lat + 1)) - xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size

a + geom_ribbon(aes(ymin=unemploy - 900, ymax=unemploy + 900)) - x, ymax, ymin, alpha, color, fill, group, linetype, size

LINE SEGMENTS

common aesthetics: x, y, alpha, color, linetype, size

b + geom_abline(aes(intercept=0, slope=1))
b + geom_hline(aes(yintercept = lat))
b + geom_vline(aes(xintercept = long))

b + geom_segment(aes(yend=lat+1, xend=long+1))
b + geom_spoke(aes(angle = 1:1155, radius = 1))

ONE VARIABLE continuous

c <- ggplot(mpg, aes(hwy)); c2 <- ggplot(mpg)

c + geom_area(stat = "bin")
x, y, alpha, color, fill, linetype, size

c + geom_density(kernel = "gaussian")
x, y, alpha, color, fill, group, linetype, size, weight

c + geom_dotplot()
x, y, alpha, color, fill

c + geom_freqpoly() x, y, alpha, color, group, linetype, size

c + geom_histogram(binwidth = 5) x, y, alpha, color, fill, linetype, size, weight

c2 + geom_qq(aes(sample = hwy)) x, y, alpha, color, fill, linetype, size, weight

discrete

d <- ggplot(mpg, aes(fl))

d + geom_bar()
x, alpha, color, fill, linetype, size, weight

TWO VARIABLES

continuous x , continuous y

e <- ggplot(mpg, aes(cty, hwy))

e + geom_label(aes(label = cty), nudge_x = 1, nudge_y = 1, check_overlap = TRUE) x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

e + geom_jitter(height = 2, width = 2)
x, y, alpha, color, fill, shape, size

e + geom_point(), x, y, alpha, color, fill, shape, size, stroke

e + geom_quantile(), x, y, alpha, color, group, linetype, size, weight

e + geom_rug(sides = "bl"), x, y, alpha, color, linetype, size

e + geom_smooth(method = lm), x, y, alpha, color, fill, group, linetype, size, weight

e + geom_text(aes(label = cty), nudge_x = 1, nudge_y = 1, check_overlap = TRUE), x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

discrete x , continuous y

f <- ggplot(mpg, aes(class, hwy))

f + geom_col(), x, y, alpha, color, fill, group, linetype, size

f + geom_boxplot(), x, y, lower, middle, upper, ymax, ymin, alpha, color, fill, group, linetype, shape, size, weight

f + geom_dotplot(binaxis = "y", stackdir = "center"), x, y, alpha, color, fill, group

f + geom_violin(scale = "area"), x, y, alpha, color, fill, group, linetype, size, weight

discrete x , discrete y

g <- ggplot(diamonds, aes(cut, color))

g + geom_count(), x, y, alpha, color, fill, shape, size, stroke

continuous bivariate distribution

h <- ggplot(diamonds, aes(carat, price))

h + geom_bin2d(binwidth = c(0.25, 500))
x, y, alpha, color, fill, linetype, size, weight

h + geom_density2d()
x, y, alpha, colour, group, linetype, size

h + geom_hex()
x, y, alpha, colour, fill, size

continuous function

i <- ggplot(economics, aes(date, unemploy))

i + geom_area()
x, y, alpha, color, fill, linetype, size

i + geom_line()
x, y, alpha, color, group, linetype, size

i + geom_step(direction = "hv")
x, y, alpha, color, group, linetype, size

visualizing error

df <- data.frame(grp = c("A", "B"), fit = 4:5, se = 1:2)
j <- ggplot(df, aes(grp, fit, ymin = fit-se, ymax = fit+se))

j + geom_crossbar(fatten = 2)
x, y, ymax, ymin, alpha, color, fill, group, linetype, size

j + geom_errorbar(), x, ymax, ymin, alpha, color, group, linetype, size, width (also **geom_errorbarh()**)

j + geom_linerange()
x, ymin, ymax, alpha, color, group, linetype, size

j + geom_pointrange()
x, y, ymin, ymax, alpha, color, fill, group, linetype, shape, size

maps

data <- data.frame(murder = USArrests$Murder, state = tolower(rownames(USArrests)))
map <- map_data("state")
k <- ggplot(data, aes(fill = murder))

k + geom_map(aes(map_id = state), map = map) **+ expand_limits(**x = map$long, y = map$lat), map_id, alpha, color, fill, linetype, size

THREE VARIABLES

seals$z <- with(seals, sqrt(delta_long^2 + delta_lat^2)); l <- ggplot(seals, aes(long, lat))

l + geom_contour(aes(z = z))
x, y, z, alpha, colour, group, linetype, size, weight

l + geom_raster(aes(fill = z), hjust=0.5, vjust=0.5, interpolate=FALSE)
x, y, alpha, fill

l + geom_tile(aes(fill = z)), x, y, alpha, color, fill, linetype, size, width

Vignettes

Many packages come with vignettes (tutorials)

List Vignettes

```
1  vignette(package = "ggplot2")
```

```
Vignettes in package ‘ggplot2’:

ggplot2-specs                   Aesthetic specifications (source, html)
extending-ggplot2               Extending ggplot2 (source, html)
profiling                       Profiling Performance (source, html)
```

Vignettes

Many packages come with vignettes (tutorials)

List Vignettes

```
1 vignette(package = "ggplot2")
```

```
Vignettes in package 'ggplot2':

ggplot2-specs                   Aesthetic specifications (source, html)
extending-ggplot2               Extending ggplot2 (source, html)
profiling                       Profiling Performance (source, html)
```

Load Vignettes

```
1 vignette("ggplot2-specs", package = "ggplot2")
```

Try it!

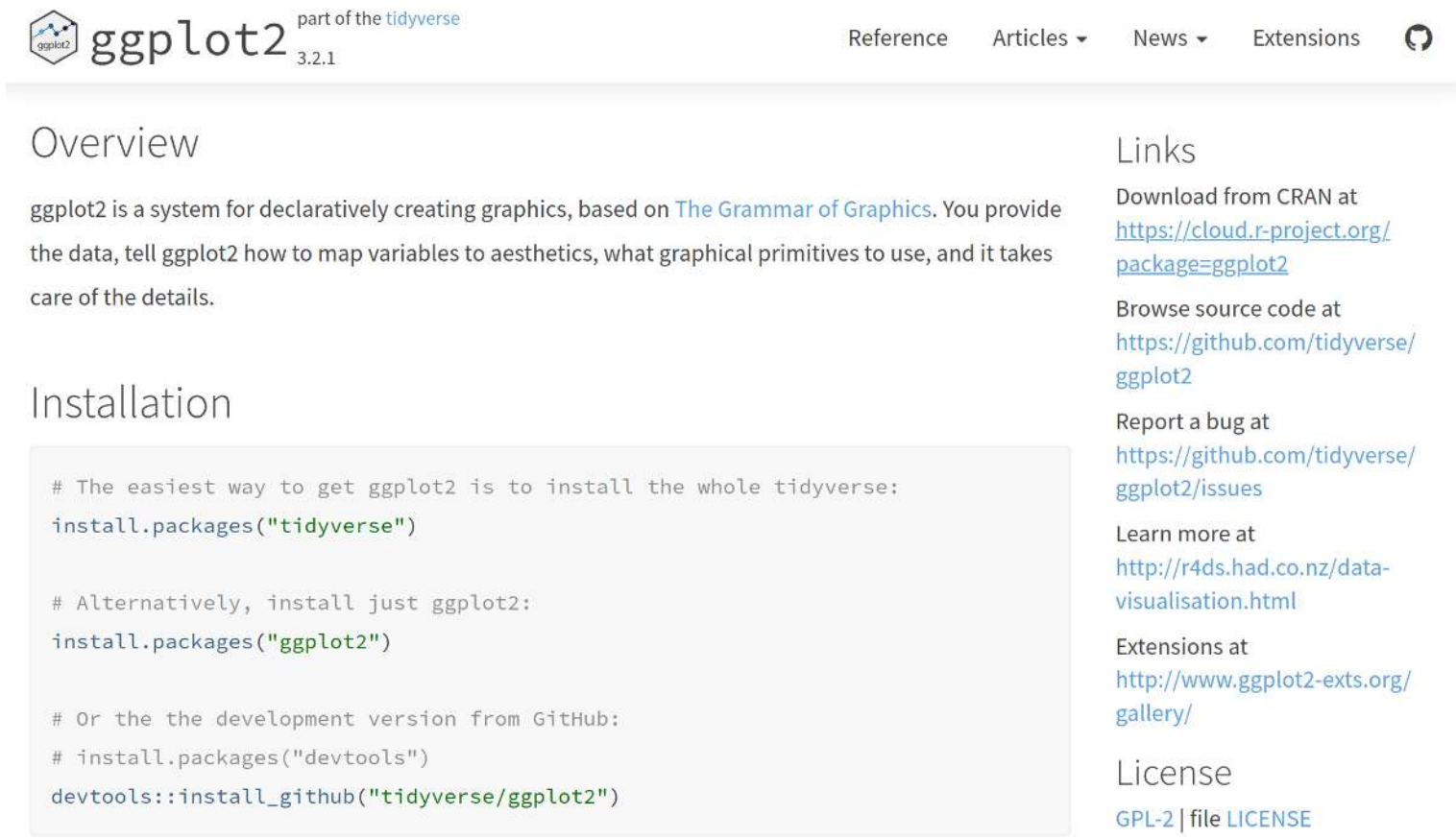
Tutorials

Vignettes are also online

- e.g., `ggplot2`
- e.g., `tidyverse`

Organizations/Websites

- Software Carpentry
- STHDA



Books!

Free Online

- R for Data Science (read it!)
- R Graphics Cookbook (how to do X)
- `ggplot2` (next level)
- Data Visualization: A practical introduction
- Geocomputation with R (spatial, GIS, maps)
- Statistical Inference via Data Science: A ModernDive into R and the tidyverse (stats)

Communities!

- rOpenSci
- Social Media
  - #RStats Twitter
  - #RStats Mastodon (e.g., Fosstodon.org or Hachyderm.io)
- Data Carpentry Lessons
- Data Science Learning Community on Slack

  (ask any question, they're really nice!)

Specific Groups

- rLadies
- MiR
- AfricaR
- AsiaR

Specific help

Examples

In R

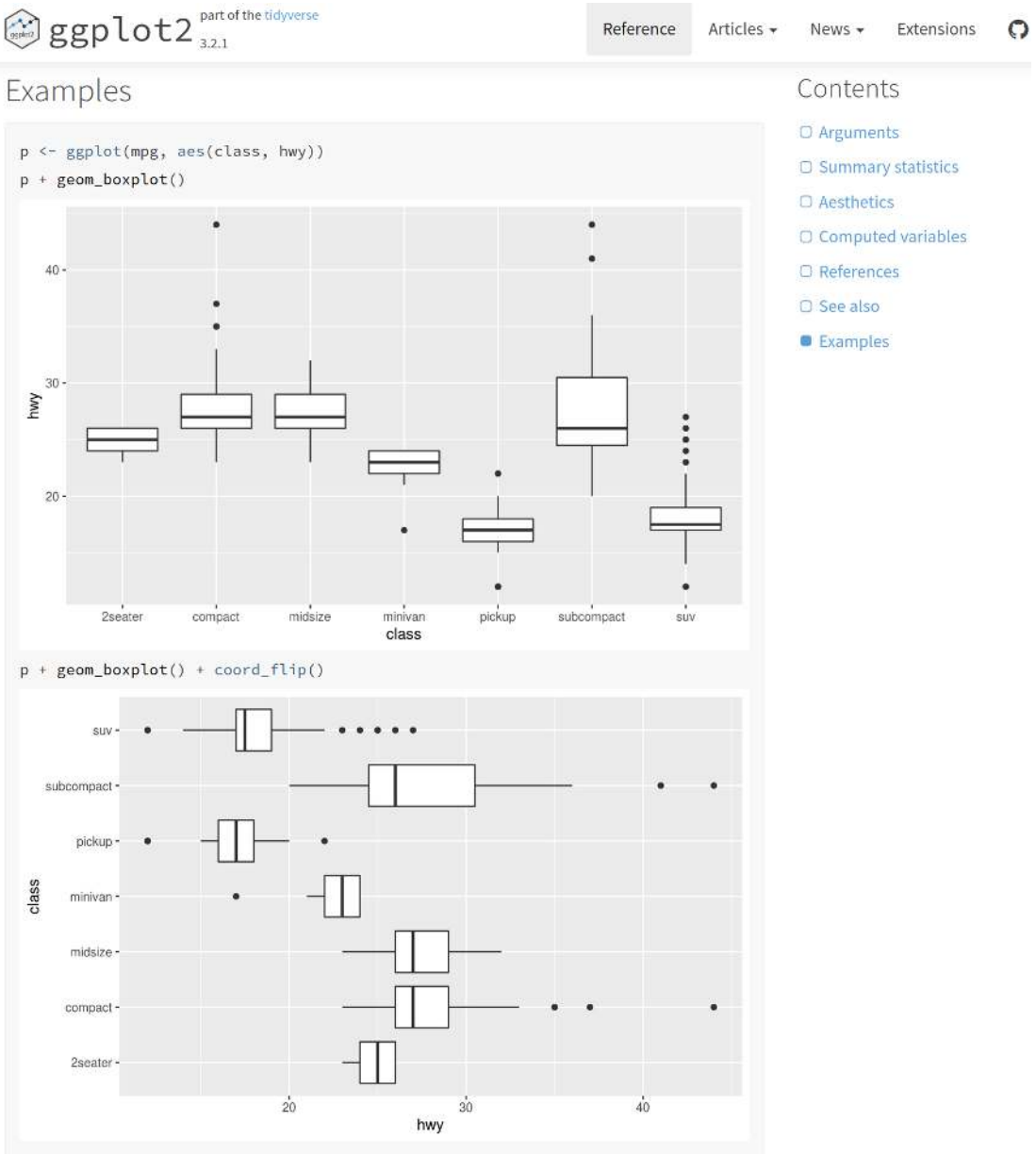
```
1  ?geom_boxplot
```

Copy and paste the examples into your console

Examples

On the web

- Nice to see expected output
- Helps figure out if it's your system or your code



Web searches

- Always include “R” in the search
- Include the package name!
- Use keywords
- Some errors are very general

Web searches

- **Always include “R” in the search**
- **Include the package name!**
  - Try “R boxplots” vs. “R boxplots ggplot2”
- **Use keywords**
  - Try “R boxplots ggplot2 notch”
- **Some errors are very general**
  - Try “R Error: object ‘m’ not found”

Stackoverflow etc.

“R how to remove duplicate rows”

Stackoverflow etc.

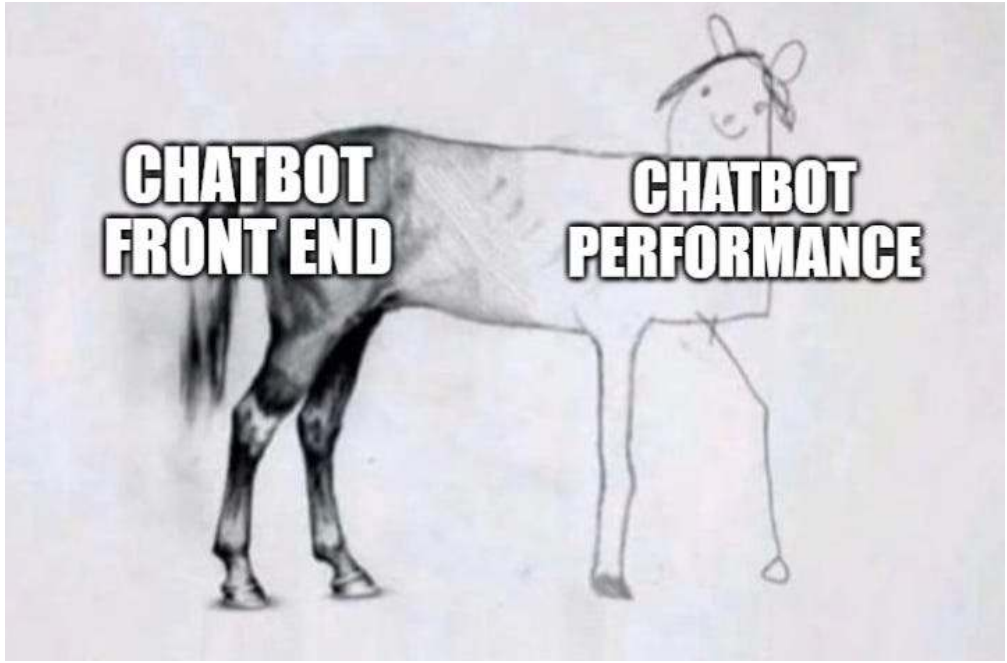
Things to consider

- Date (i.e., R version, Package Version)
- Packages used (`tidyverse`? R base? A mix?)
- What are the example data?
  - `mtcars` and `iris` are commonly used data sets built into R base
  - `msleep` and `diamonds` are commonly used data sets built into `ggplot2`
- What are the example columns?
- What is actually required to answer *your* question?

AI (specifically LLMs) ✨

General Cautions

- Can be useful, can be painful
- Free models are so-so
- R changes fast, so AI answers can be out of date
- Own your work



AI (specifically LLMs) ✨

Good usecases: Use AI to…

- *Support* your work, not *do* you work
- Remind yourself (enhanced search)
- Help troubleshooting
  - Rubber duck that answers back
  - Even incorrect answers can help
- Ask for suggestions for improvement

Bad usecases: Do NOT use AI to…

- Create code you can't evaluate (Too soon)
- Have AI create code you don't evaluate (Too fast)
- Work with private/sensitive data

Asking people for Help

Not useful

- “I got an error”
- “It didn’t work”

Asking people for Help

Not useful

- “I got an error”
- “It didn’t work”

Better!

- “I got *this* error”
- “It didn’t give me *this*”

Asking people for Help

Not useful

- “I got an error”
- “It didn’t work”

Better!

- “I got *this* error”
- “It didn’t give me *this*”

Best!!

- “I did *this* and I got *this* error”
- “I expected it to do *this*, but in fact the output was *this*”

Asking people for Help

Not useful

- “I got an error”
- “It didn’t work”

Better!

- “I got *this* error”
- “It didn’t give me *this*”

Best!!

- “I did *this* and I got *this* error”
- “I expected it to do *this*, but in fact the output was *this*”

Best of the Best!!!

- “I did *this* [small reproducible code, including data set] and I got *this* [exact error/output]”

Reproducible Examples

- Minimal code and data required to reproduce the error
- Often preparing this actually helps you solve the error!
- Includes
  - packages (`library()`)
  - data
  - runnable code

Reproducible Examples

How do I change the order of `vore`?

Not reproducible

```
ggplot(data = m, aes(x = vore, y = awake, fill = `Body Size`)) +
  theme_bw() +
  theme(axis.title.x = element_blank()) +
  geom_boxplot() +
  scale_fill_viridis_d() +
  labs(y = "Awake time (hrs)",
       title = "Awake time by Diet")
```

```
Error:
! object 'm' not found
```

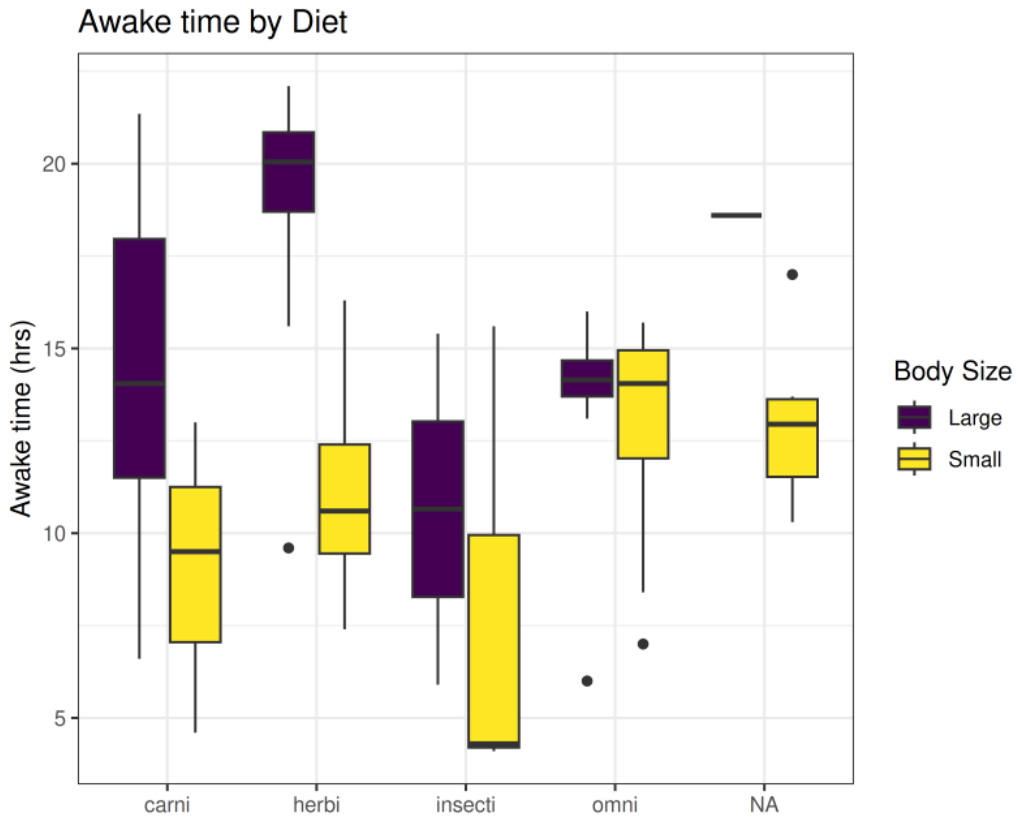
- No indication of packages
- No indication of what `m` is

Reproducible Examples

How do I change the order of `vore`?

Reproducible, but not minimal

```
1  library(ggplot2)
2
3  m <- msleep |>
4    mutate(`Body Size` = if_else(bodywt > median(bodywt),
5                                 "Large", "Small"))
6
7  ggplot(m, aes(x = vore, y = awake, fill = `Body Size`)) +
8    theme_bw() +
9    theme(axis.title.x = element_blank()) +
10   geom_boxplot() +
11   scale_fill_viridis_d() +
12   labs(y = "Awake time (hrs)",
13        title = "Awake time by Diet")
```

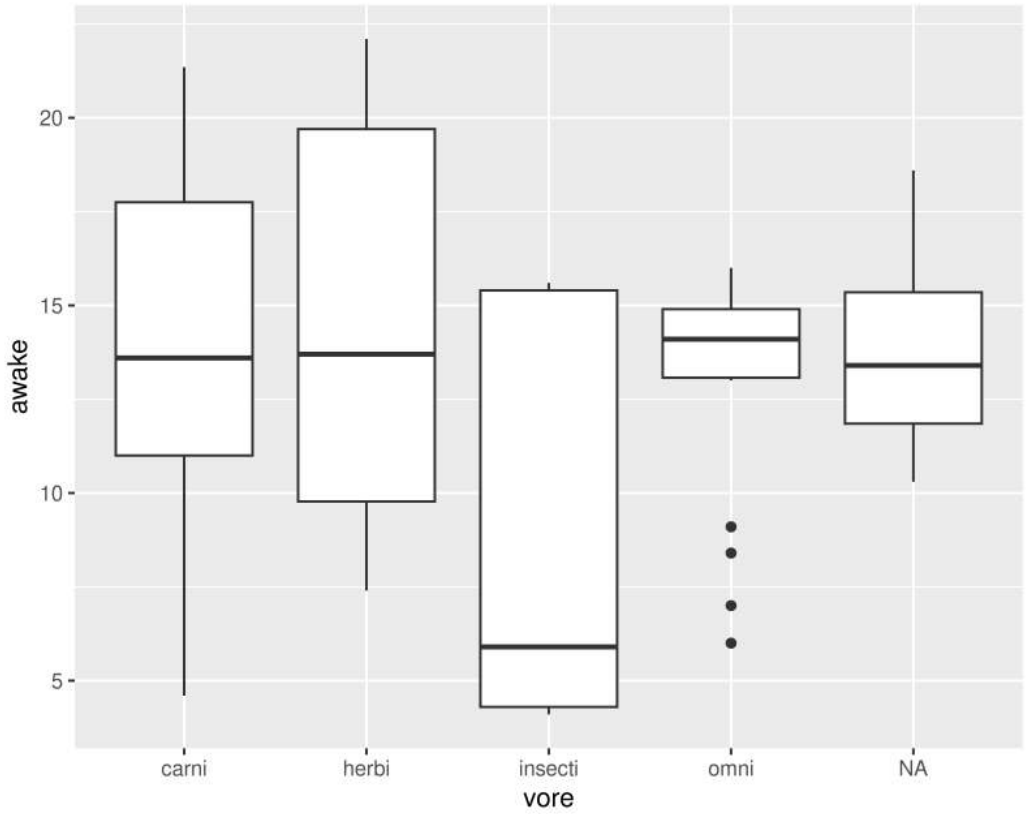


Reproducible Examples

How do I change the order of `vore`?

Reproducible AND Minimal

```
1  library(ggplot2)
2
3  ggplot(msleep, aes(x = vore, y = awake)) +
4    geom_boxplot()
```



Paying it forward

Citing Software

In-line Text

- Software name
- Version
- Programmers/authors OR Journal article releasing the software (if available)

Bibliography

- Journal article releasing the program **OR**
- Programmers/authors
- Year of release
- Program Name
- URL

Citing R

Inline

“All statistical analyses were performed with R statistical software (v4.5.2, R Core Team 2025).”

Bibliography

R Core Team (2025). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Citing R

Version information

```
1 R.Version()$version.string
```

```
[1] "R version 4.5.2 (2025-10-31)"
```

Citation information

```
1 citation()
```

```
To cite R in publications use:

  R Core Team (2025). _R: A Language and Environment for Statistical
  Computing_. R Foundation for Statistical Computing, Vienna, Austria.
  <https://www.R-project.org/>.
```

Citing R Packages

Inline

“All statistical analyses were performed with R statistical software (v4.0.3, R Core Team 2020). We performed Type III ANOVAs using the ‘car’ package for R (v3.0.10, Fox and Weisberg 2019).”

Bibliography

John Fox and Sanford Weisberg (2019). An R Companion to Applied Regression, Third Edition. Thousand Oaks CA: Sage.

Citing R Packages

Version information

```
1 packageVersion("car")
```

```
[1] '3.1.5'
```

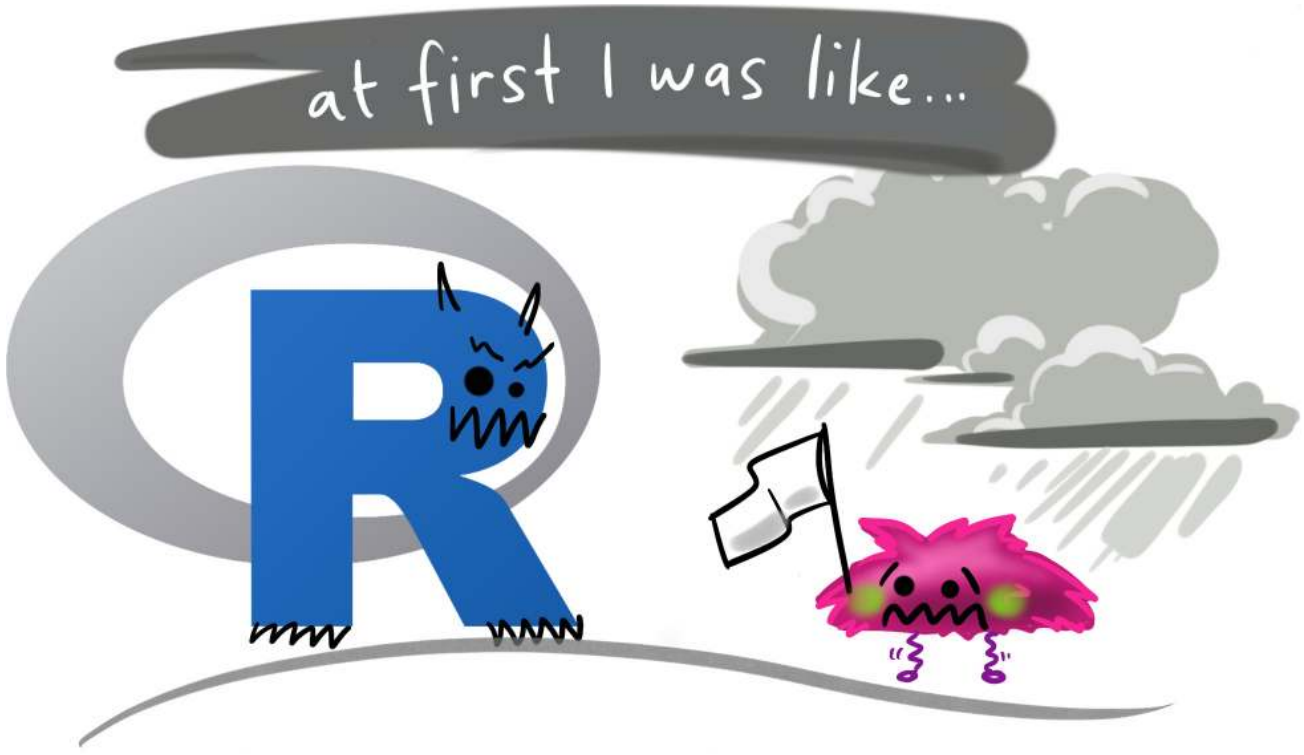
Citation information

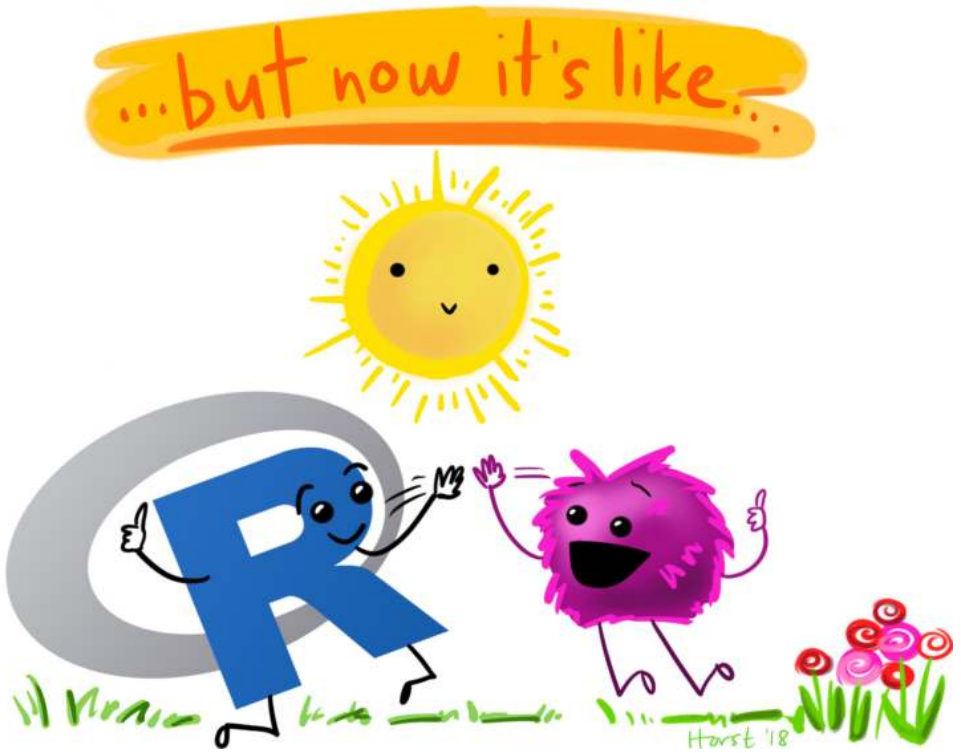
```
1 citation("car")
```

```
To cite the car package in publications use:

  Fox J, Weisberg S (2019). _An R Companion to Applied Regression_,
  Third edition. Sage, Thousand Oaks CA.
  <https://www.john-fox.ca/Companion/>.
```

See more about citing packages in my rOpenSci blog post: How to Cite R and R packages





You made it!

Thank you!

(Feedback!)

Artwork by @allison_horst