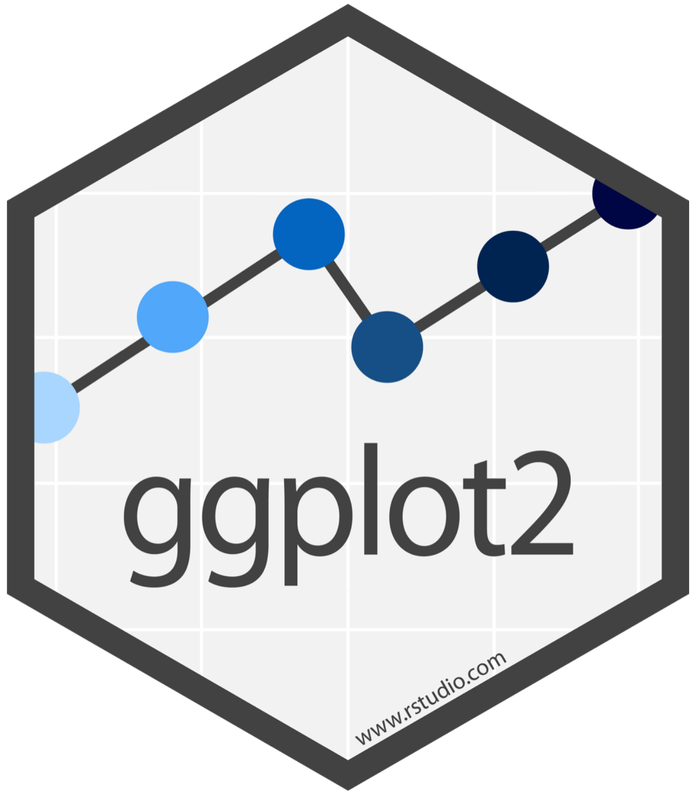
FUTURE EDUCATION MODENA

UNIMORE UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

C/LAB Contamination Lab

Visualize Data with



FUTURE
EDUCATION
MODENA

What is FEM?

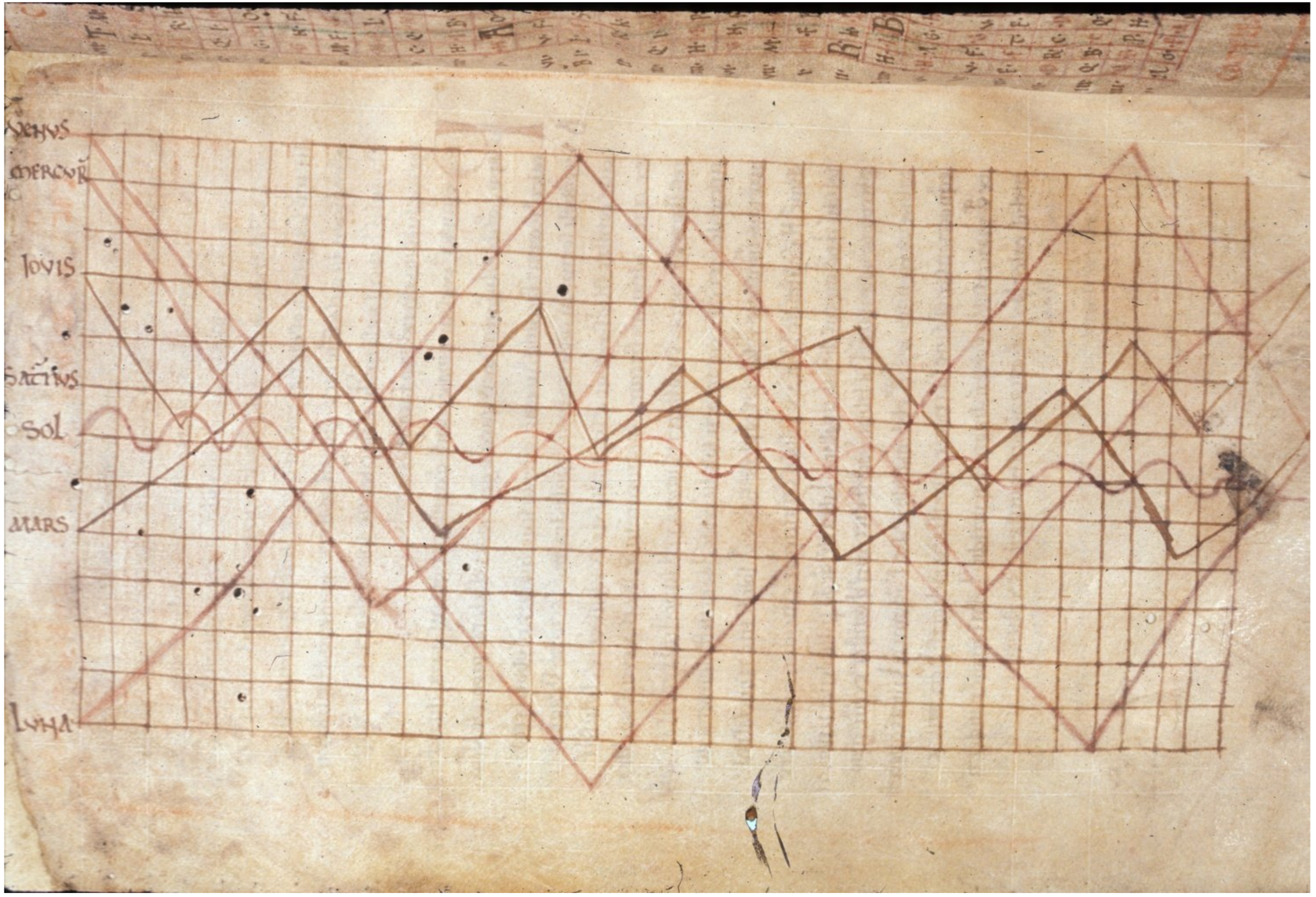
FEM – *Future Education Modena* – is an international EdTech center based in Modena, Italy.
It has started its activities on March 19th, 2019
Funded by **Fondazione Cassa Di Risparmio di Modena** and created by the company **Wonderful Education**, FEM is an independent entity hosted by the Cultural Center *AGO - Modena Fabbriche Culturali*. Its broad aims include:

1. **To increase the potential and to elevate** the role of education in society with a particular respect to the relationship between **education, technology and innovation** *(e.g. motivation, involvement, desire for education)*

2. To **investigate** the **implications of technology in education**, promoting a **research-led agenda for educational technologies** (*e.g. digital experience and well-being, media and information literacy, parenting and technology*)

3. To **tackle emerging educational needs by** developing and delivering innovative methodological approaches *(e.g. challenge-based learning, involvement and pleasure, personal growth)* to build an original vision of 21st century skills

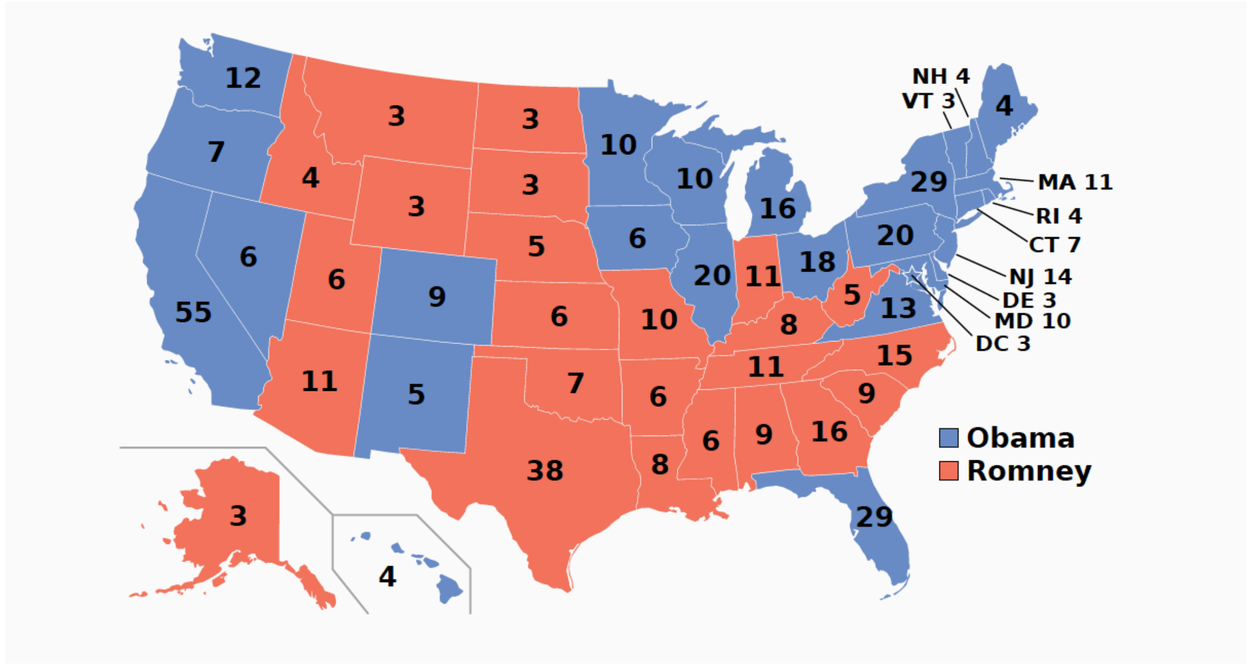
What is data science?

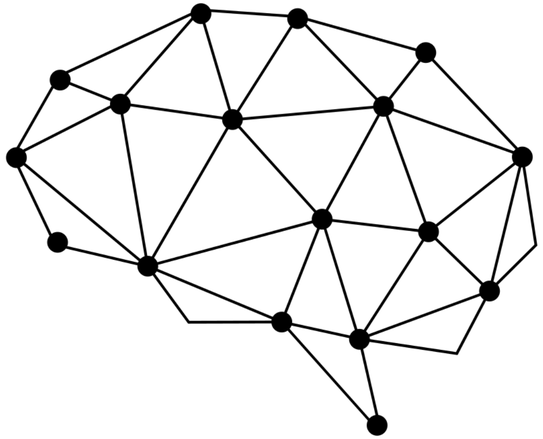

SATVRNVS
MERCVRI
IOVIS
MARS
LVNA

FUTURE EDUCATION MODENA

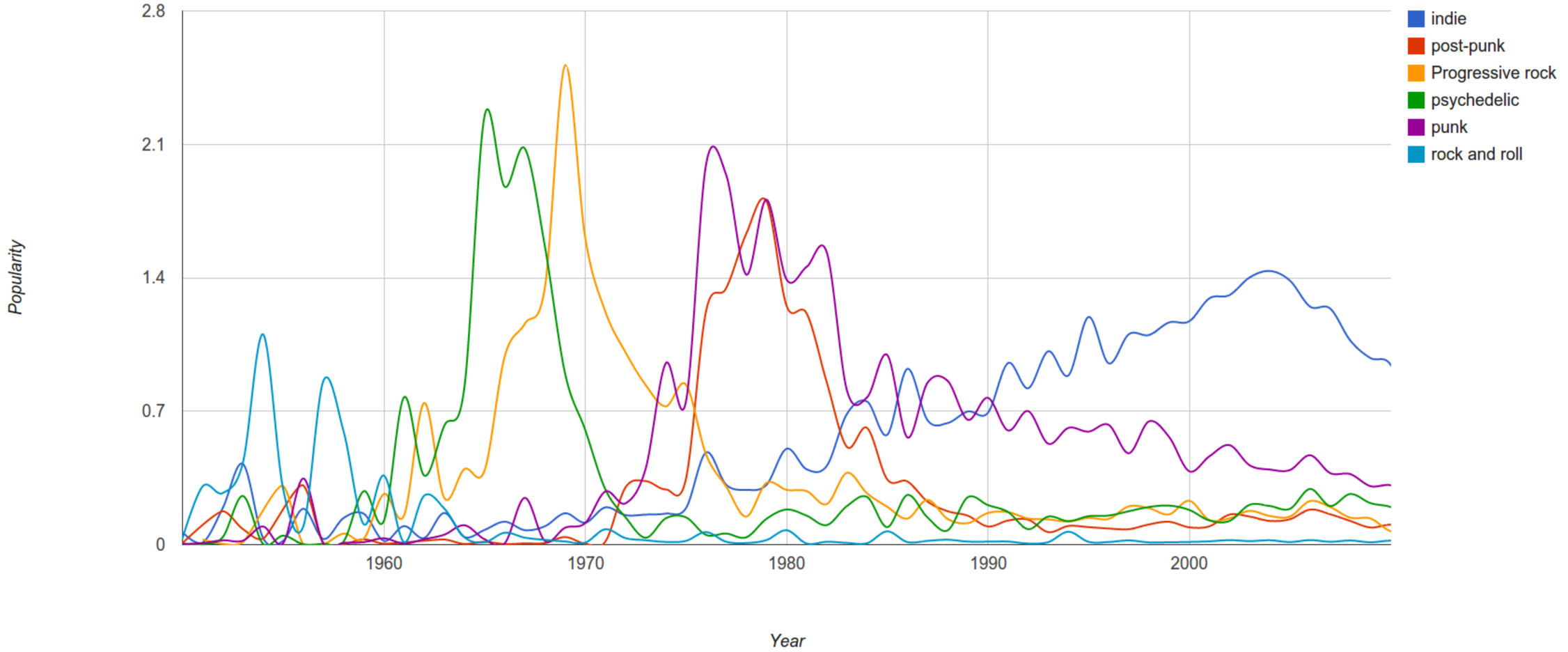
UNIMORE UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

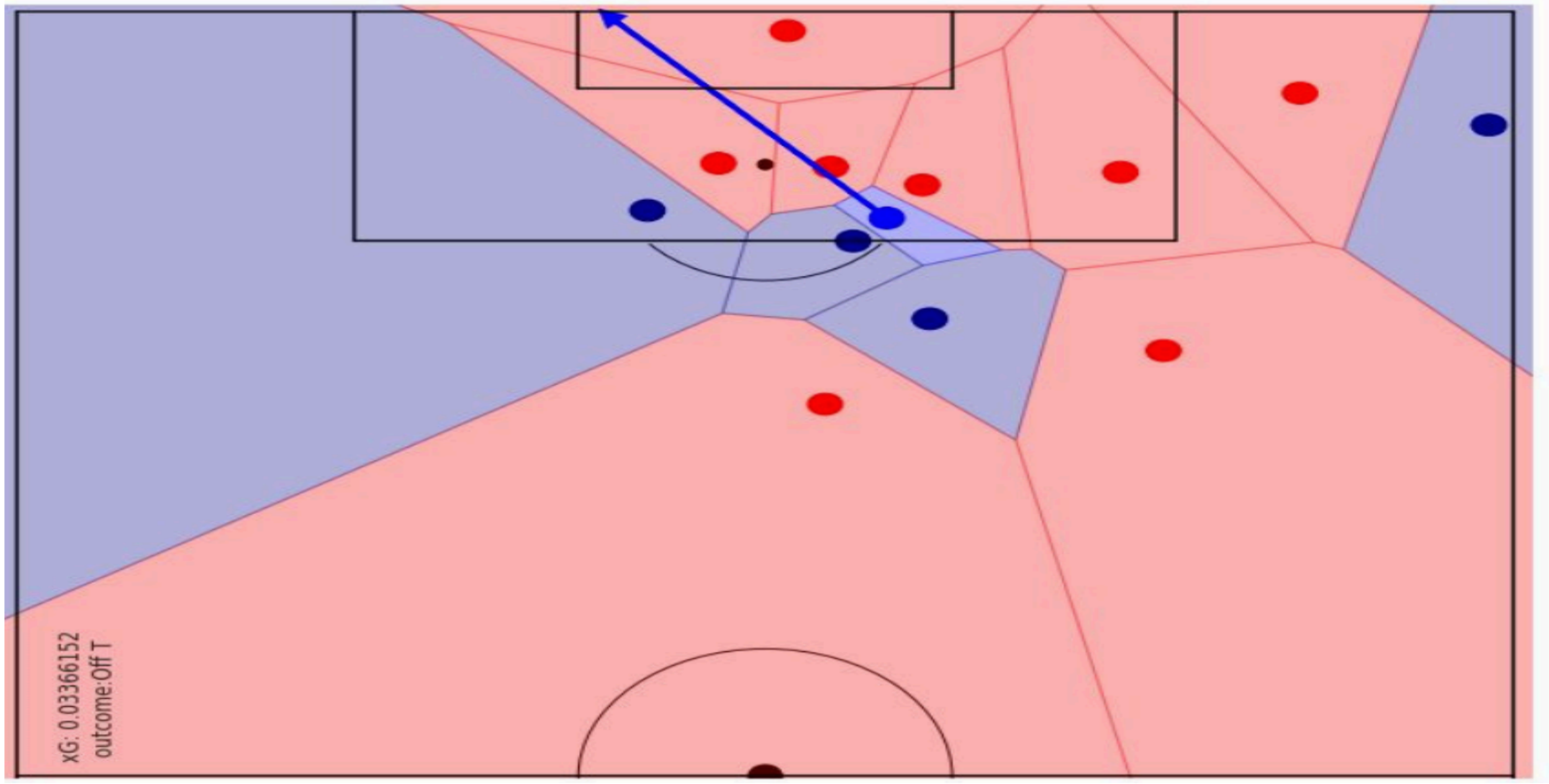
C/LAB Contamination Lab





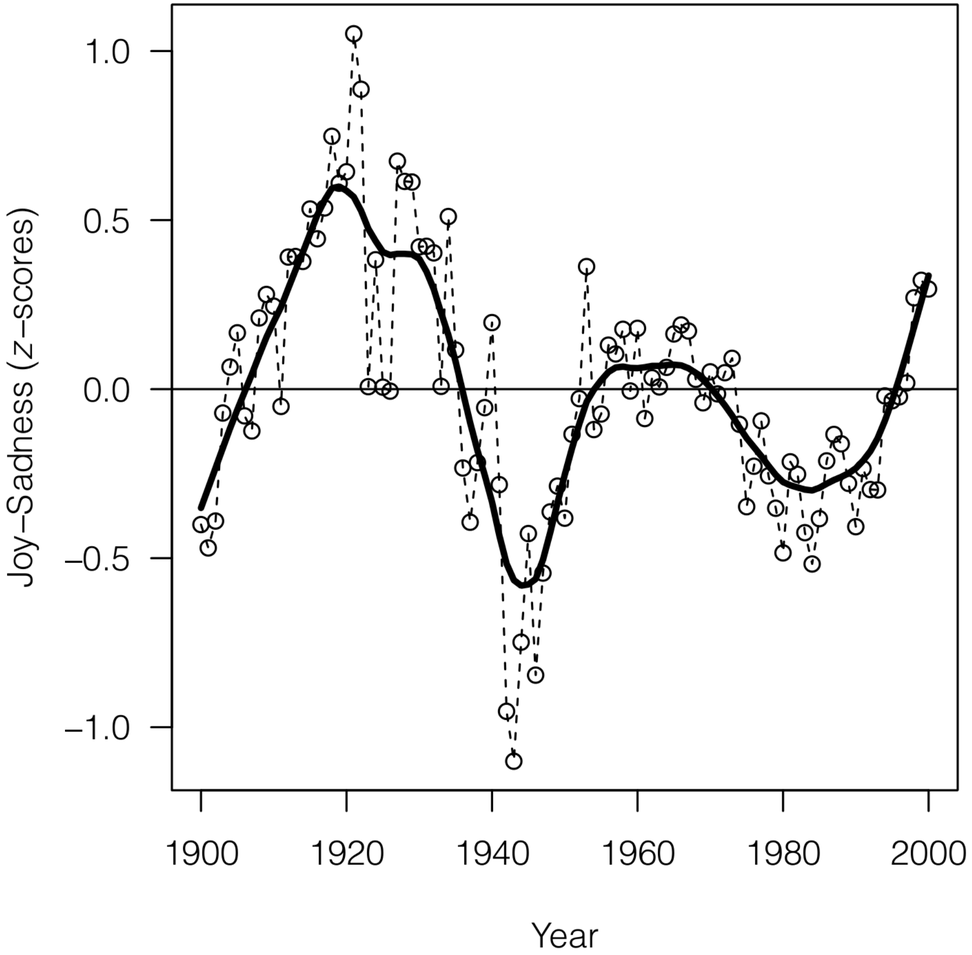
Cambridge Analytica

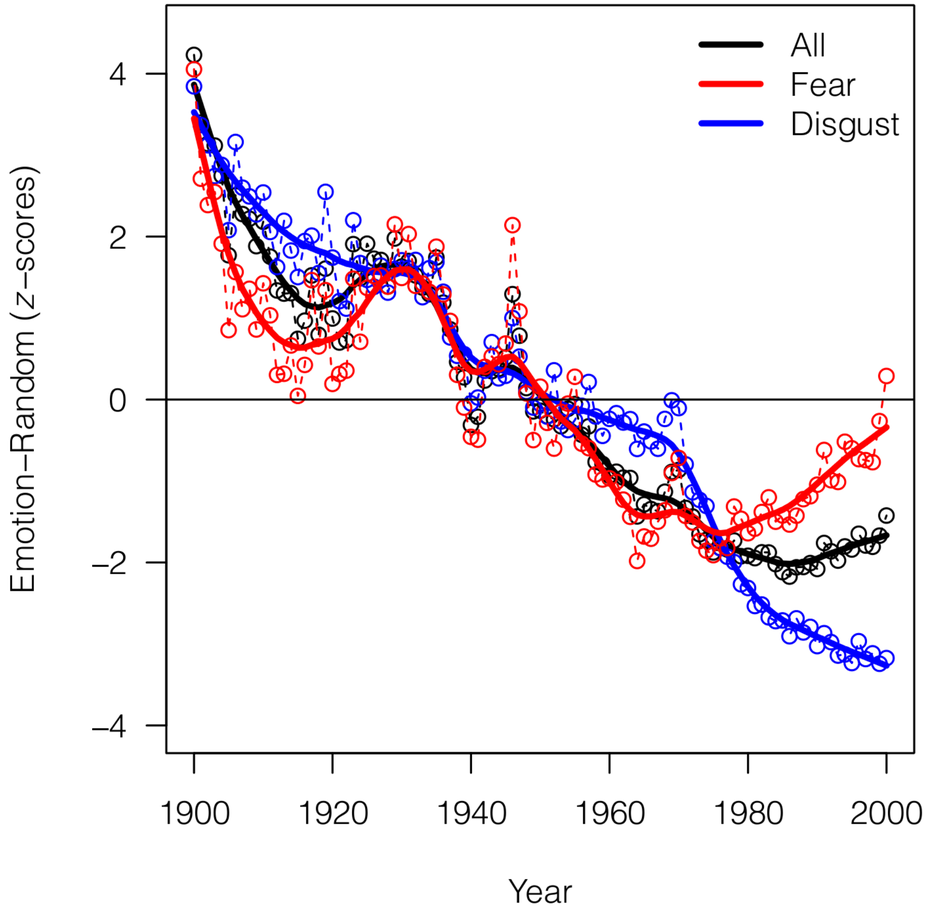

2.8
2.1
1.4
0.7
0
Popularity
1960
1970
1980
1990
2000
Year
indie
post-punk
Progressive rock
psychedelic
punk
rock and roll

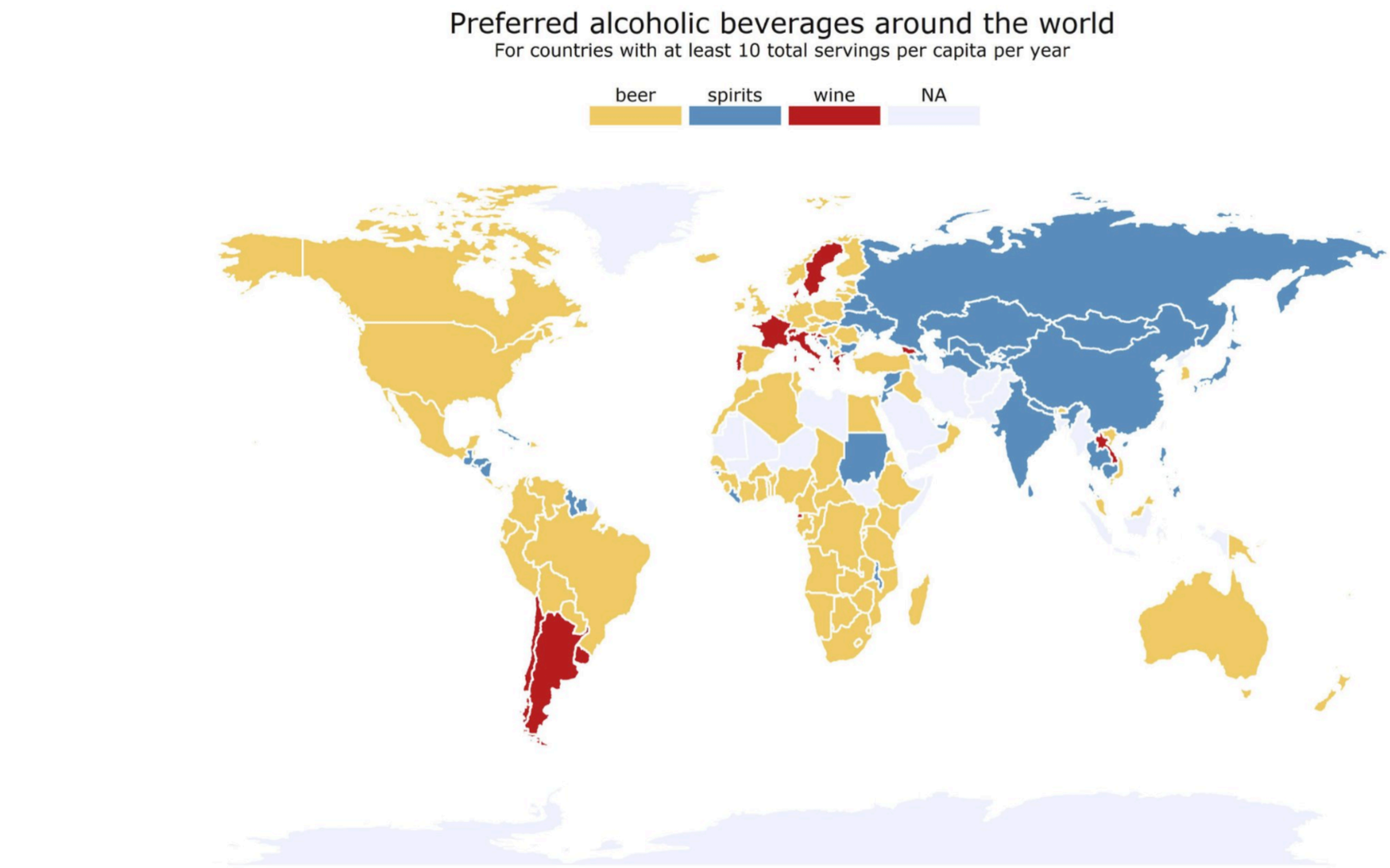

xG: 0.0336152
outcome:Off T

Acerbi et al. 2013. T**he Expression of Emotions in 20th Century Books**. PLoS ONE 8(3).

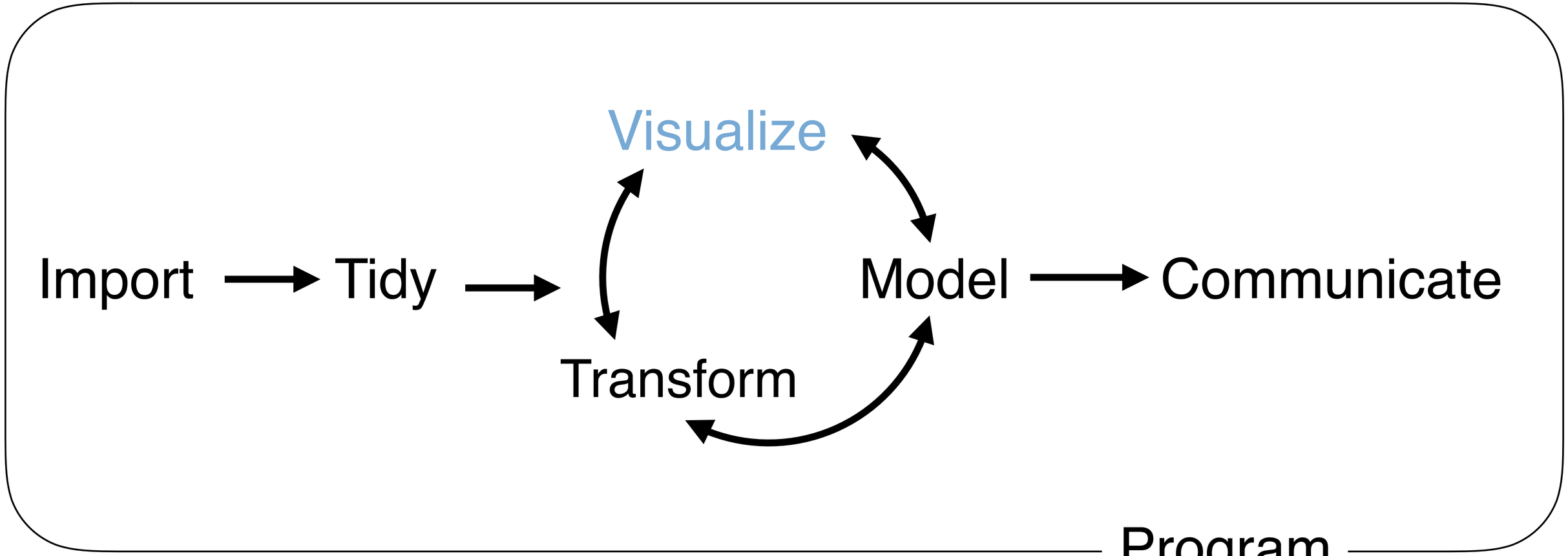
Have the words that we choose to use in our collective literature changed over time and does that tell us something about culture?






Preferred alcoholic beverages around the world
For countries with at least 10 total servings per capita per year
beer
spirits
wine
NA
Alcohol Consumption by @veerlevanson

(Applied) Data Science

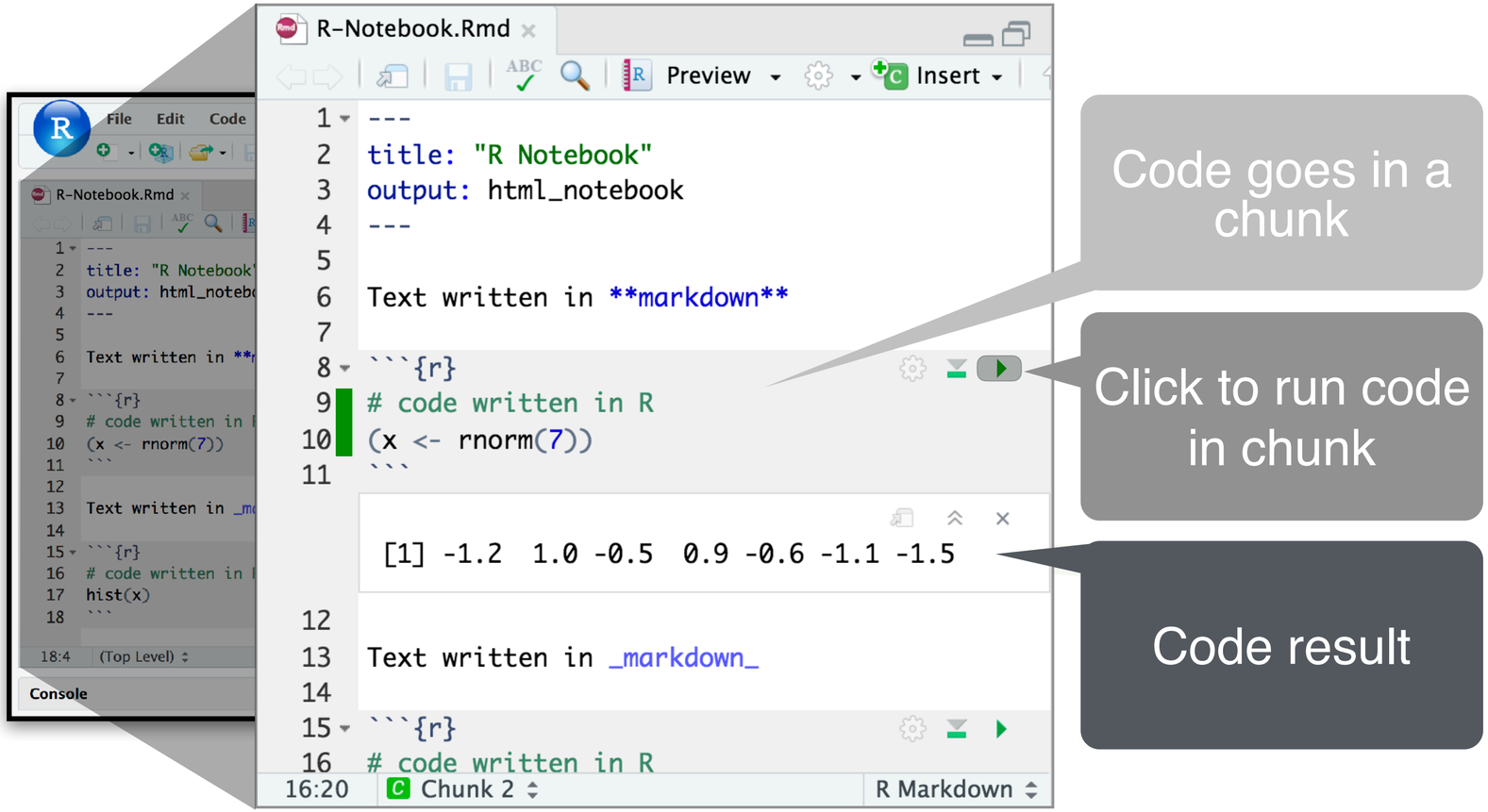


"The simple graph has brought more information to the data analyst’s mind than any other device. "

- John Tukey

R Markdown

An authoring format for Data Science.



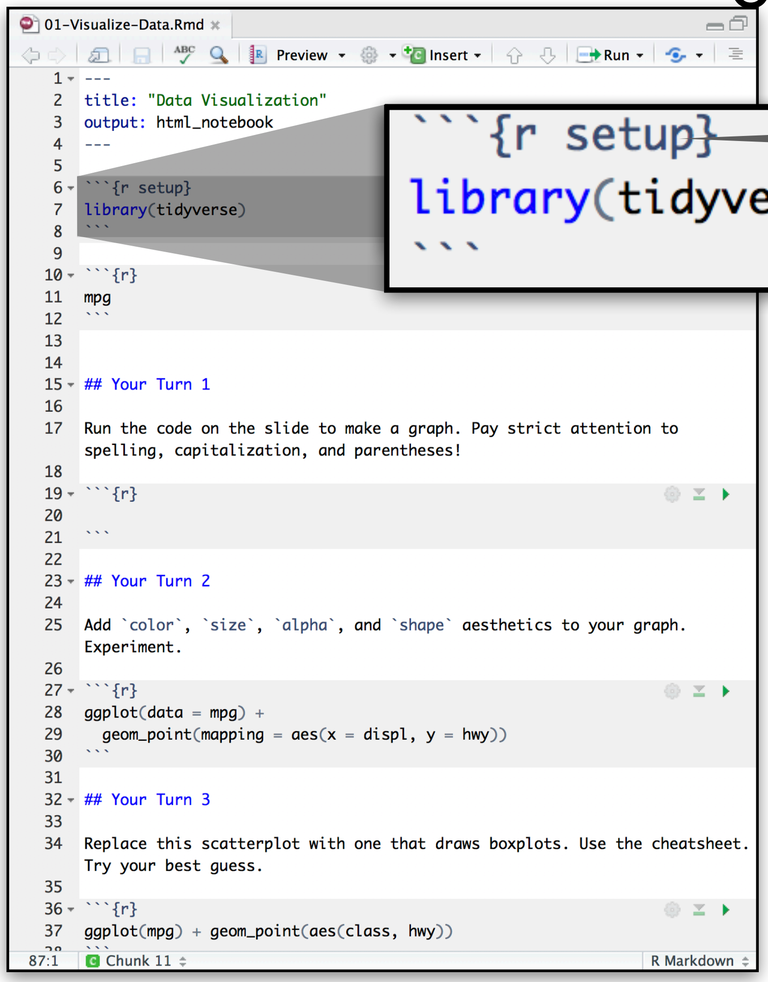
Code chunks

Insert a chunk of R code with

```
```{r}
# some code
```
```

Setup

The setup chunk is always run once before anything else




```{r setup}
library(tidyverse)
```

chunk labels are optional, the setup label is special

mpg

Fuel economy data for 38 models of car

```
mpg
```

manufacturer <chr>	displ <dbl>	year <int>	cyl <int>	trans <chr>	drv <chr>	cty <int>	hwy <int>	fl <chr>	class <chr>
audi	1.8	1999	4	auto(l5)	f	18	29	p	compact
audi	1.8	1999	4	manual(m5)	f	21	29	p	compact
audi	2.0	2008	4	manual(m6)	f	20	31	p	compact
audi	2.0	2008	4	auto(av)	f	21	30	p	compact
audi	2.8	1999	6	auto(l5)	f	16	26	p	compact
audi	2.8	1999	6	manual(m5)	f	18	26	p	compact
audi	3.1	2008	6	auto(av)	f	18	27	p	compact

Quiz

Confer with your group.

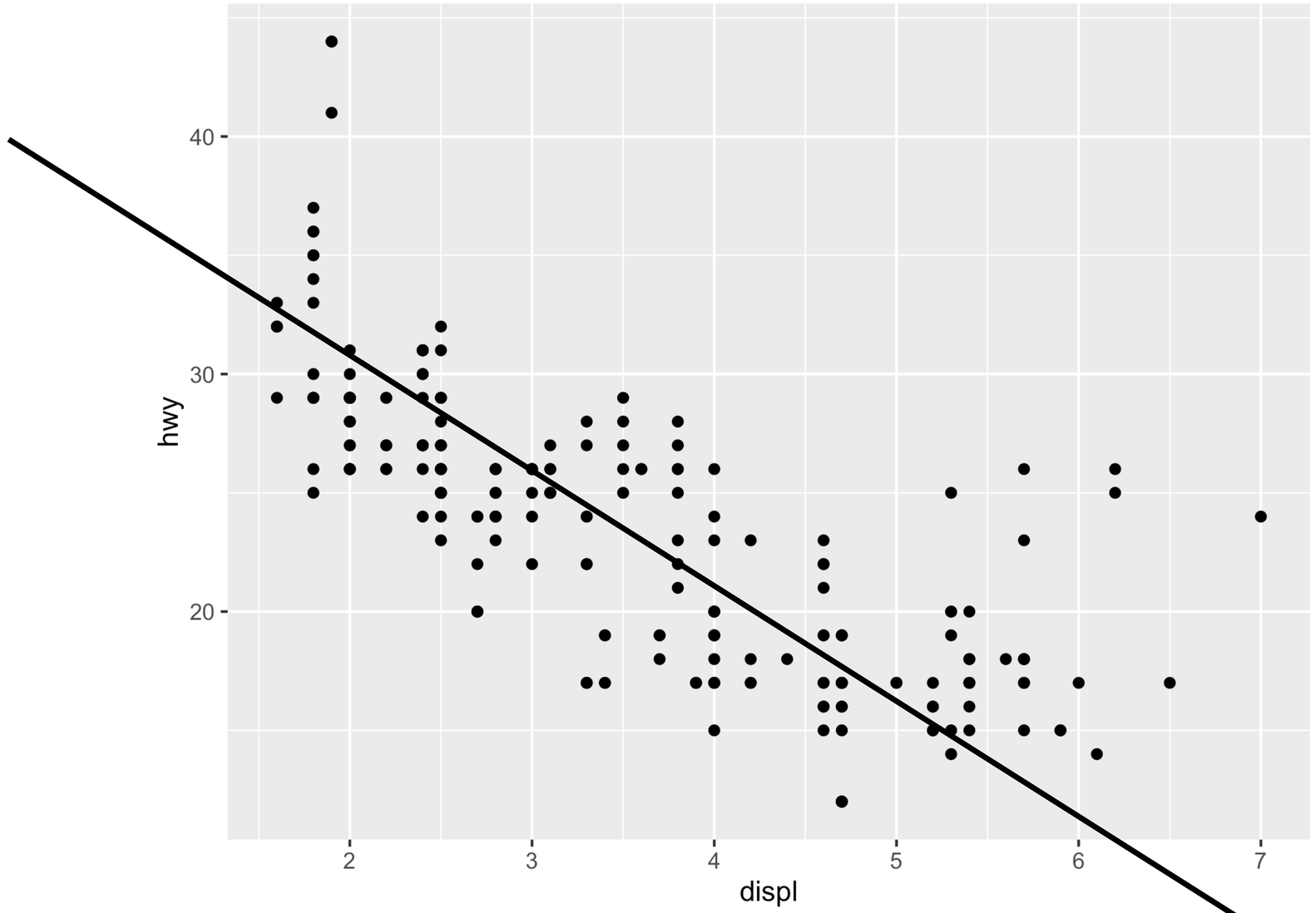
What relationship do you expect to see between engine size (displ) and mileage (hwy)?

No peeking ahead!

Your Turn 1

Run this code in 02-Visualize-Exercises.Rmd to make a graph. Pay strict attention to spelling, capitalization, and parentheses!

```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy))
```



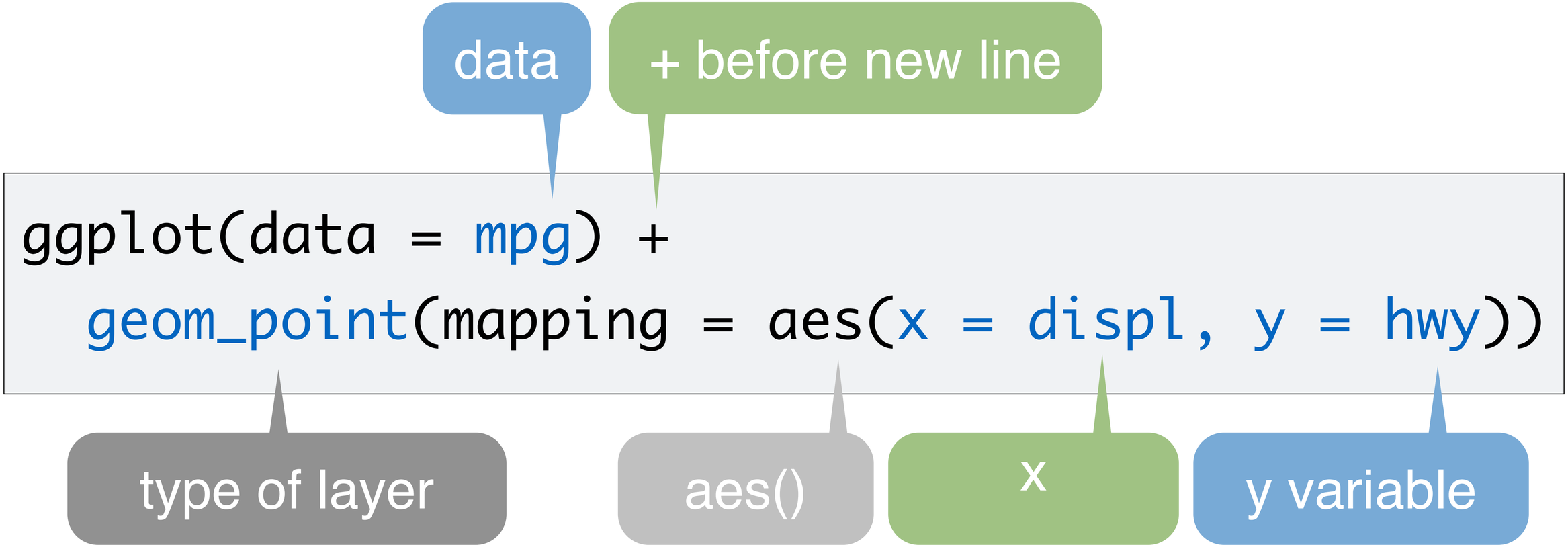

```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy))
```

1. "Initialize" a plot with ggplot()
2. Add layers with geom_ functions

```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy))
```

Pro tip: Always put the + at the end of a line, Never at the start

```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy))
```

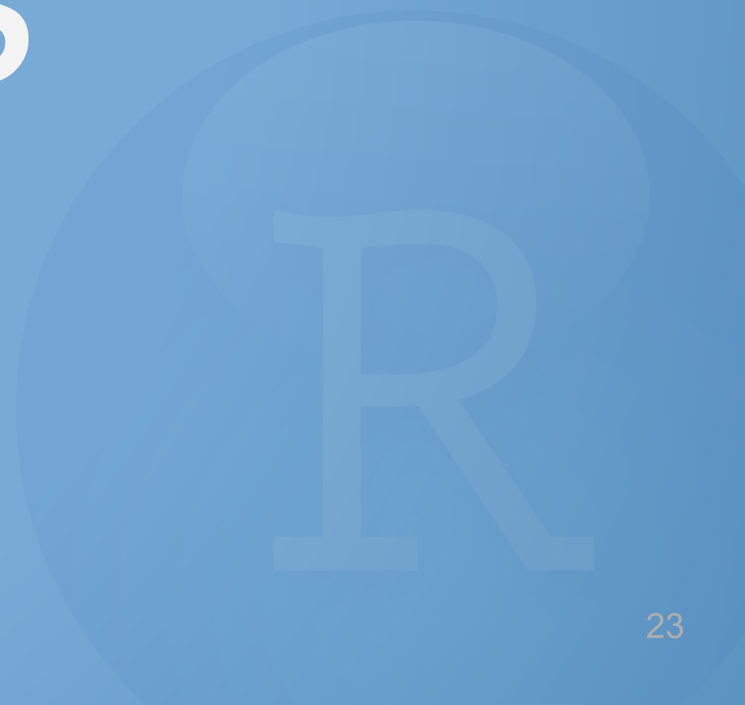

data
+ before new line
ggplot(data = mpg) +
geom_point(mapping = aes(x = displ, y = hwy))
type of layer
aes()
x
y variable

A template

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

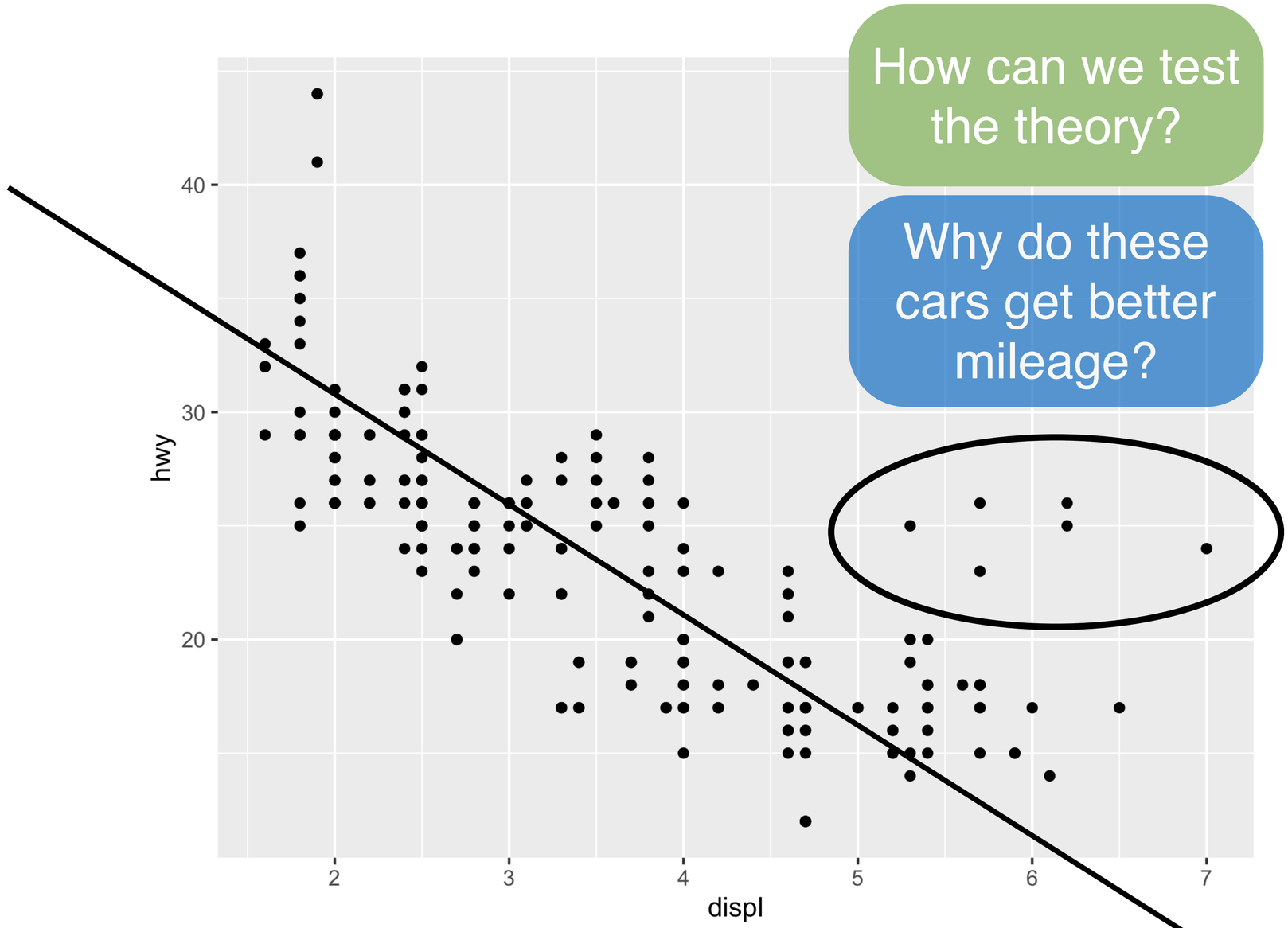
```
  geom_point(mapping = aes(x = displ, y = hwy))
```

Mappings



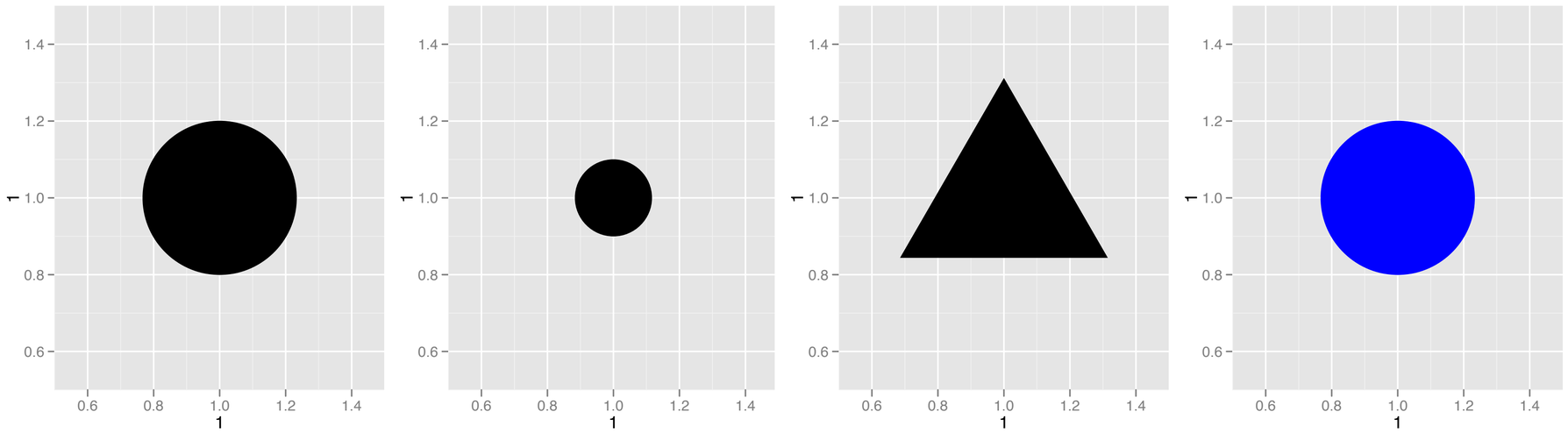
"The greatest value of a picture is when it forces us to notice what we never expected to see."

- John Tukey




```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy))
```

Aesthetics




Visual Space
Data Space
color
class
Red
Brown
Green
Aqua
Blue
Violet
Pink
2seater
compact
midsize
minivan
pickup
subcompact
suv

Aesthetics

aesthetic property

Variable to map it to

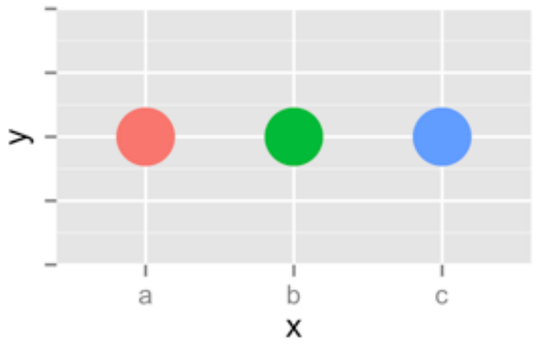
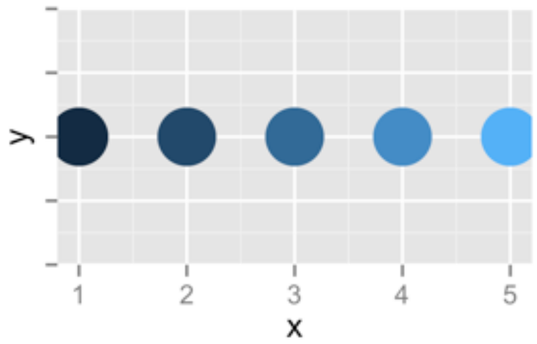
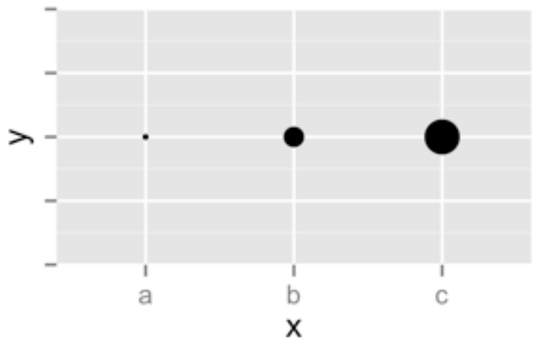
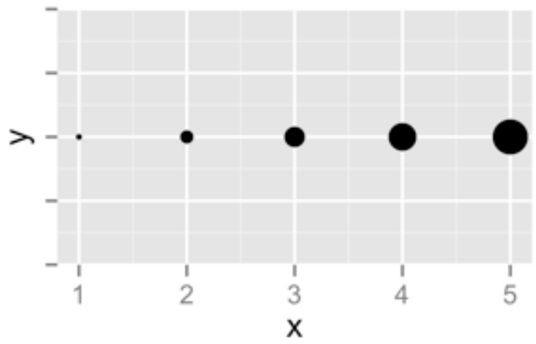
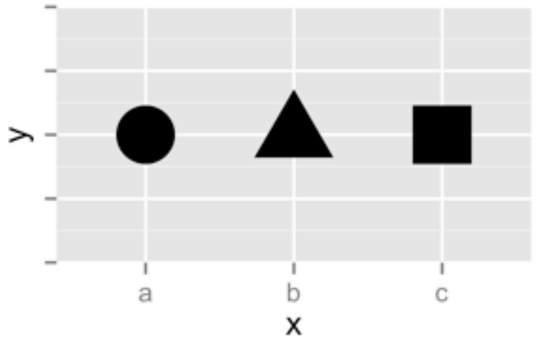
```
ggplot(mpg) + geom_point(aes(x = displ, y = hwy, color = class))
ggplot(mpg) + geom_point(aes(x = displ, y = hwy, size = class))
ggplot(mpg) + geom_point(aes(x = displ, y = hwy, shape = class))
ggplot(mpg) + geom_point(aes(x = displ, y = hwy, alpha = class))
```

Your Turn 2

In the next chunk, add color, size, alpha, and shape aesthetics to your graph. Experiment.

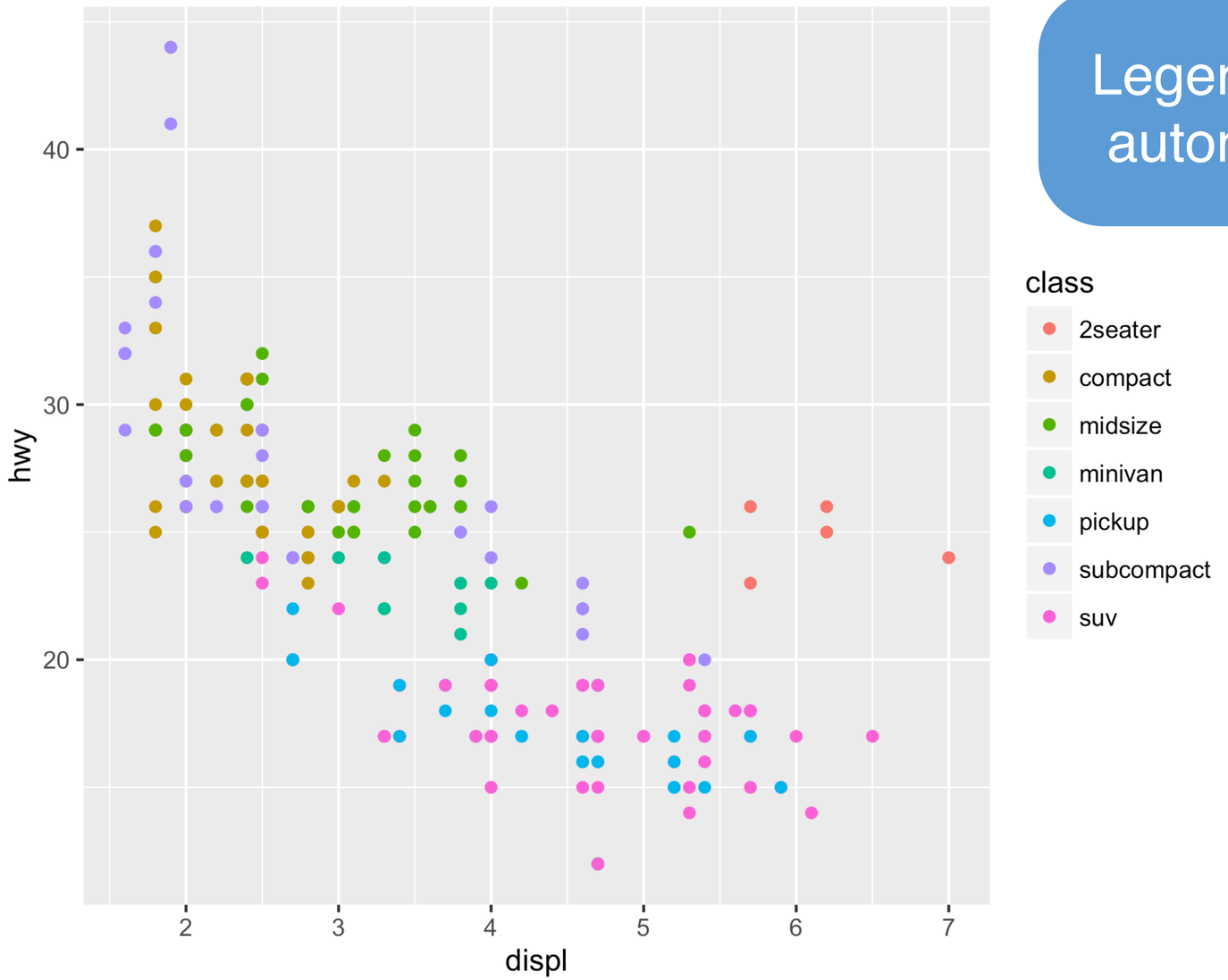
Do different things happen when you map aesthetics to discrete and continuous variables?

What happens when you use more than one aesthetic?

	Discrete	Continuous
Color		
Size		
Shape		

https://twitter.com/allison_horst?lang=en

ggplot2



Legend added automatically

```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy, color = class))
```

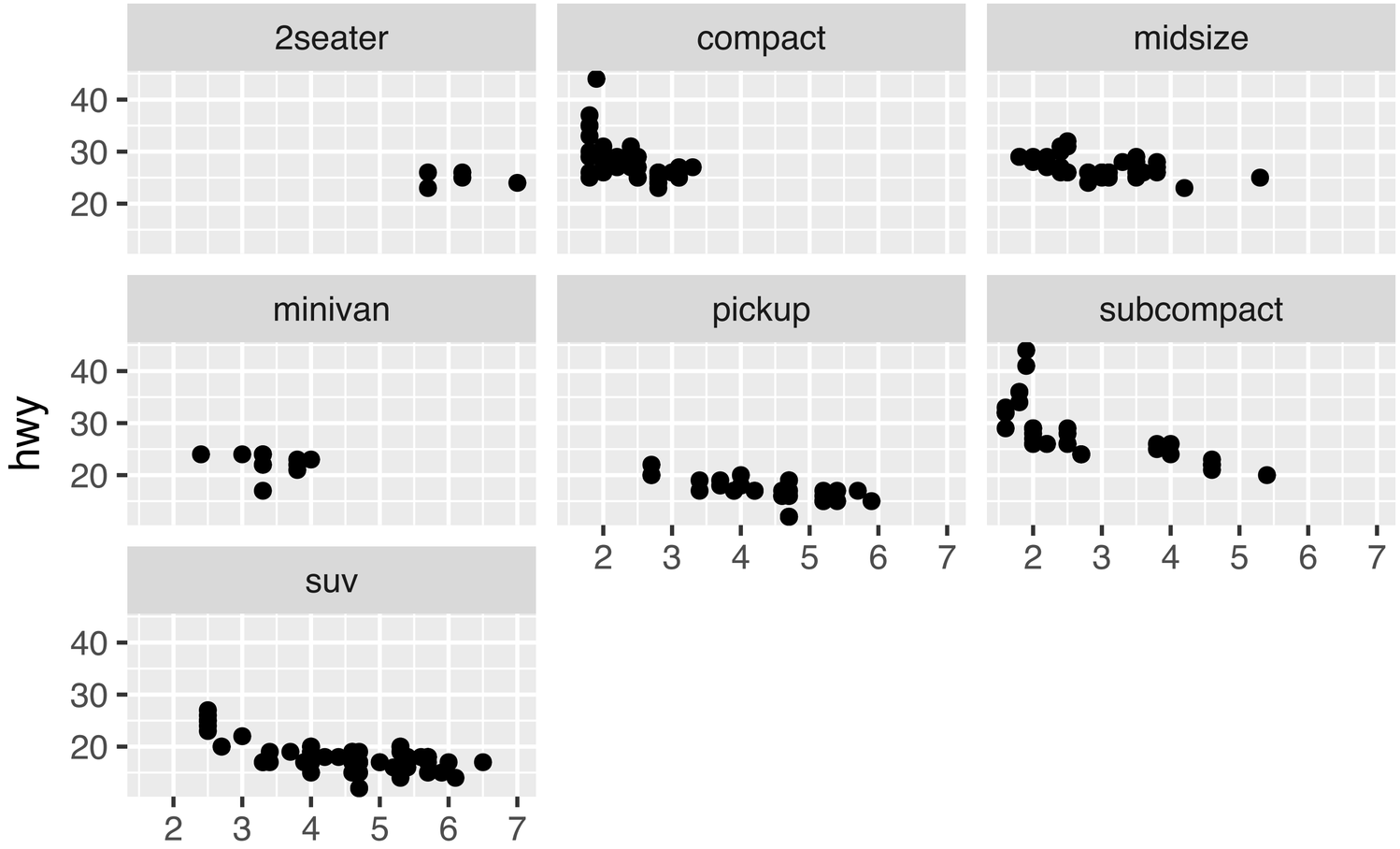
Error!

```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy), color = class)
```

Facets

Facets

Subplots that display subsets of the data.



Help me

What do facet_grid and facet_wrap do?

```
q <- ggplot(mpg) + geom_point(aes(x = displ, y = hwy))
q + facet_grid(. ~ cyl)
q + facet_grid(drv ~ .)
q + facet_grid(drv ~ cyl)
q + facet_wrap(~ class)
```

summary

facet_grid() - 2D grid, rows ~ cols, . for no split
facet_wrap() - 1D ribbon wrapped into 2D

A ggplot2 template

Make any plot by filling in the parameters of this template

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>)) +
  <FACET_FUNCTION>
```

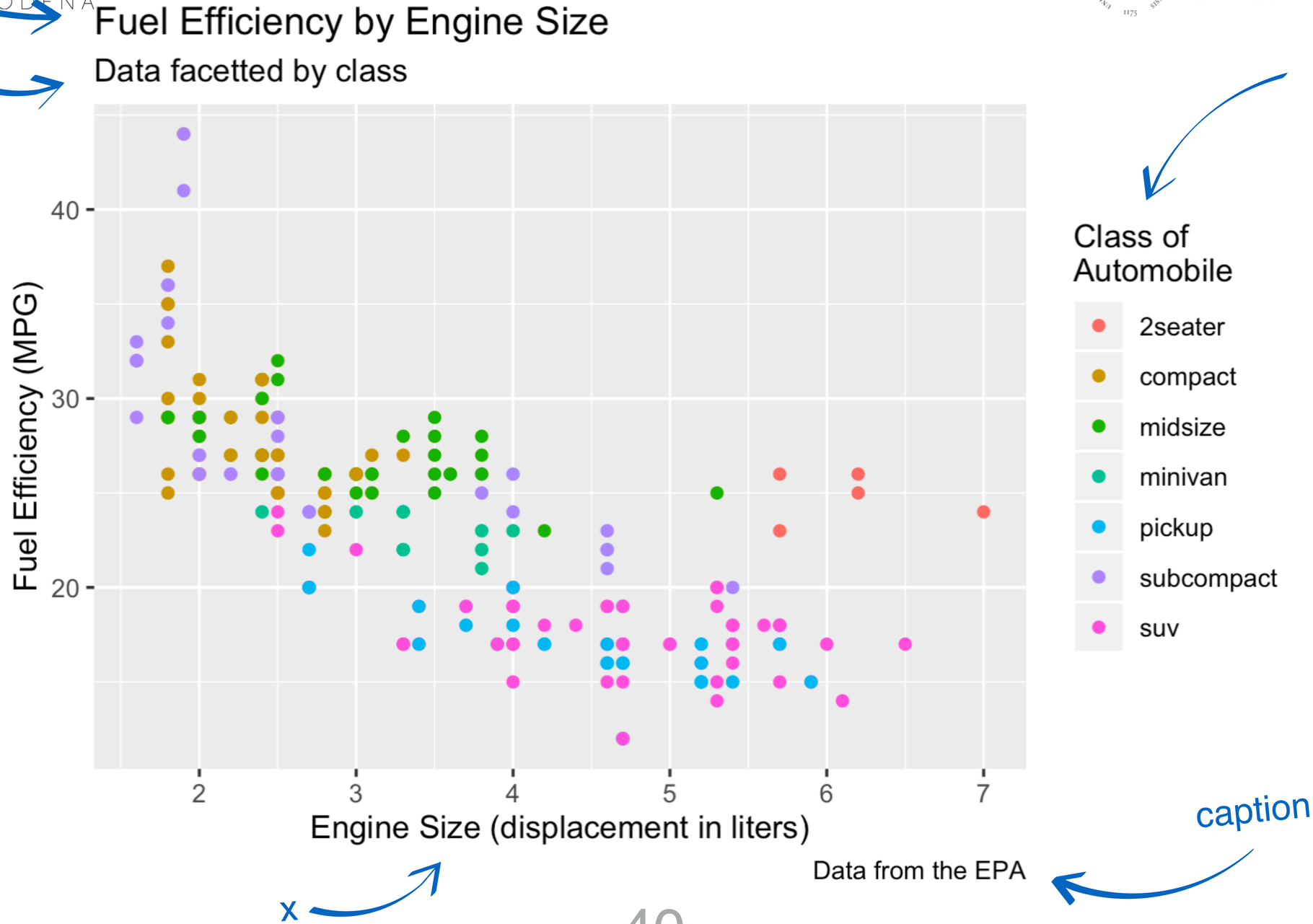
Your Turn 3

Add the black code to your graph. What does it do?

```
ggplot(data = mpg) +
  geom_point(mapping = aes(displ, hwy, color = class)) +
  labs(title = "Fuel Efficiency by Engine Size",
       subtitle = "Data facetted by class",
       x = "Engine Size (displacement in liters)",
       y = "Fuel Efficiency (MPG)",
       color = "Class of\nAutomobile",
       caption = "Data from the EPA")
```

Title

SUBTitle



color

y

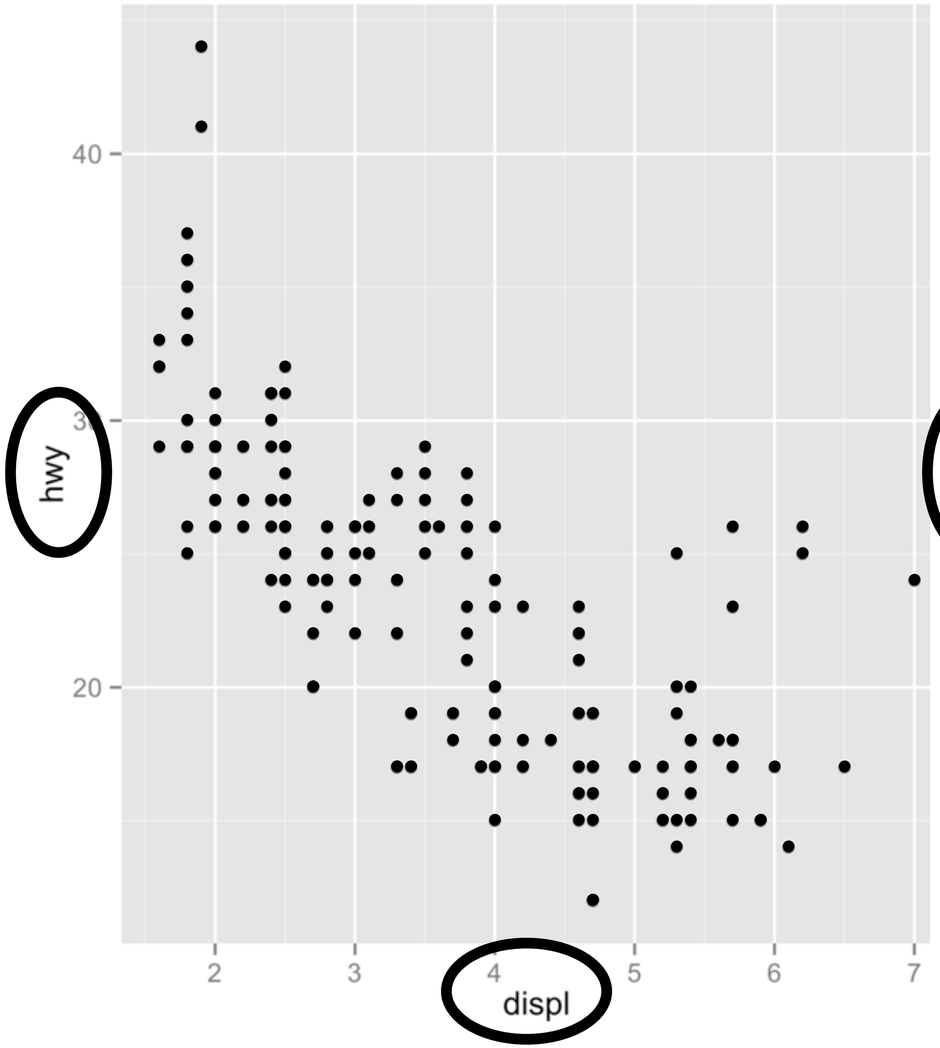
x

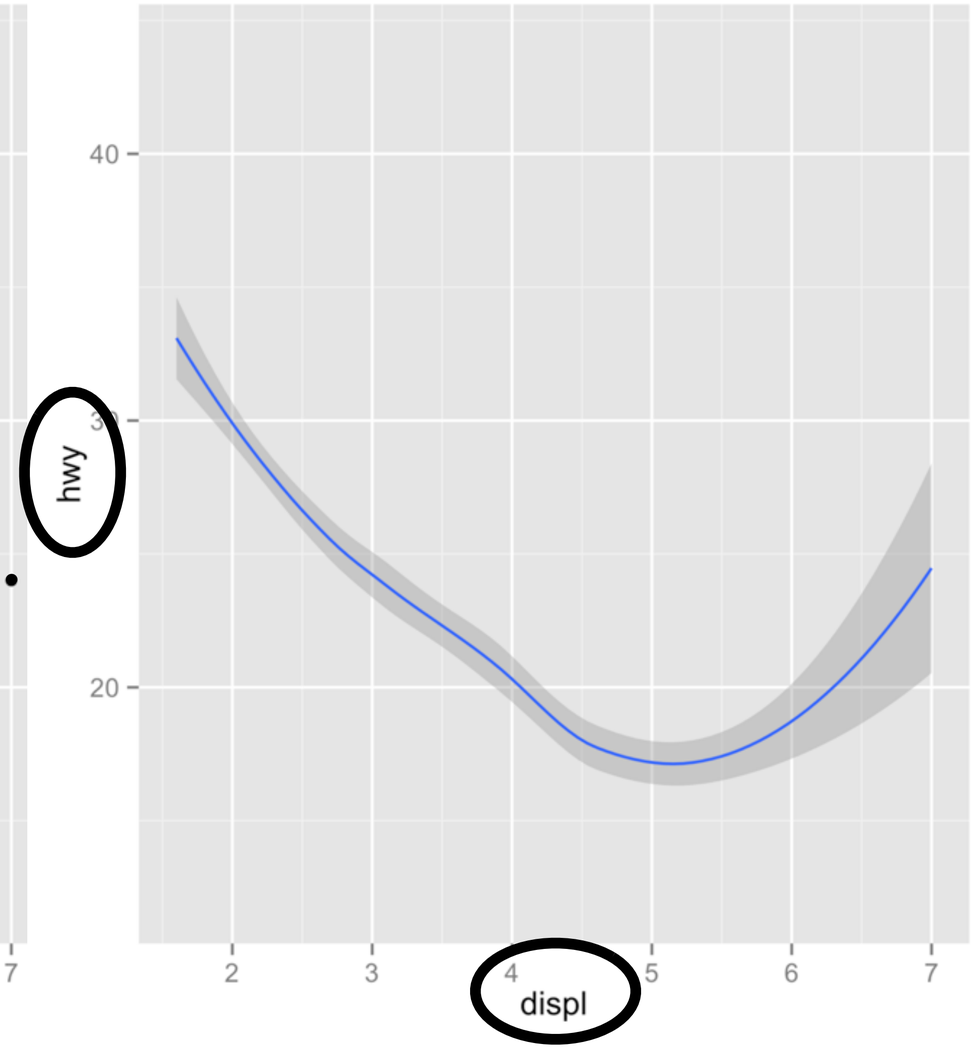
caption

Geoms

How are these plots similar?

Same: x var, y var, data

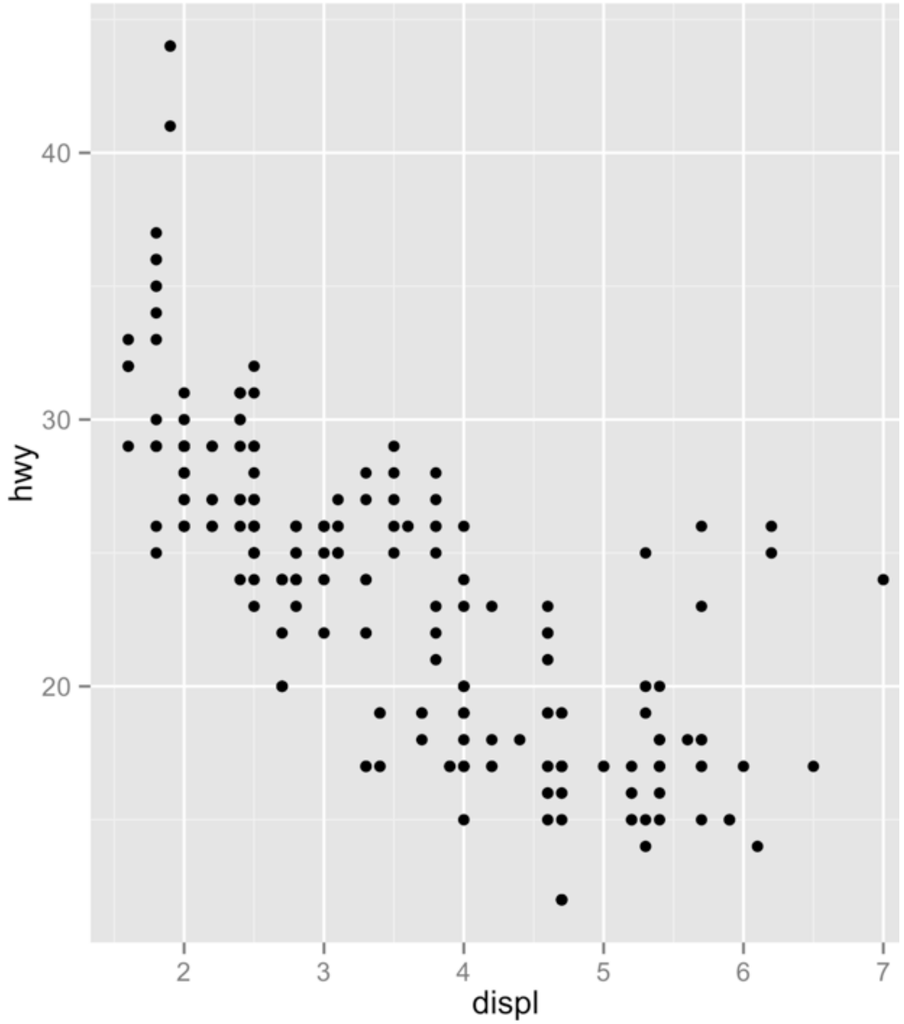


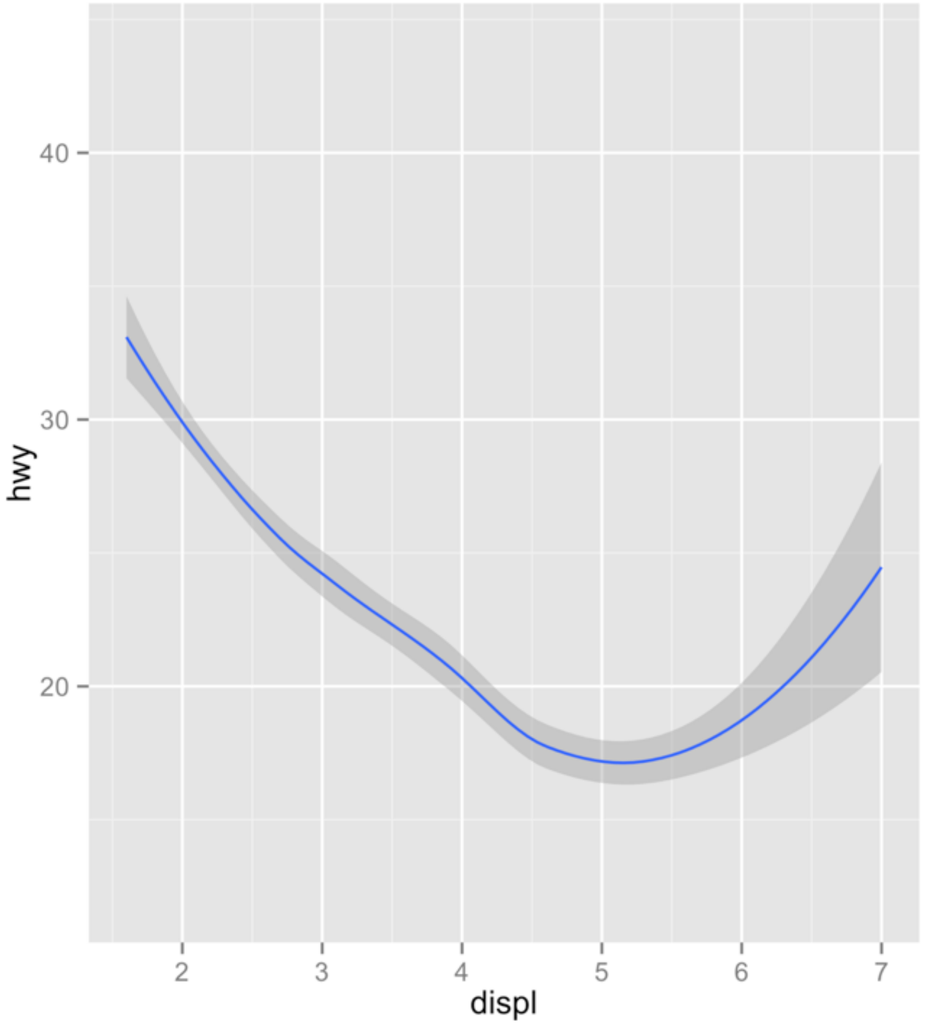


How are these plots different?

Different: geometric object (geom),

e.g. the visual object used to represent the data





ggplot2

geoms

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

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Studio Cloud

Learn | Guide | What's New | Primers | Cheat Sheets | Garrett Grolemund

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- R In 90 Minutes
- Welcome-to-the-Tidyverse
- New Space

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- Guide
- What's New
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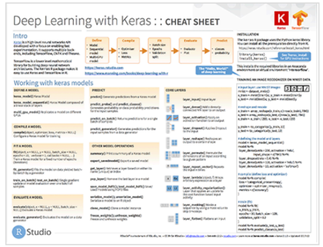
Studio Cheat Sheets

Cheat sheets make it easy to learn and use your favorite R packages and the RStudio IDE.

Deep Learning with Keras

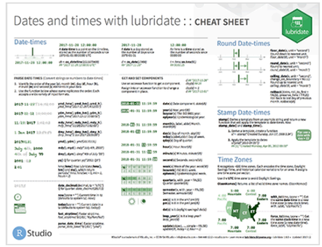


Download

Keras is a high-level neural networks API developed with a focus on enabling fast experimentation. Keras supports both convolution based networks and recurrent networks (as well as combinations of the two), runs seamlessly on both CPU and GPU devices, and is capable of running on top of multiple back-ends including TensorFlow, CNTK, and Theano.

Updated December 2017

Dates and Times

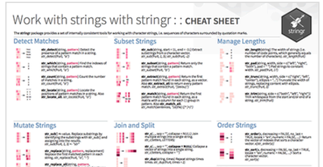


Download

Lubridate makes it easier to work with dates and times in R. This lubridate cheatsheet covers how to round dates, work with time zones, extract elements of a date or time, parse dates into R and more. The back of the cheatsheet describes lubridate's three timespan classes: periods, durations, and intervals; and explains how to do math with date-times.

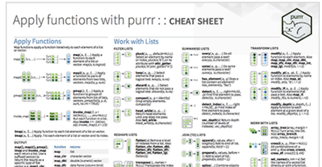
Updated December 2017

Work with Strings



The stringr package provides an easy to use toolkit for working with strings, i.e. character data, in R. This cheatsheet guides you through stringr's functions for manipulating strings. The back

Apply Functions

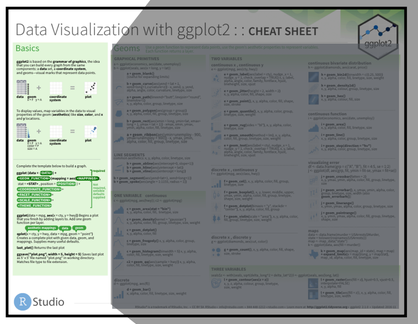


The purrr package makes it easy to work with lists and functions. This cheatsheet will remind you how to manipulate lists with purrr as well as how to apply functions iteratively to each element of a list

ggplot2

geom_ functions

Each requires a mapping argument.



Geoms

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

ggplot2

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=z)**)** - 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

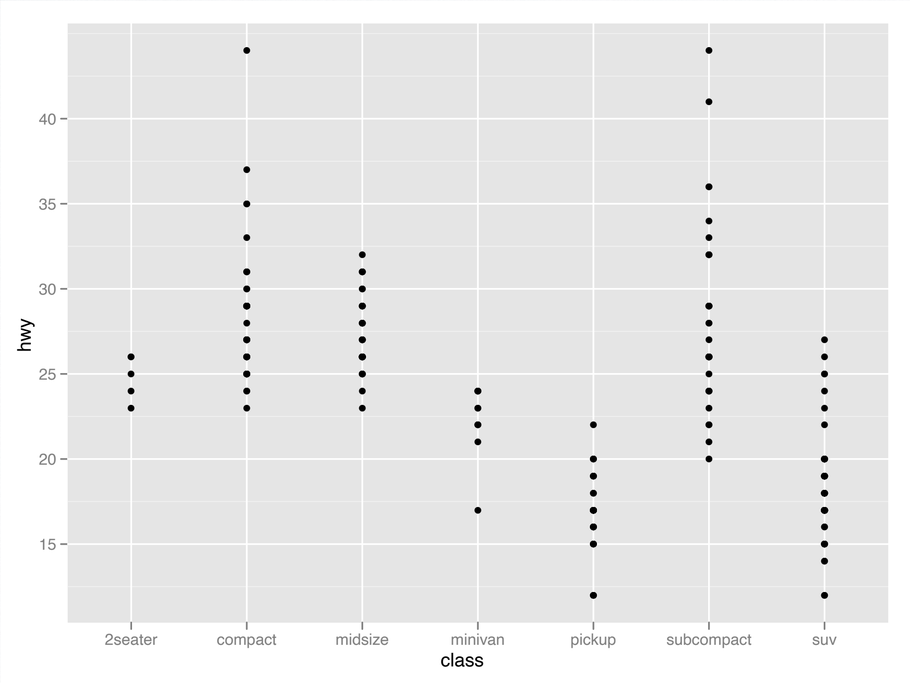
l + geom_raster(aes(fill = z), hjust=0.5, vjust=0.5, interpolate=FALSE**)**
x, y, alpha, fill

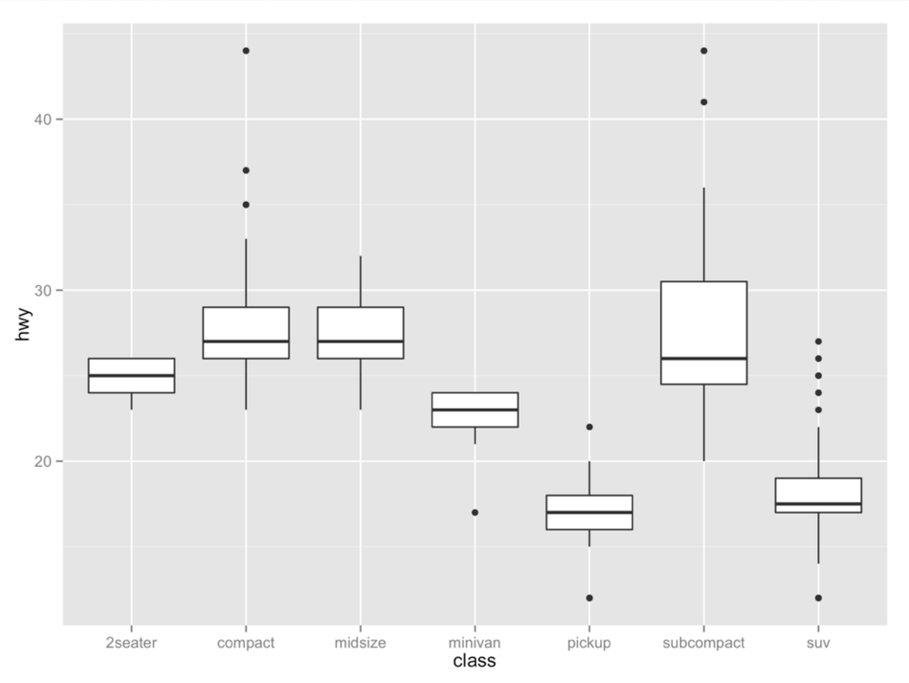
l + geom_tile(aes(fill = z)**)**, x, y, alpha, color, fill, linetype, size, width

ggplot2

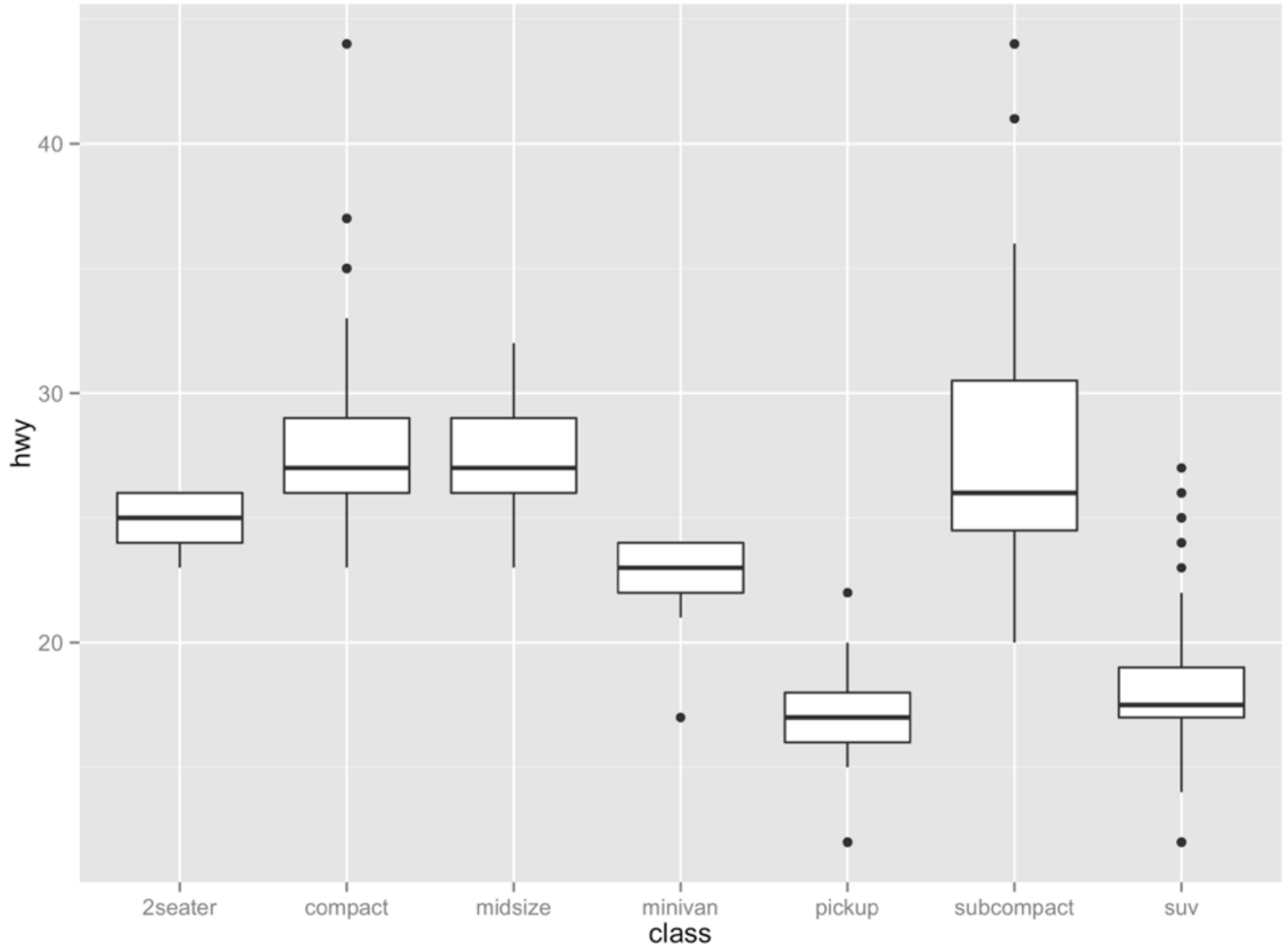
Your Turn 4

With your partner, decide how to replace this scatterplot with one that draws boxplots. Use the cheatsheet. Try your best guess.






```
ggplot(mpg) + geom_point(aes(class, hwy))
```

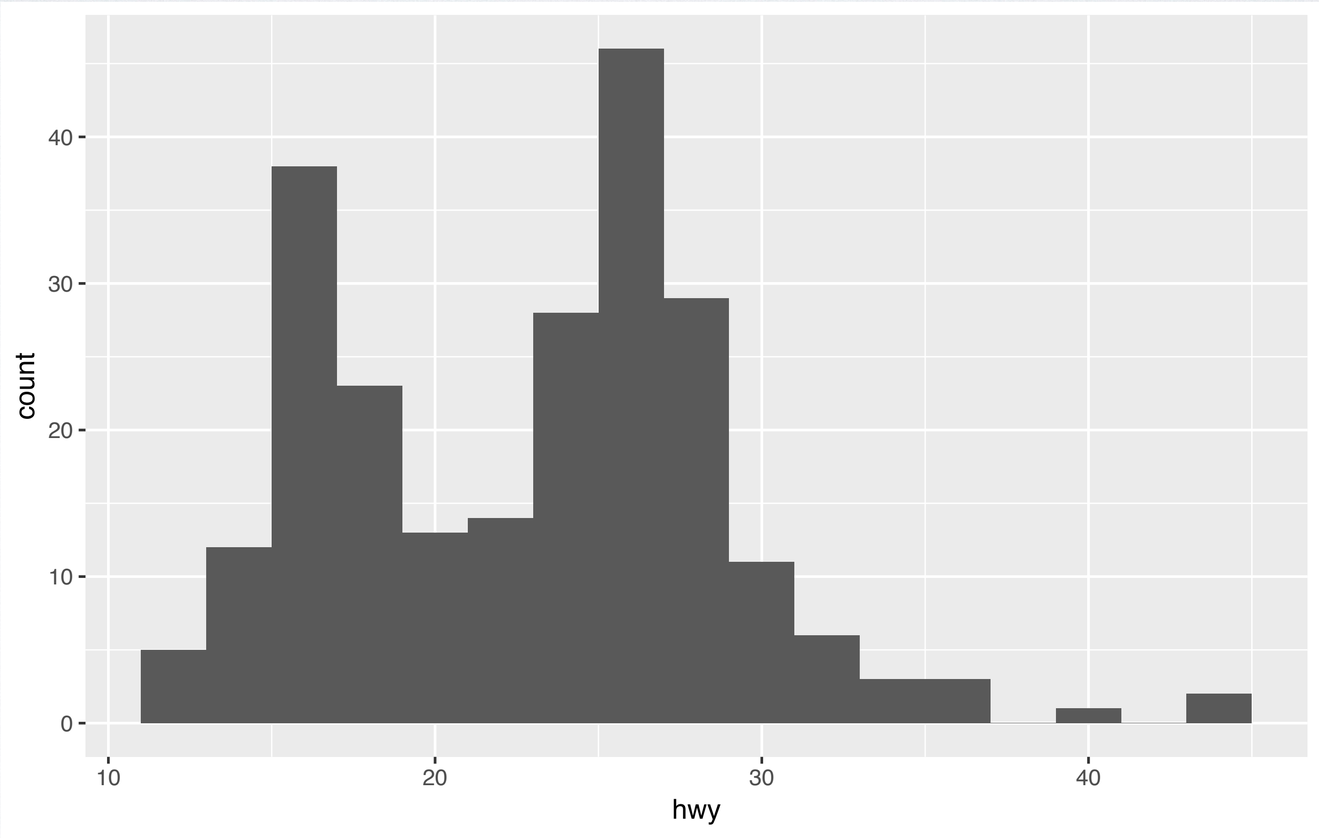


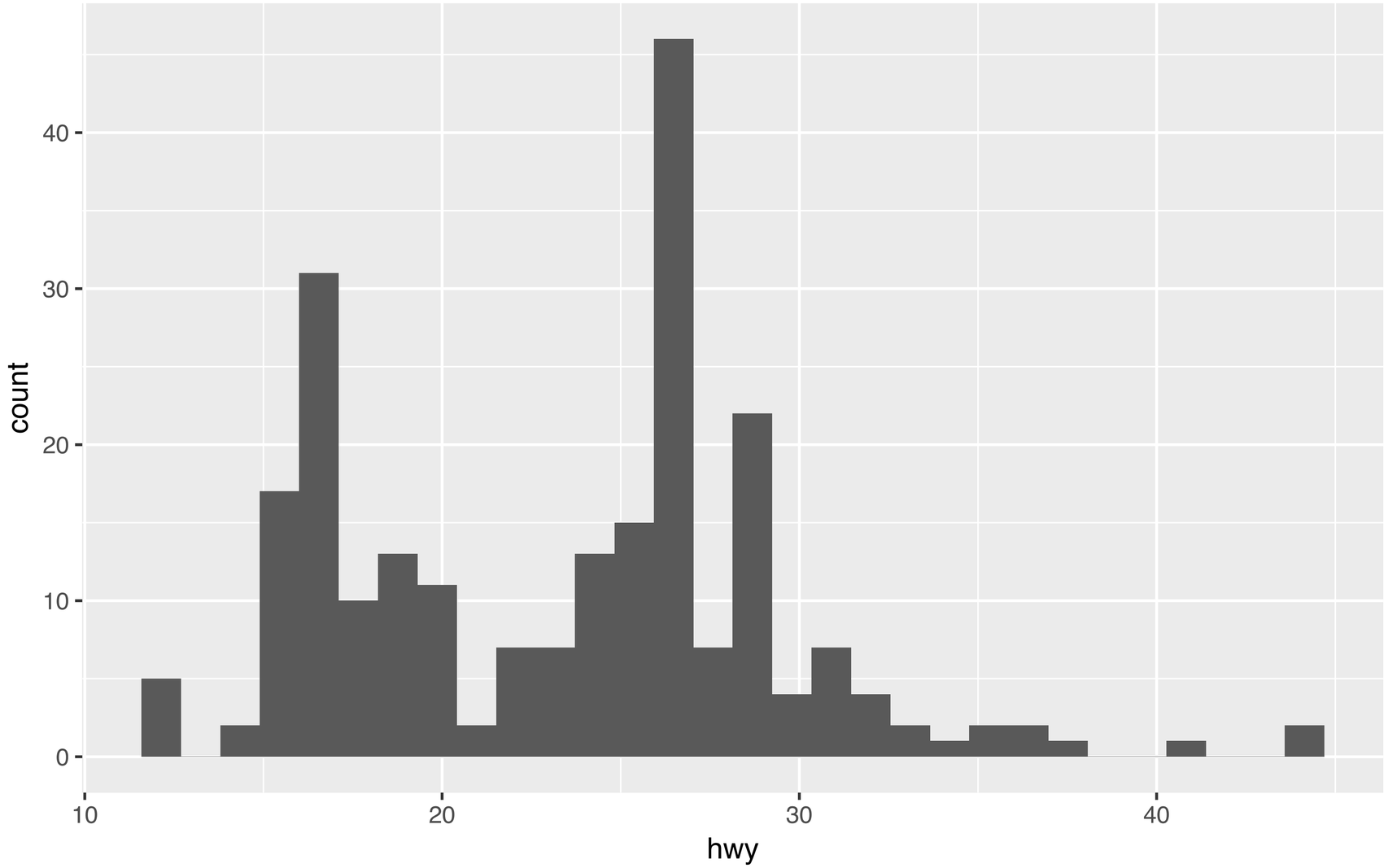

```
ggplot(data = mpg) +
  geom_boxplot(mapping = aes(x = class, y = hwy))
```

ggplot2

Your Turn 5

With a partner, make the histogram of hwy below. Use the cheatsheet. Hint: do not supply a y variable.

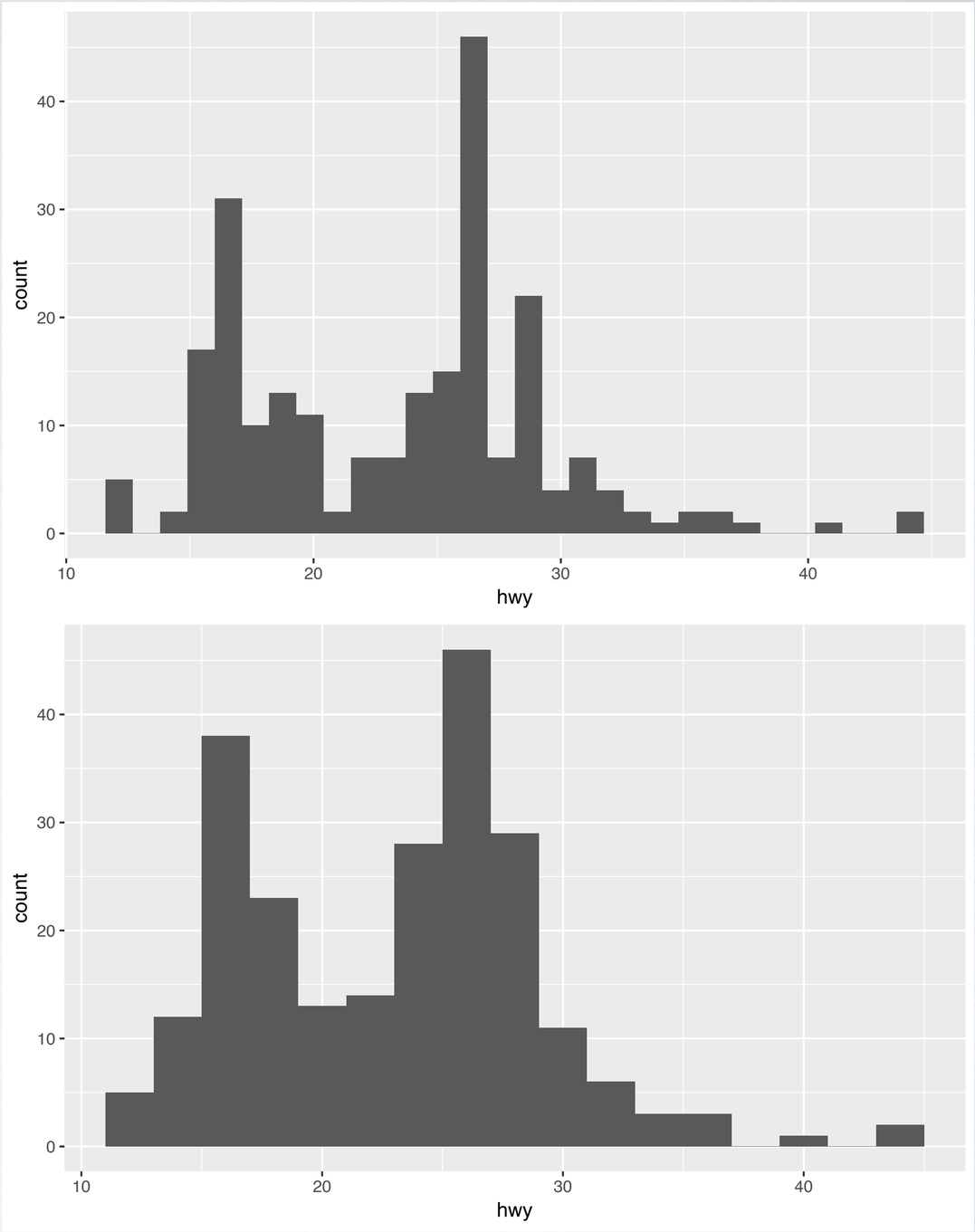





```
ggplot(data = mpg) +
  geom_histogram(mapping = aes(x = hwy))
```

Quiz

What is the difference?



"Help" pages

To open the documentation for a function, type

```
?geom_histogram
```

?

function name (no parentheses)

geom_freqpoly {ggplot2} R Documentation

Histograms and frequency polygons

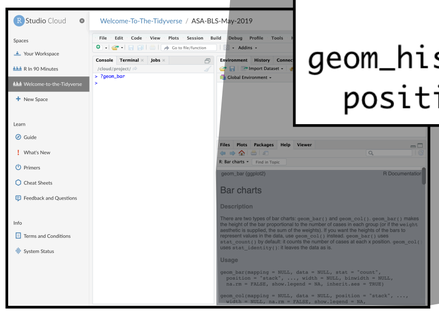
Description

Visualise the distribution of a single continuous variable by dividing the x axis into bins and counting the number of observations in each bin. Histograms (`geom_histogram()`) display the counts with bars; frequency polygons (`geom_freqpoly()`) display the counts with lines. Frequency polygons are more suitable when you want to compare the distribution across the levels of a categorical variable.

Usage

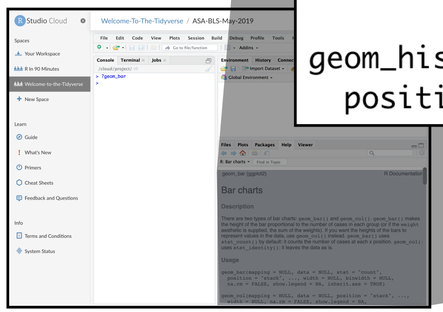
```
geom_freqpoly(mapping = NULL, data = NULL, stat = "bin",
  position = "identity", ..., na.rm = FALSE, show.legend = NA,
  inherit.aes = TRUE)

geom_histogram(mapping = NULL, data = NULL, stat = "bin",
  position = "stack", ..., binwidth = NULL, bins = NULL,
```



Tips

- scan page for relevant info
- ignore things that don't make sense
- try out the examples



geom_freqpoly {ggplot2} R Documentation

Histograms and frequency polygons

Description

Visualise the distribution of a single continuous variable by dividing the x axis into bins and counting the number of observations in each bin. Histograms (`geom_histogram()`) display the counts with bars; frequency polygons (`geom_freqpoly()`) display the counts with lines. Frequency polygons are more suitable when you want to compare the distribution across the levels of a categorical variable.

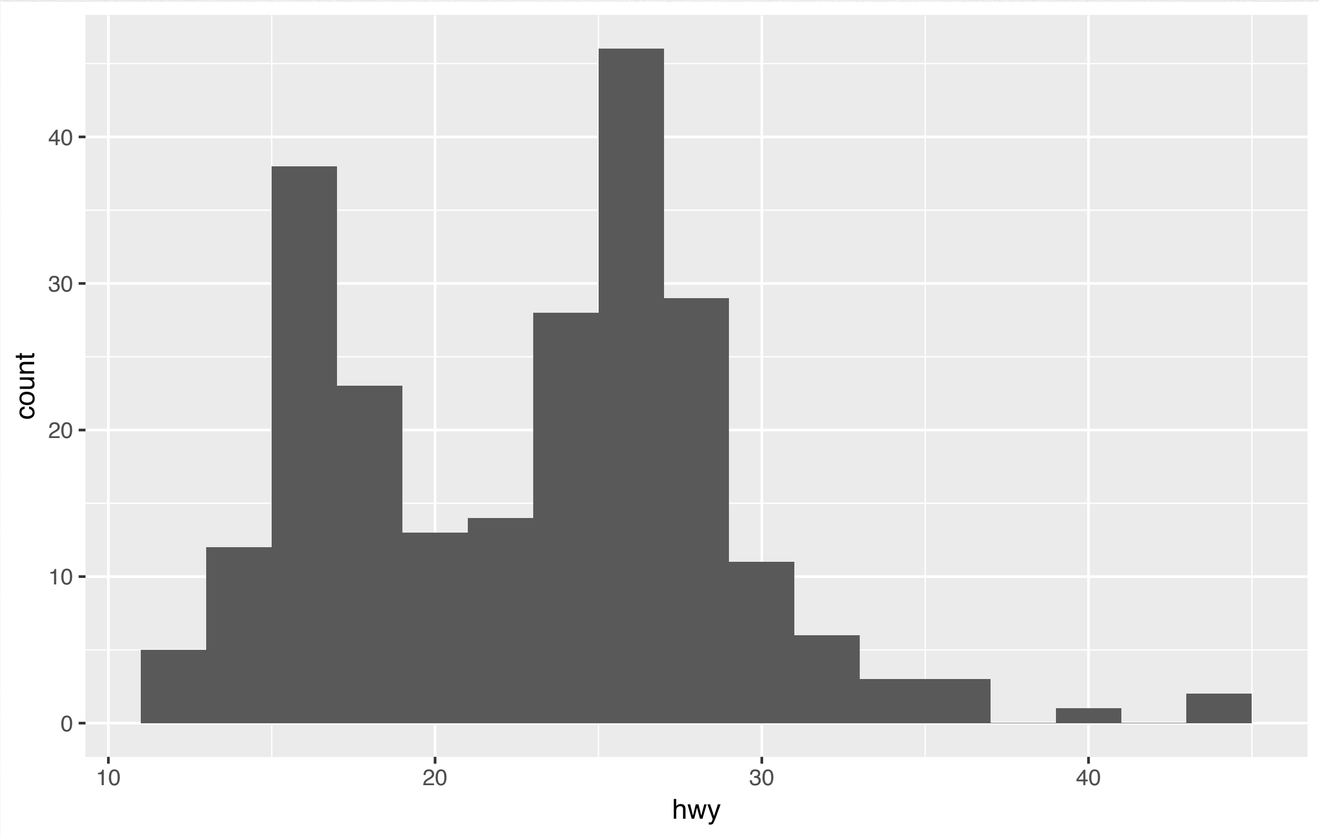
Usage

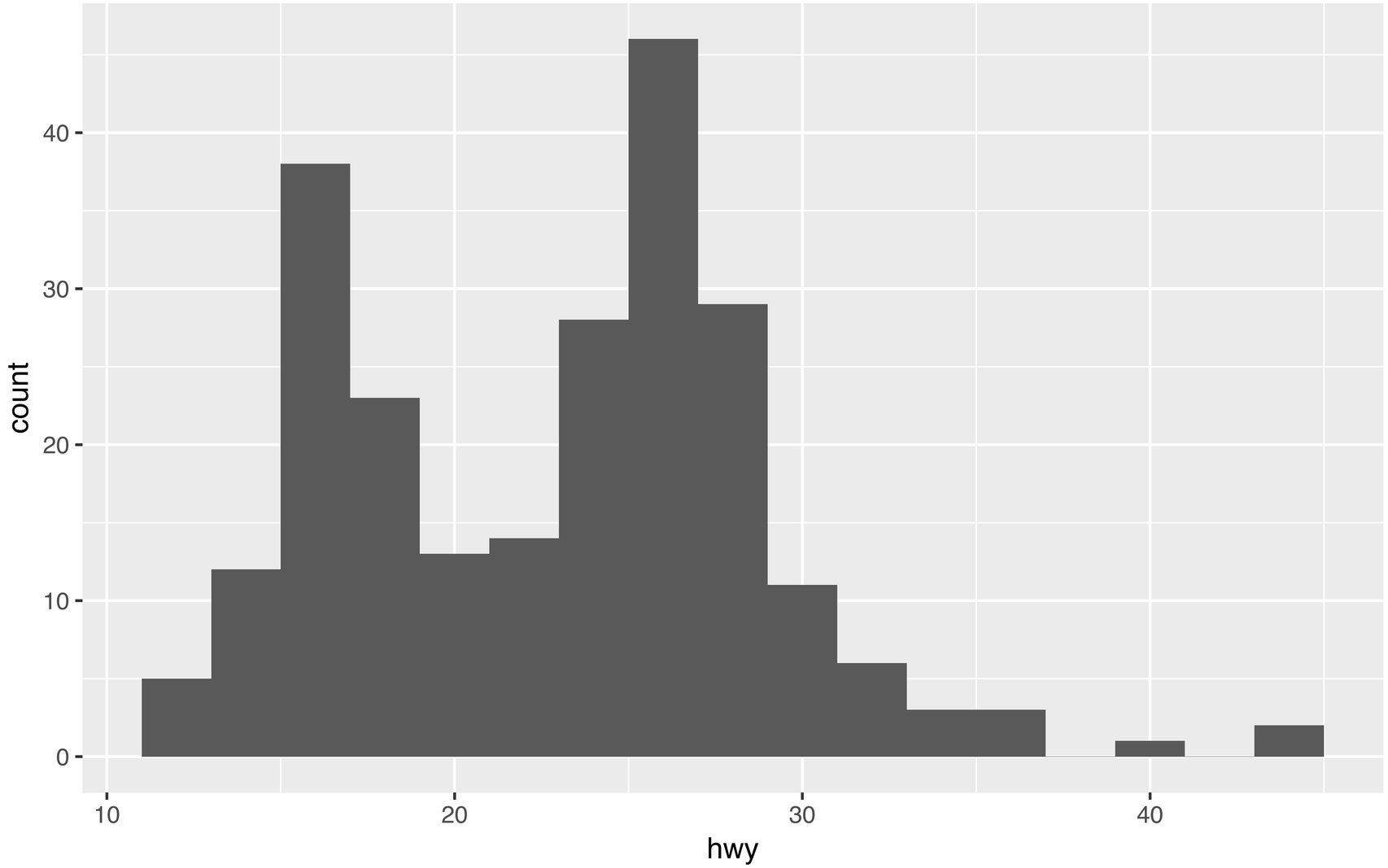
```
geom_freqpoly(mapping = NULL, data = NULL, stat = "bin",
  position = "identity", ..., na.rm = FALSE, show.legend = NA,
  inherit.aes = TRUE)

geom_histogram(mapping = NULL, data = NULL, stat = "bin",
  position = "stack", ..., binwidth = NULL, bins = NULL,
```

Your Turn 6

Use the help page for geom_histogram to make the bins 2 mpg wide.






```
ggplot(data = mpg) +
  geom_histogram(mapping = aes(x = hwy), binwidth = 2)
```

ggplot2.tidyverse.org

Create Elegant Data Visualisati ×

Garrett

ggplot2.tidyverse.org

ggplot2 part of the tidyverse

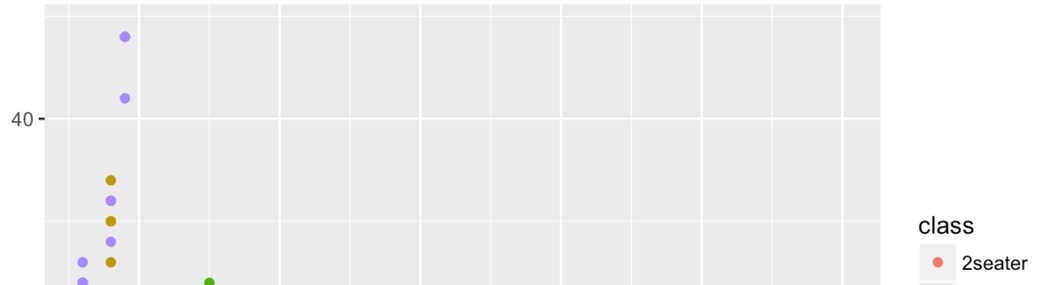
Reference Articles News

Usage

It's hard to succinctly describe how ggplot2 works because it embodies a deep philosophy of visualisation. However, in most cases you start with `ggplot()`, supply a dataset and aesthetic mapping (with `aes()`). You then add on layers (like `geom_point()` or `geom_histogram()`), scales (like `scale_colour_brewer()`), faceting specifications (like `facet_wrap()`) and coordinate systems (like `coord_flip()`).

```
library(ggplot2)

ggplot(mpg, aes(displ, hwy, colour = class)) +
  geom_point()
```



Links

Download from CRAN at https://cran.r-project.org/package=ggplot2

Browse source code at https://github.com/tidyverse/ggplot2

Report a bug at https://github.com/tidyverse/ggplot2/issues

Learn more at http://r4ds.had.co.nz/data-visualisation.html

License

GPL-2 | file LICENSE

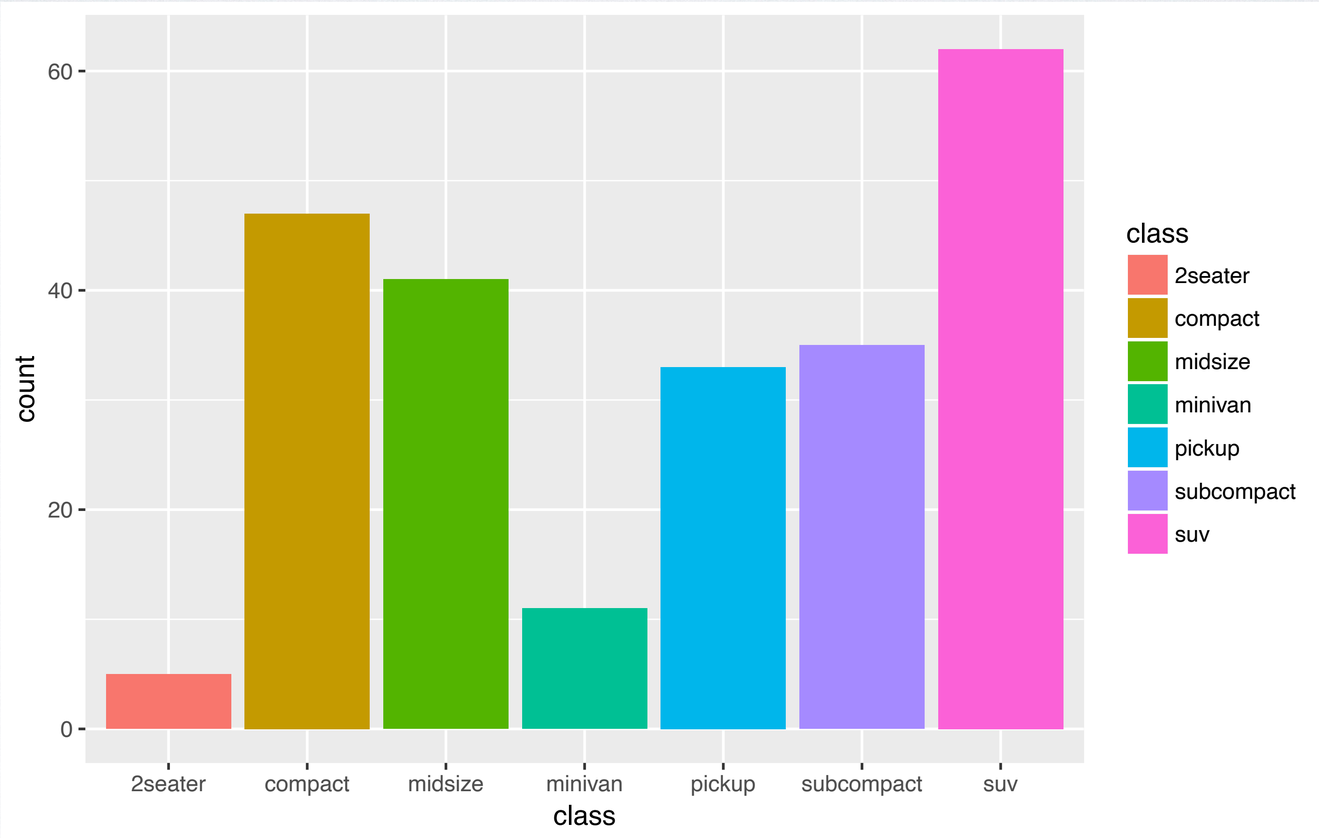
Developers

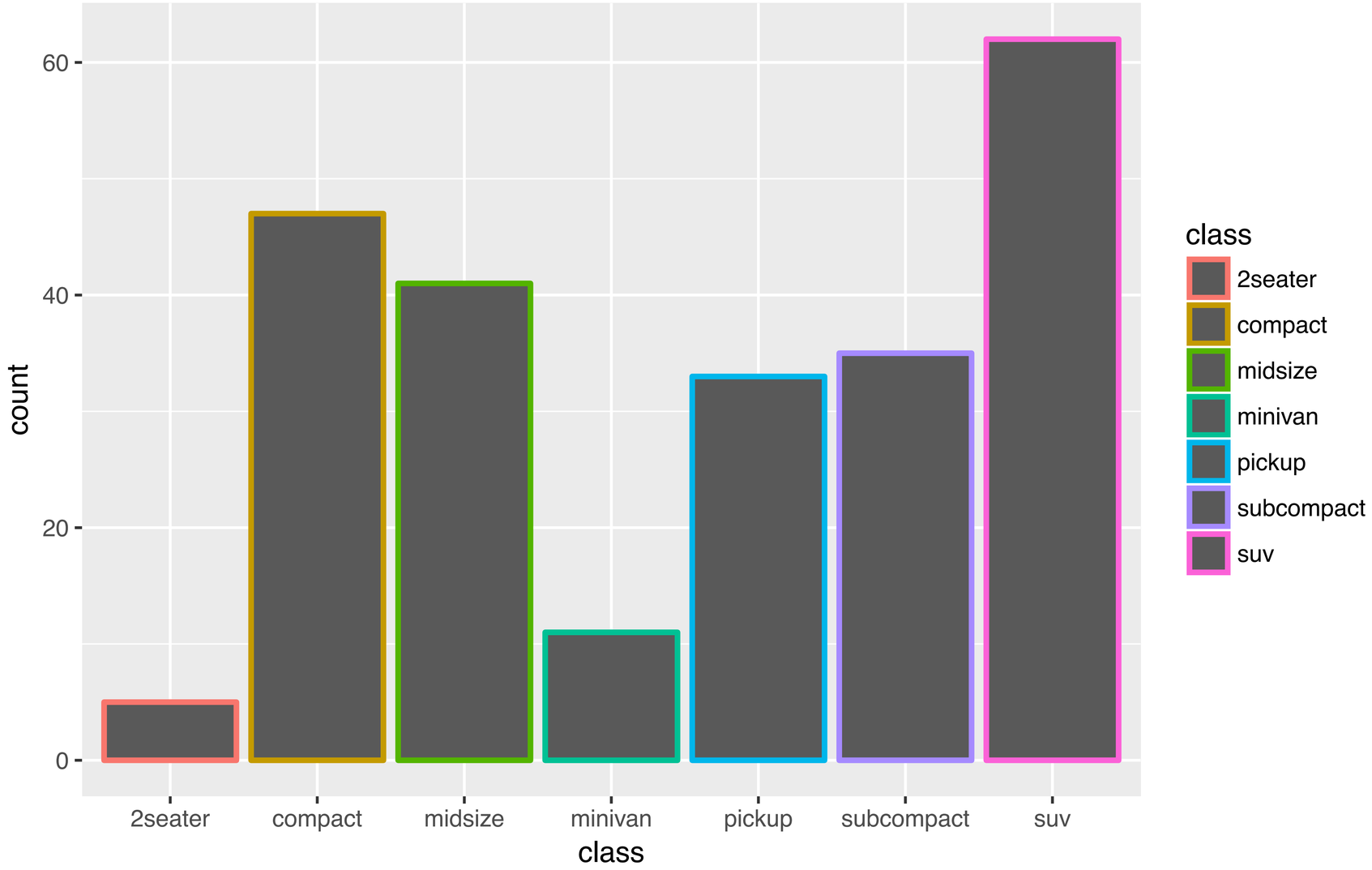
Hadley Wickham

Author, maintainer

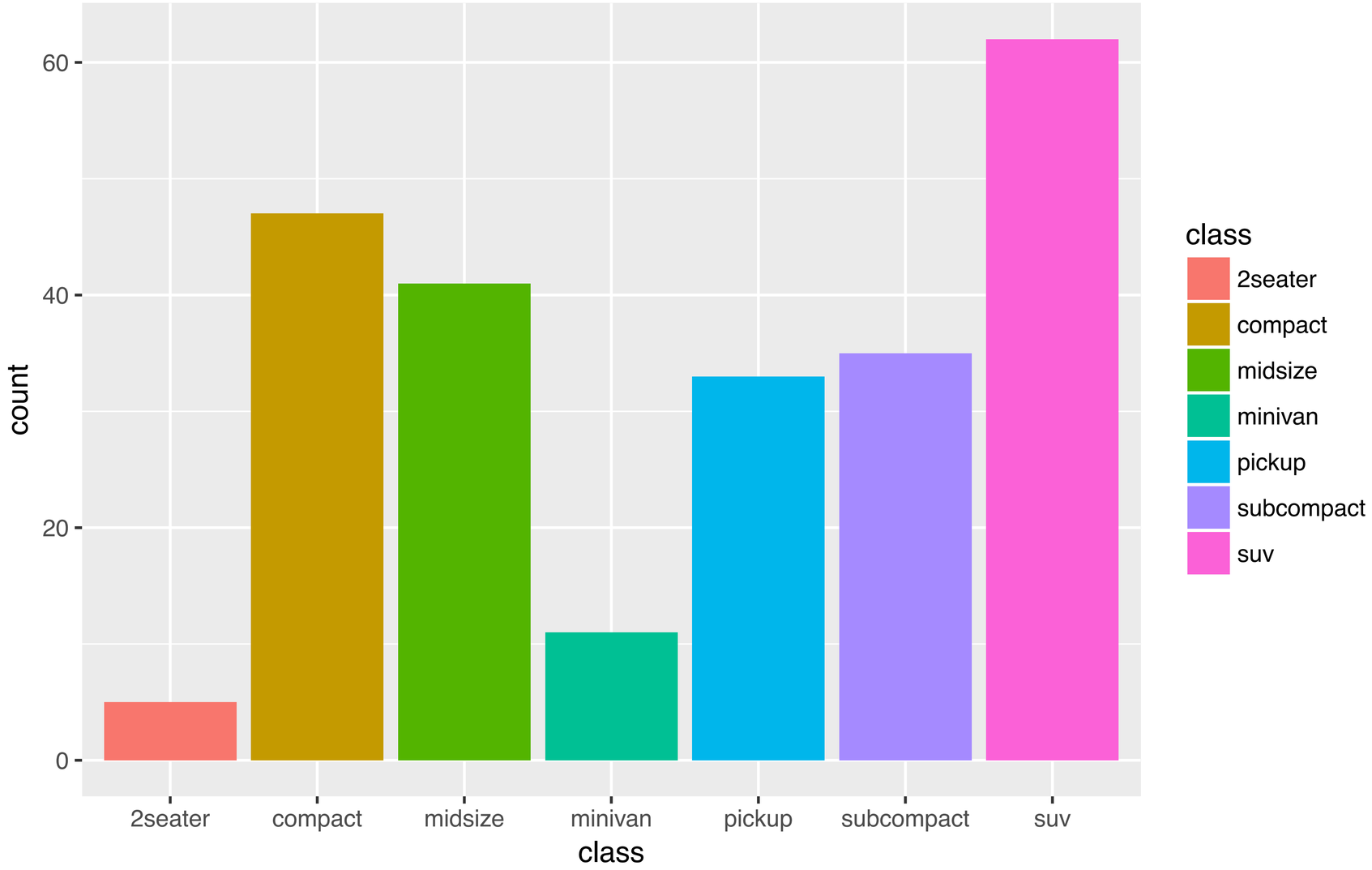
Your Turn 7

With a partner, make the bar chart of class below. Use the cheatsheet. Hint: do not supply a y variable.

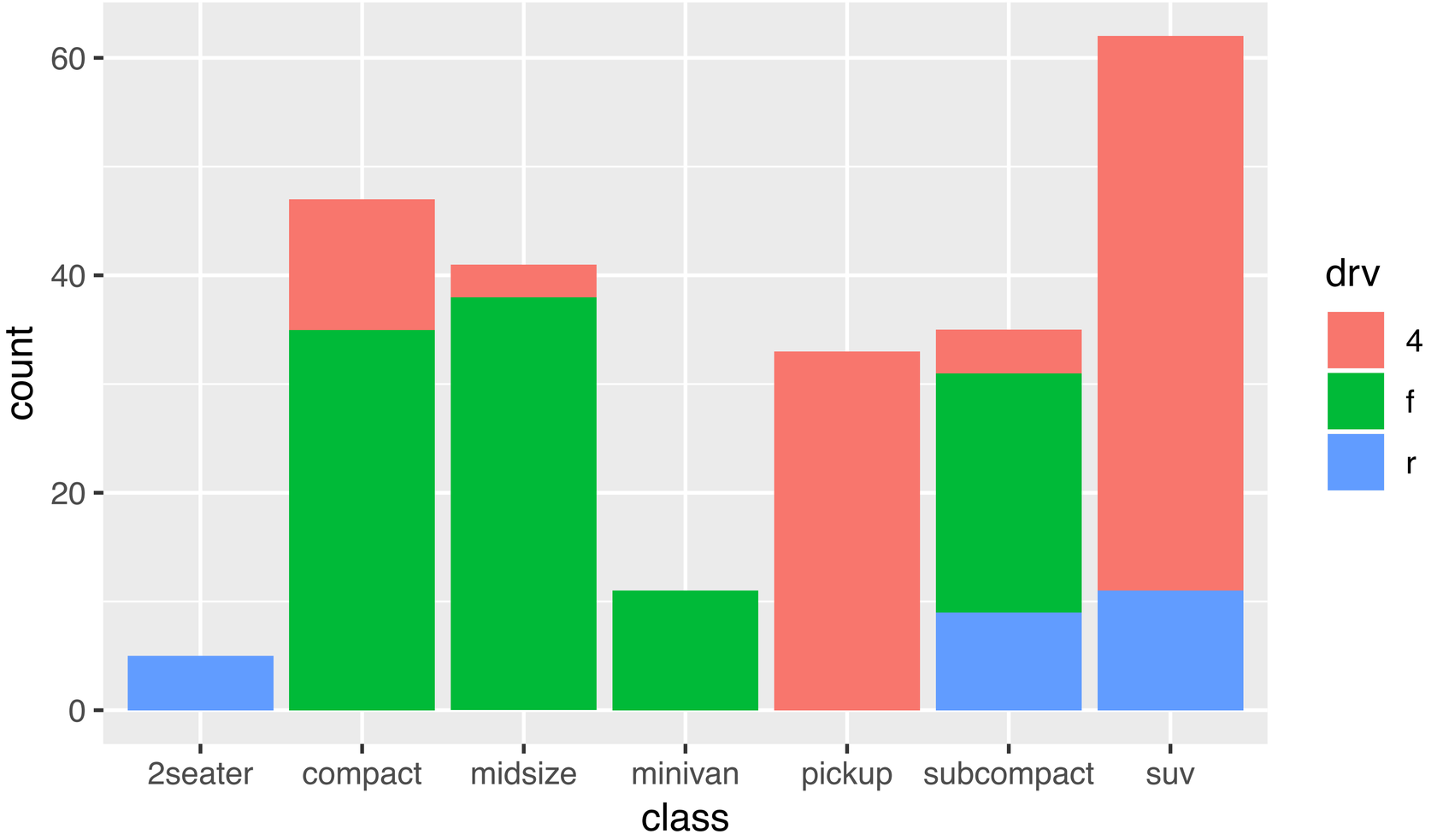





```
ggplot(data = mpg) +
  geom_bar(mapping = aes(x = class, color = class))
```




```
ggplot(data = mpg) +
  geom_bar(mapping = aes(x = class, fill = class))
```

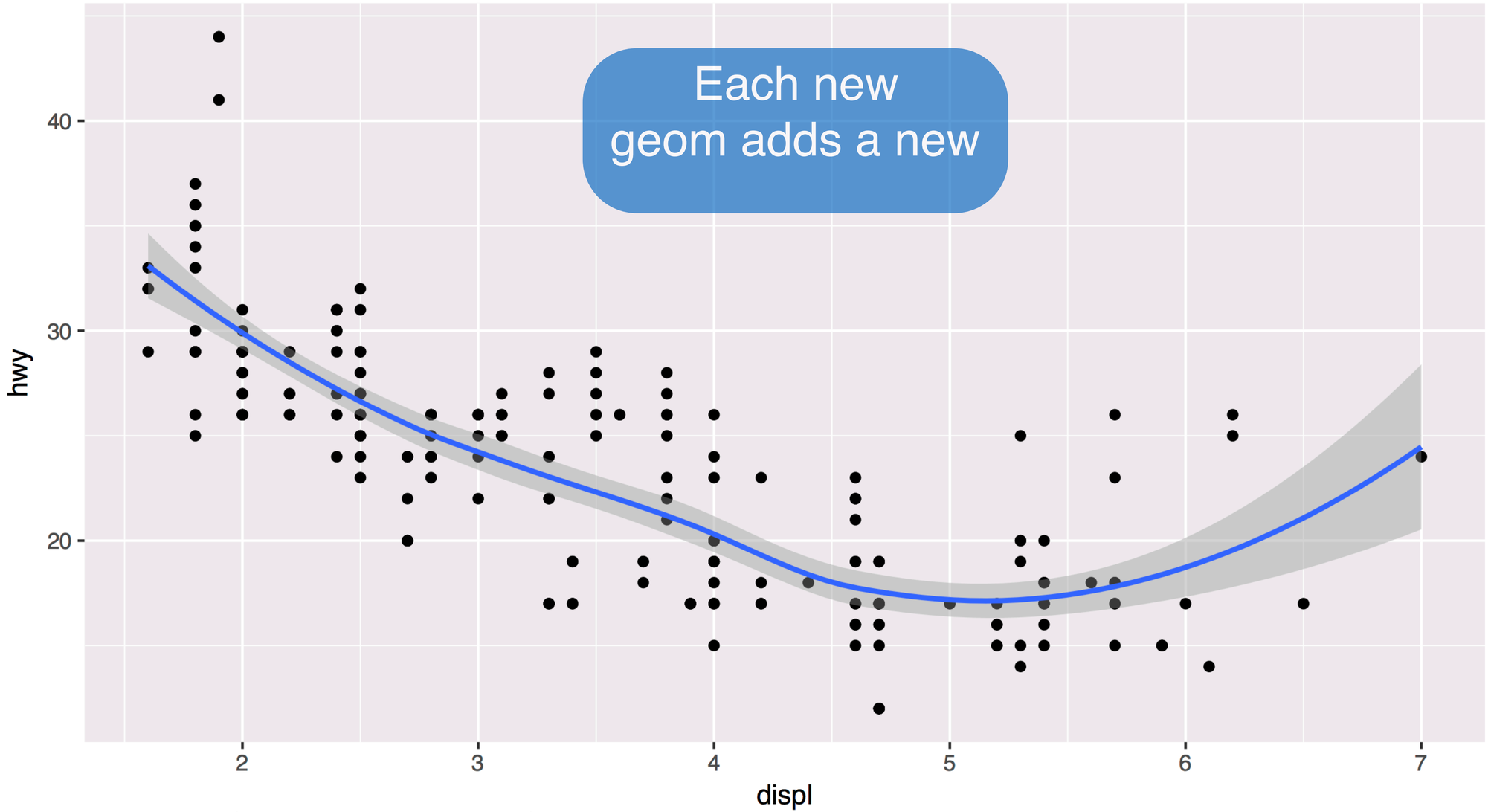



```
ggplot(data = mpg) +
  geom_bar(mapping = aes(x = class, fill = drv))
```

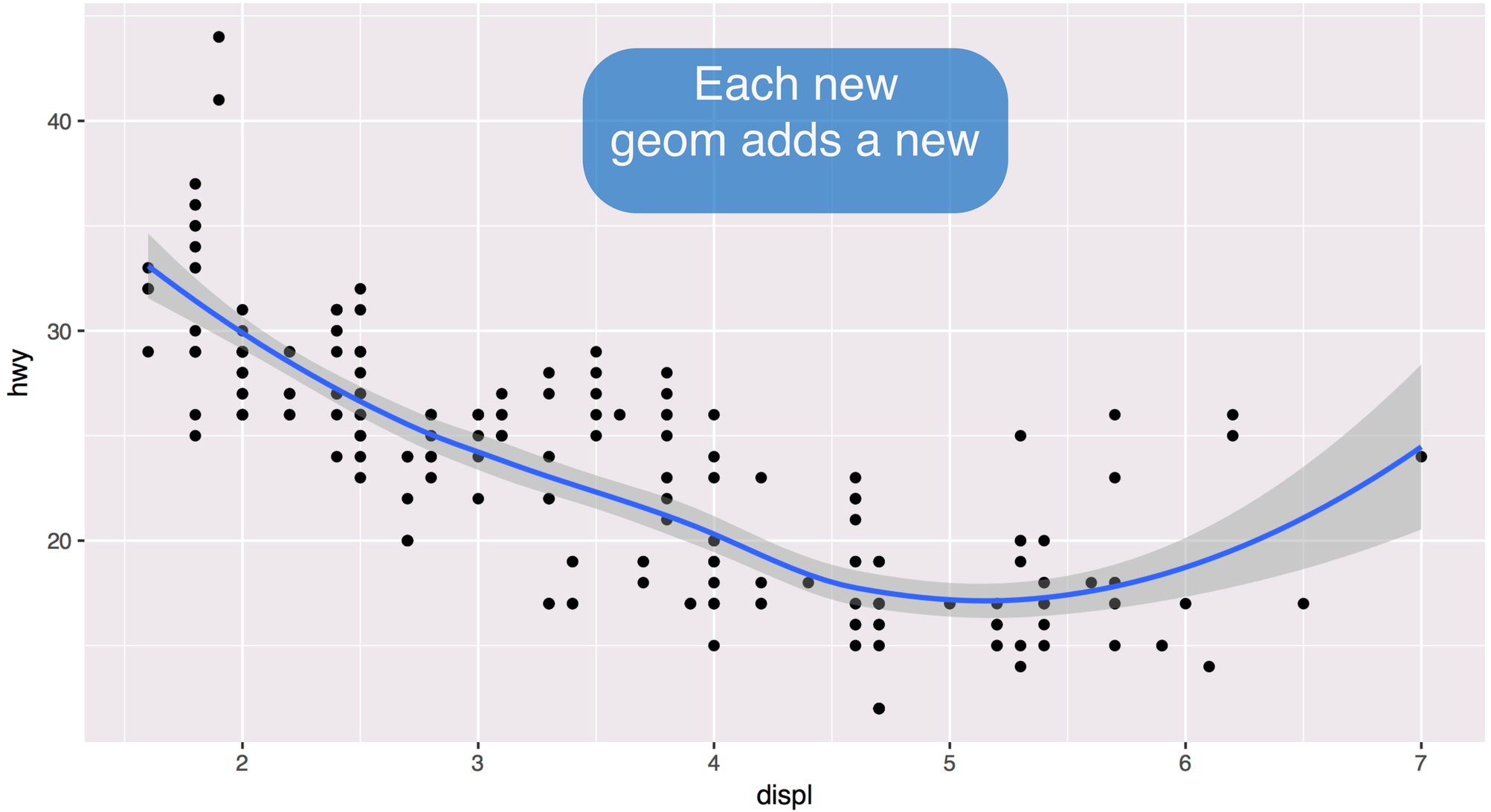
Quiz

What will this code do?

```
ggplot(mpg) +
  geom_point(aes(displ, hwy)) +
  geom_smooth(aes(displ, hwy))
```



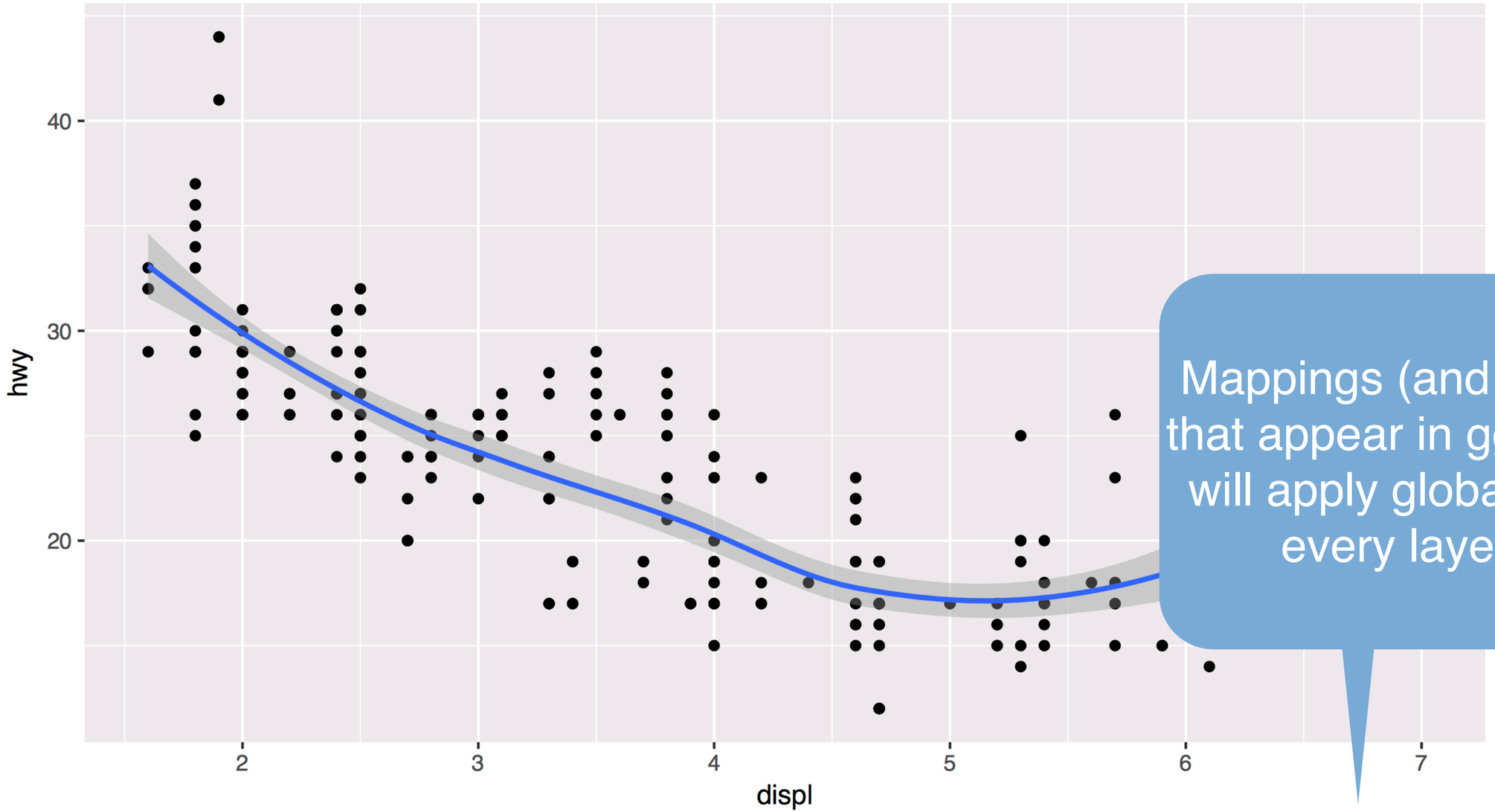

```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy)) +
  geom_smooth(mapping = aes(x = displ, y = hwy))
```




```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy)) +
  geom_smooth(mapping = aes(x = displ, y = hwy))
```

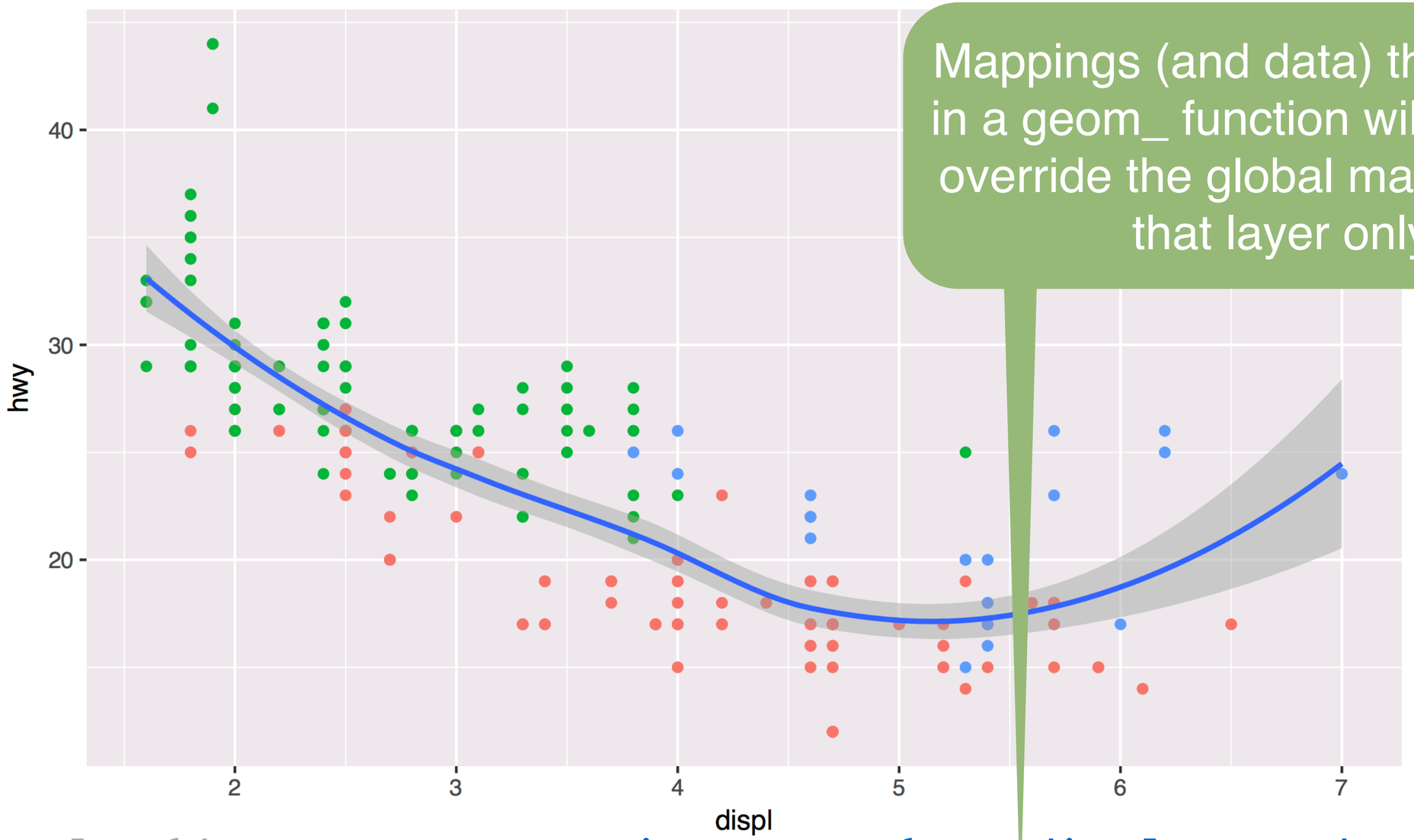
ggplot2

global vs. local



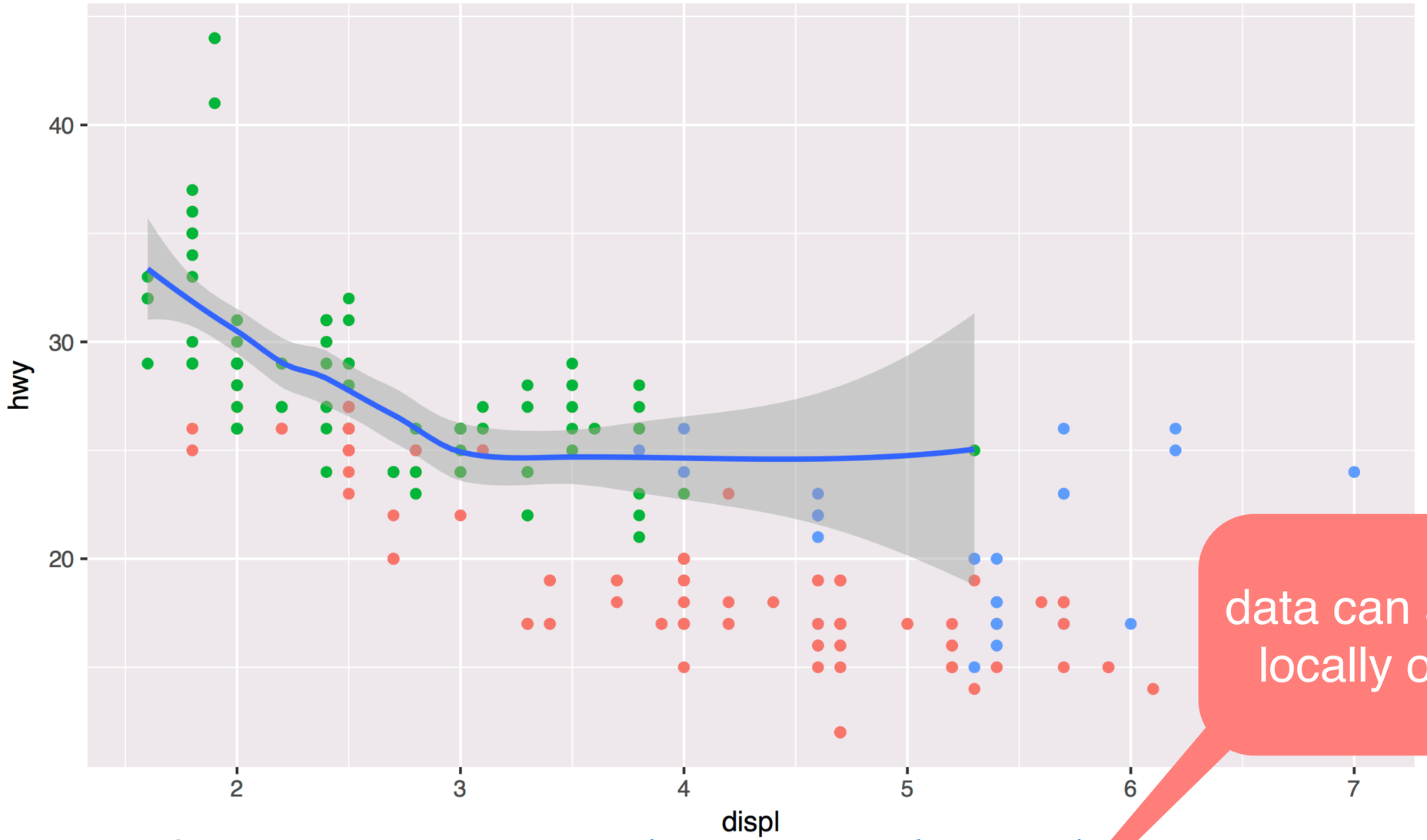
Mappings (and data) that appear in ggplot() will apply globally to every layer

```
ggplot(data = mpg, mapping = aes(x = displ, y = hwy)) +
  geom_point() +
  geom_smooth()
```



Mappings (and data) that appear in a geom_ function will add to or override the global mappings for that layer only

```
ggplot(data = mpg, mapping = aes(x = displ, y = hwy)) +
  geom_point(mapping = aes(color = drv)) +
  geom_smooth()
```



data can also be set locally or globally

```
ggplot(data = mpg, mapping = aes(x = displ, y = hwy)) +
  geom_point(mapping = aes(color = drv)) +
  geom_smooth(data = filter(mpg, drv == "f"))
```

Quiz

What is different about this plot? Run the code!

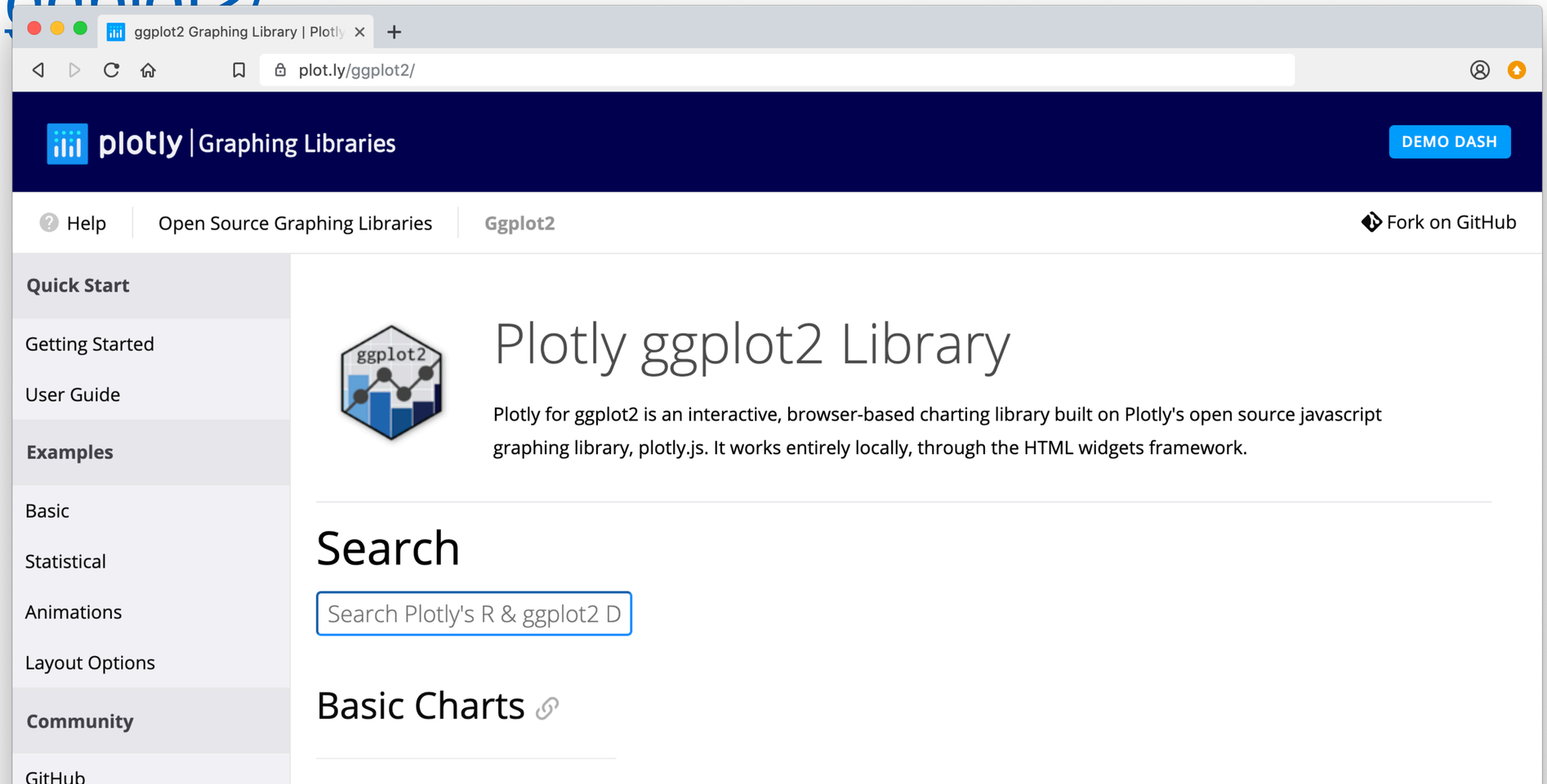
```
p <- ggplot(mpg) +
  geom_point(aes(displ, hwy)) +
  geom_smooth(aes(displ, hwy))


library(plotly)
ggplotly(p)
```

interactivity

Plotly

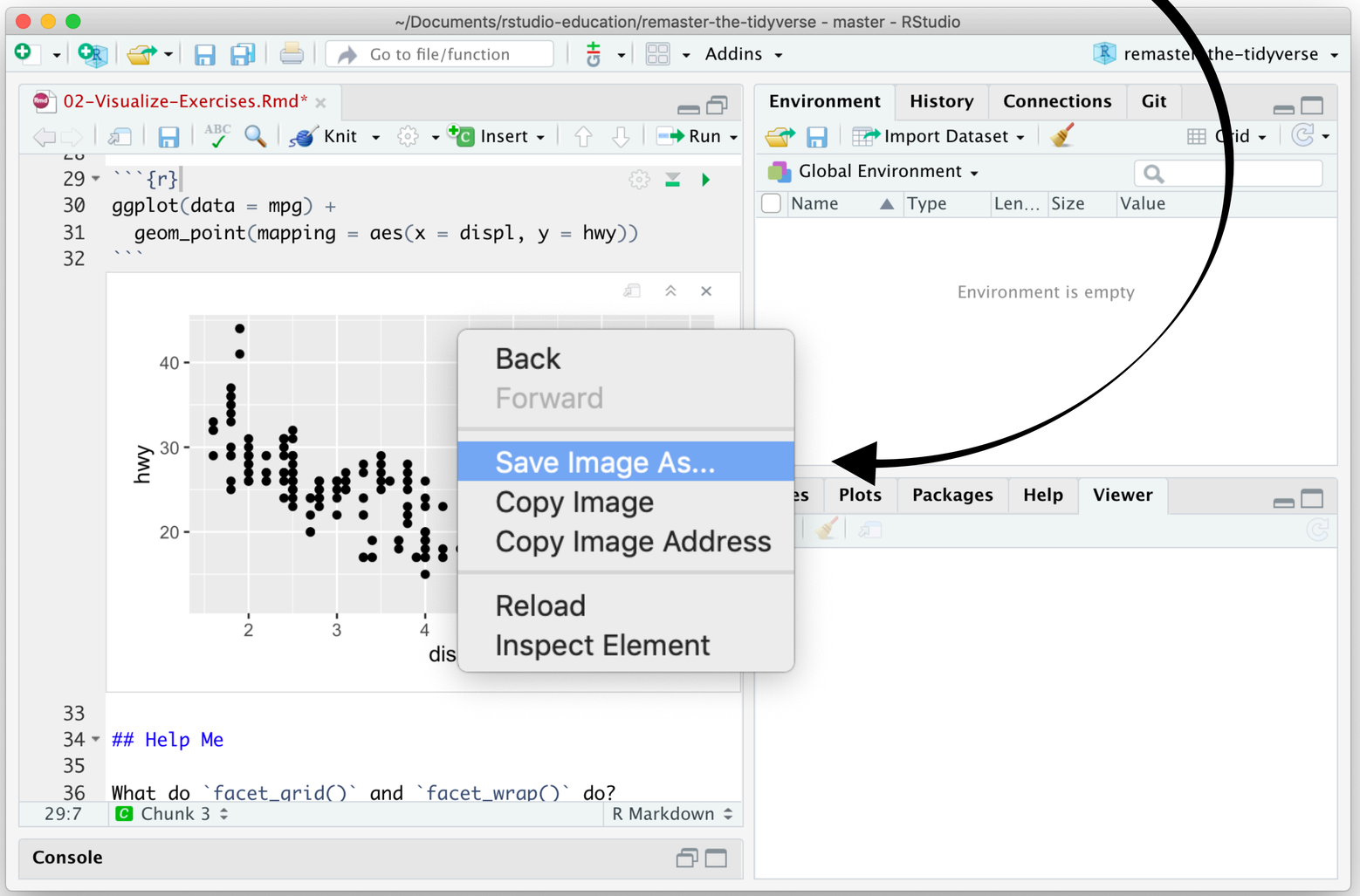
Tools for making interactive plots. plot.ly/ggplot2/



Saving graphs

GUI method

Right click on the plot



Code method

ggsave() saves the last plot.
Uses size on screen:

```
ggsave("my-plot.pdf")
ggsave("my-plot.png")
```

Specify size in inches

```
ggsave("my-plot.pdf", width =
```

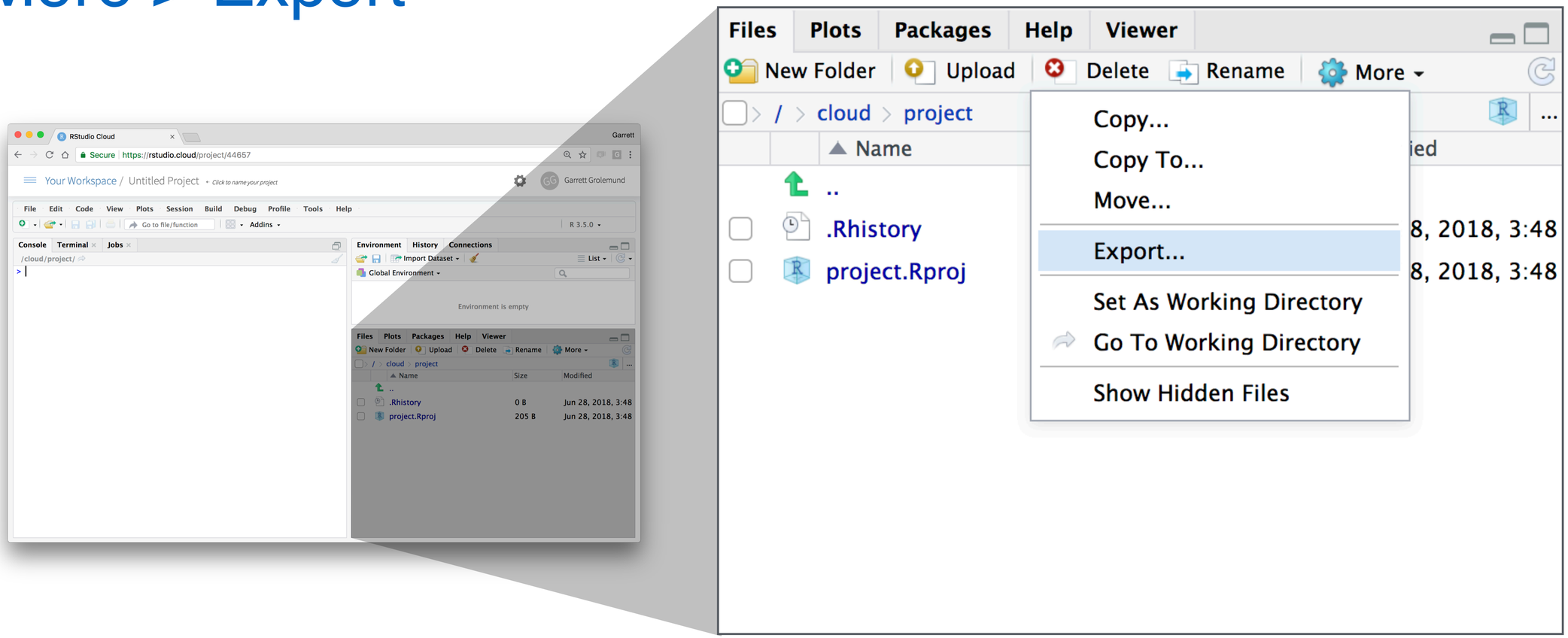
Q: But where will it save it?

A: Alongside your .Rmd

Download files

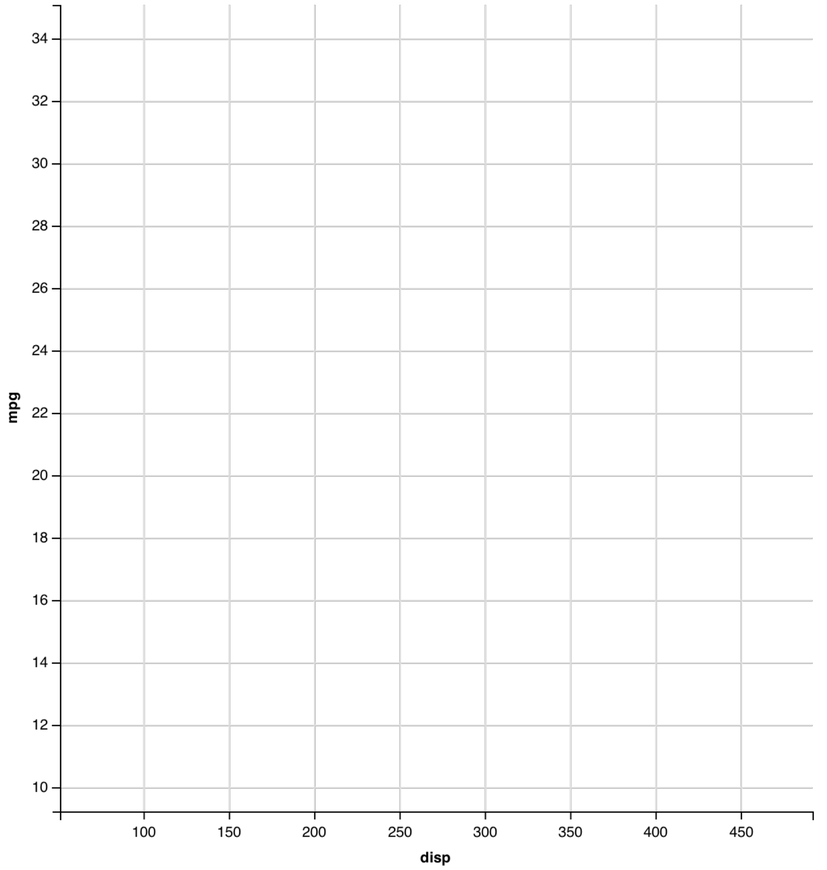
In the files pane, check next to the file(s) to download

More > Export



Grammar of Graphics

mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1



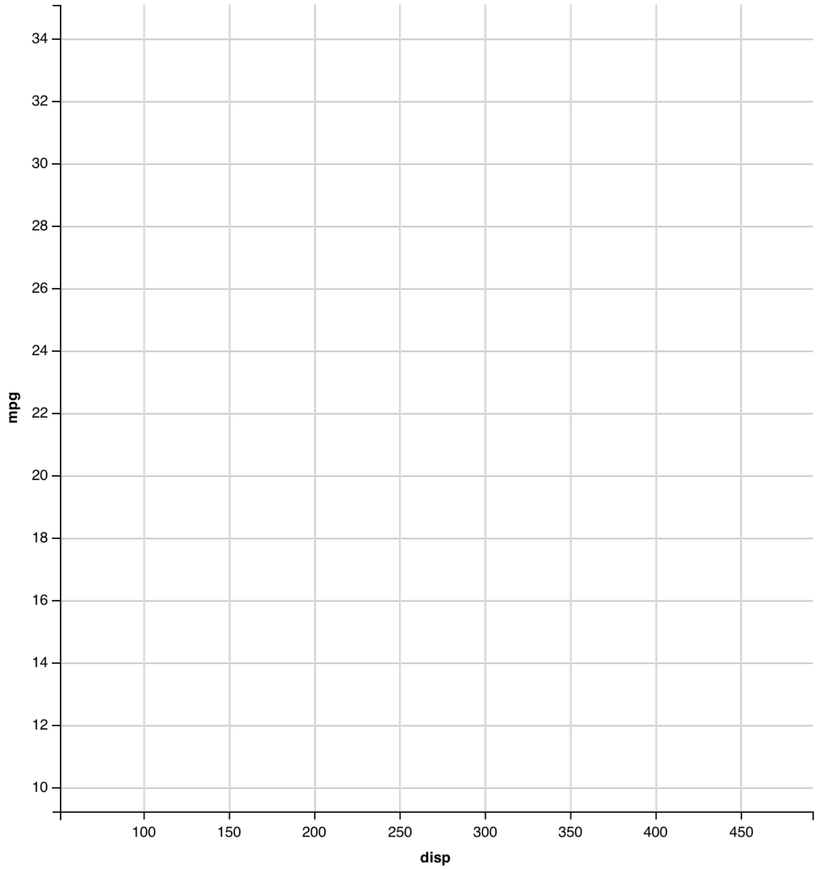
data geom

ggplot2

mappings

fill

mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1



data geom

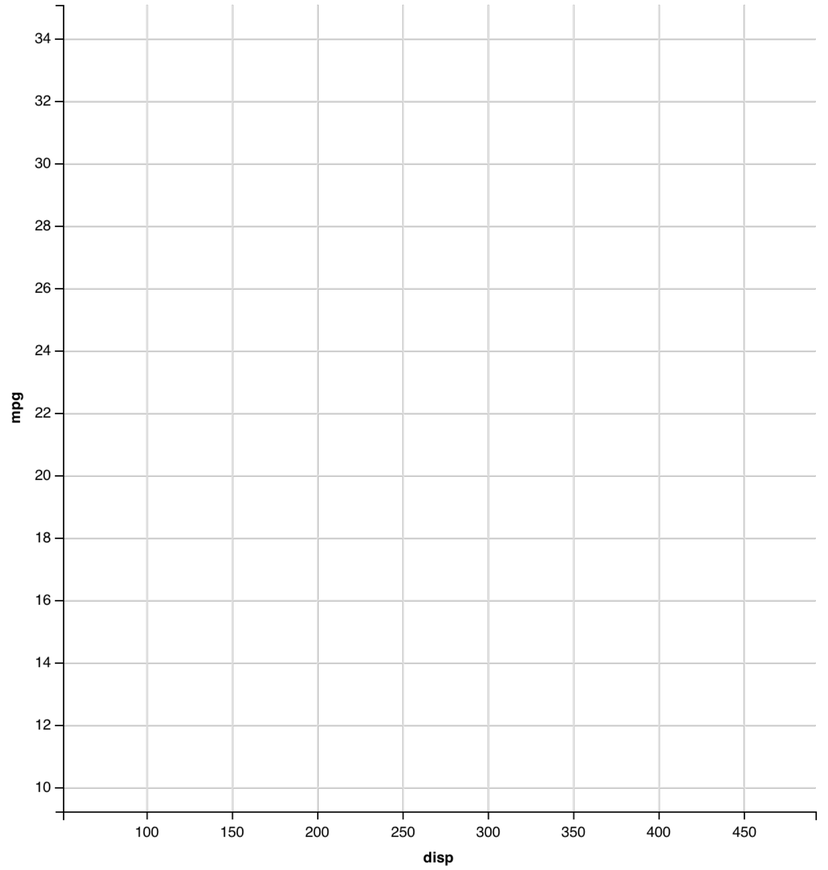
ggplot2

mappings

shape

fill

mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1



data

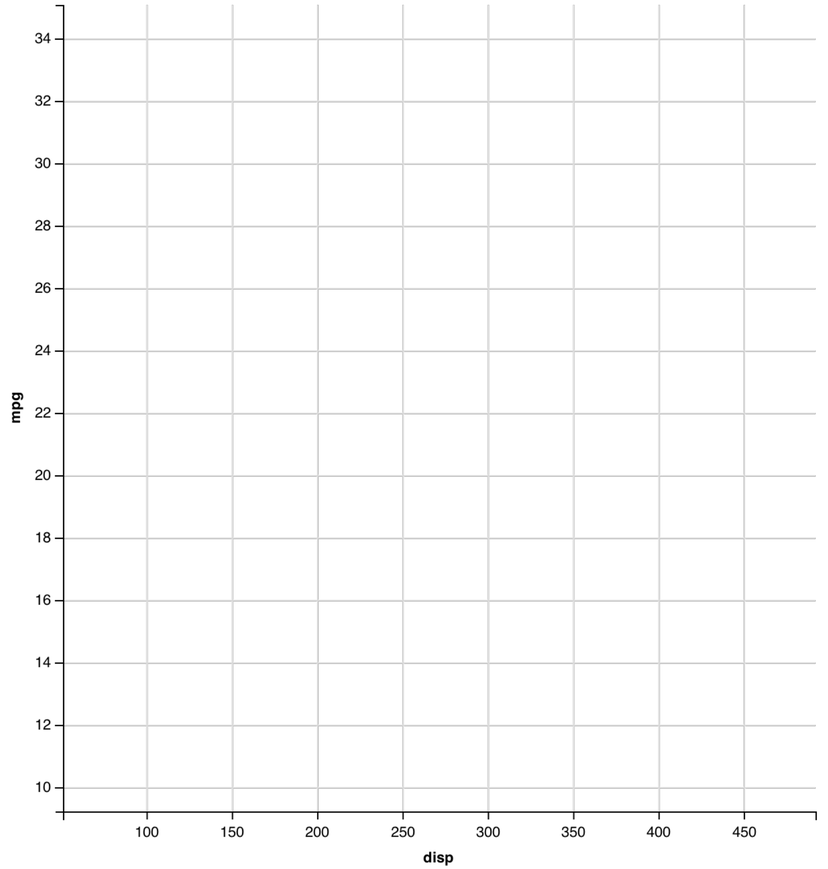
geom

ggplot2

mappings

shape x fill

mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1



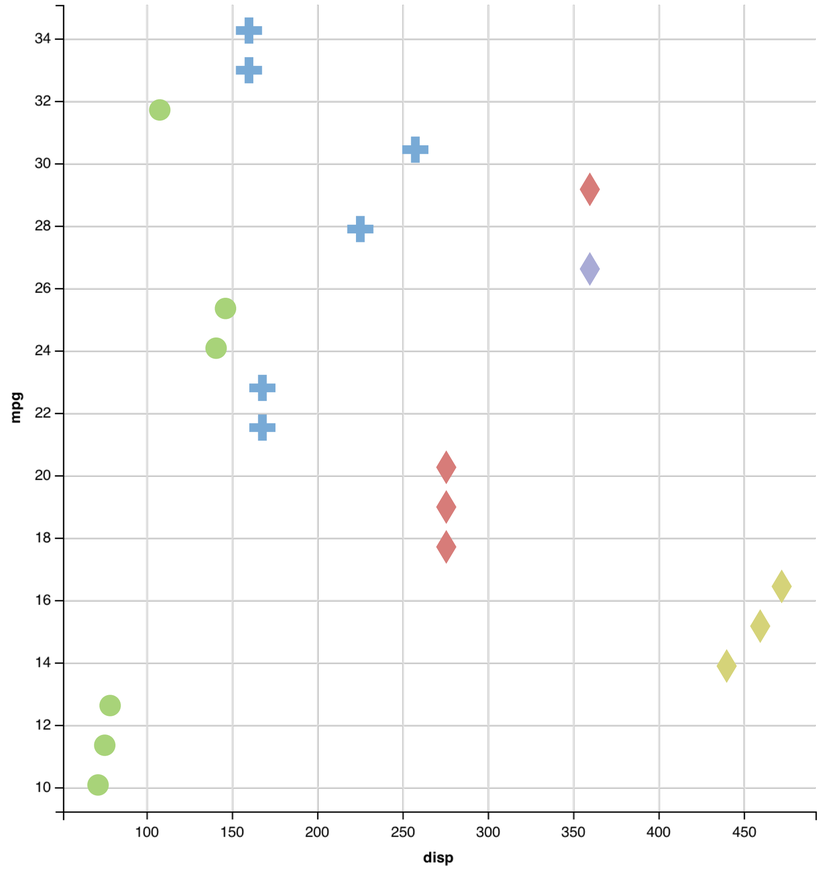
data geom

ggplot2

mappings

y shape x fill

mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1



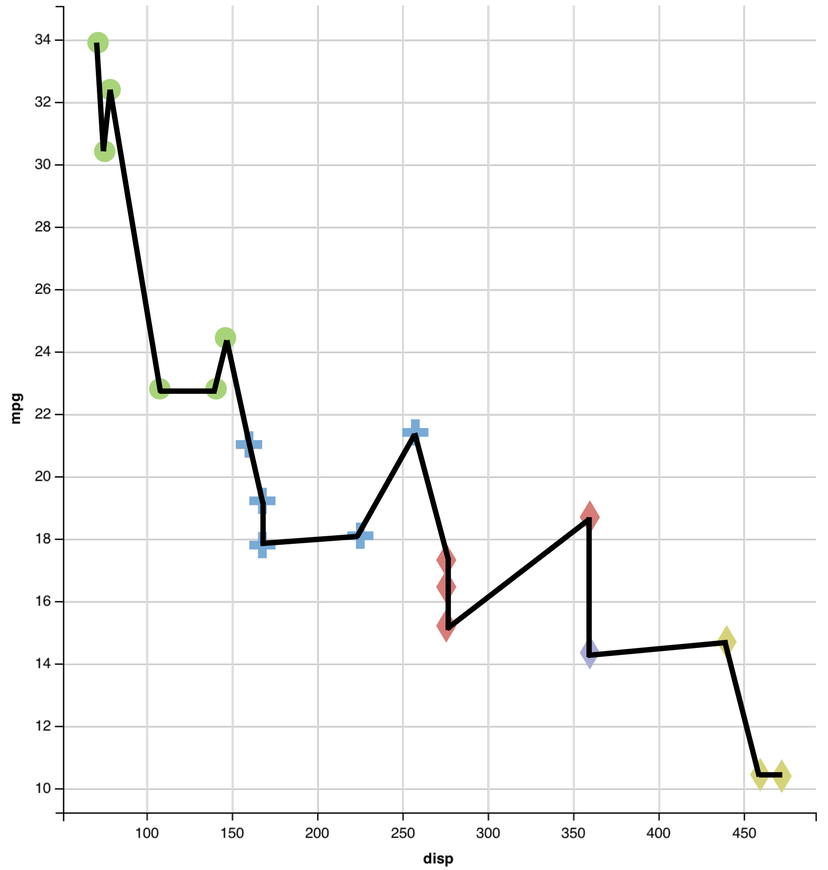
data geom

ggplot2

mappings

y shape x fill

mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1



data

geom

points

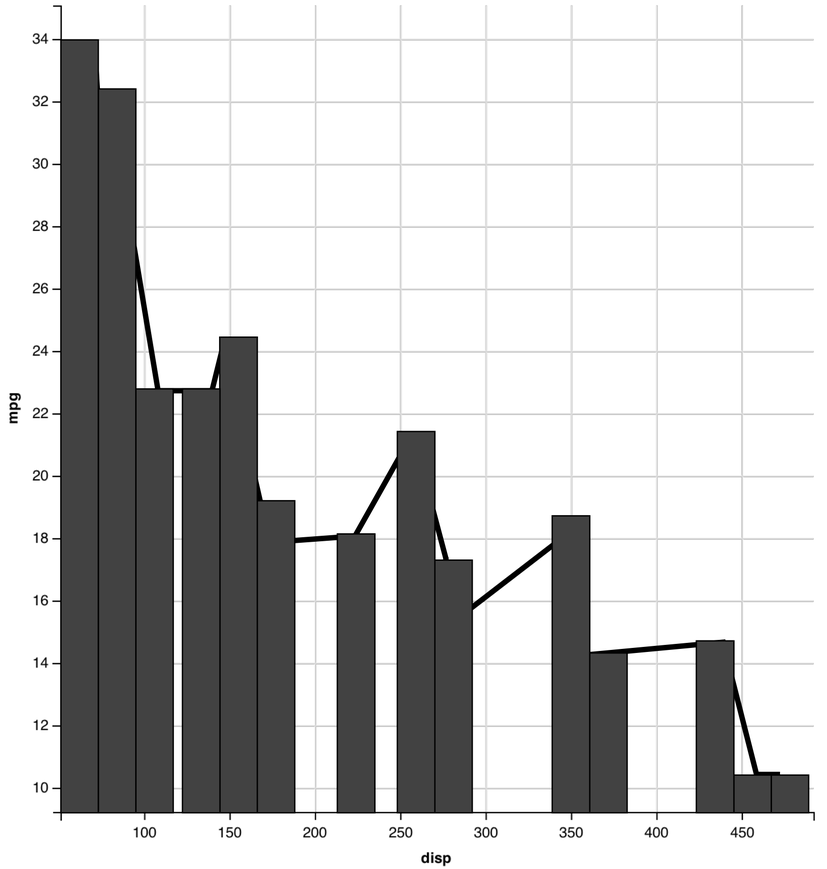
lines

ggplot2

mappings

y x

mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1



data

geom

points

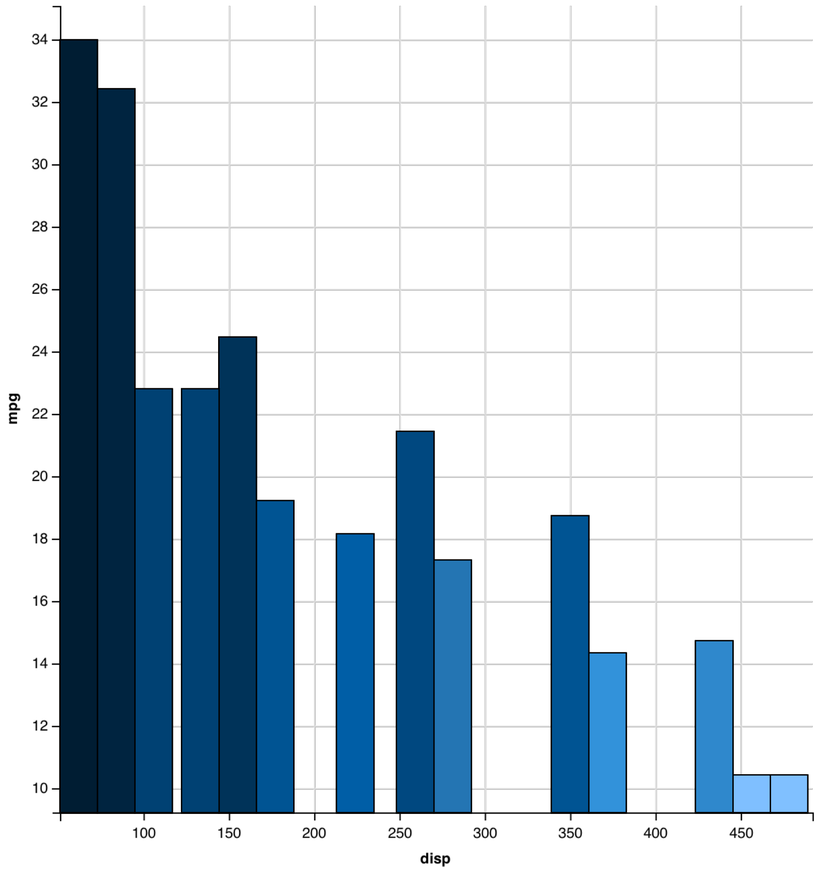
lines

bars

mappings

y fill

mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1



data

geom

points

lines

bars

ggplot2

To make a graph

[template]

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

To make a graph

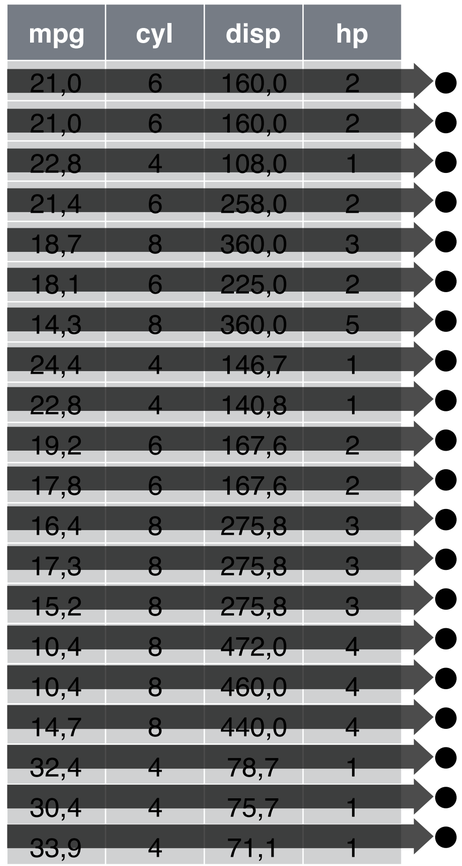
mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1

data

1. Pick a data set

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

To make a graph



mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1

data geom

1. Pick a data set

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

2. Choose a geom to display cases

To make a graph

mappings

fill

mpg	cyl	disp	hp
21,0	6	160,0	2
21,0	6	160,0	2
22,8	4	108,0	1
21,4	6	258,0	2
18,7	8	360,0	3
18,1	6	225,0	2
14,3	8	360,0	5
24,4	4	146,7	1
22,8	4	140,8	1
19,2	6	167,6	2
17,8	6	167,6	2
16,4	8	275,8	3
17,3	8	275,8	3
15,2	8	275,8	3
10,4	8	472,0	4
10,4	8	460,0	4
14,7	8	440,0	4
32,4	4	78,7	1
30,4	4	75,7	1
33,9	4	71,1	1

data

geom

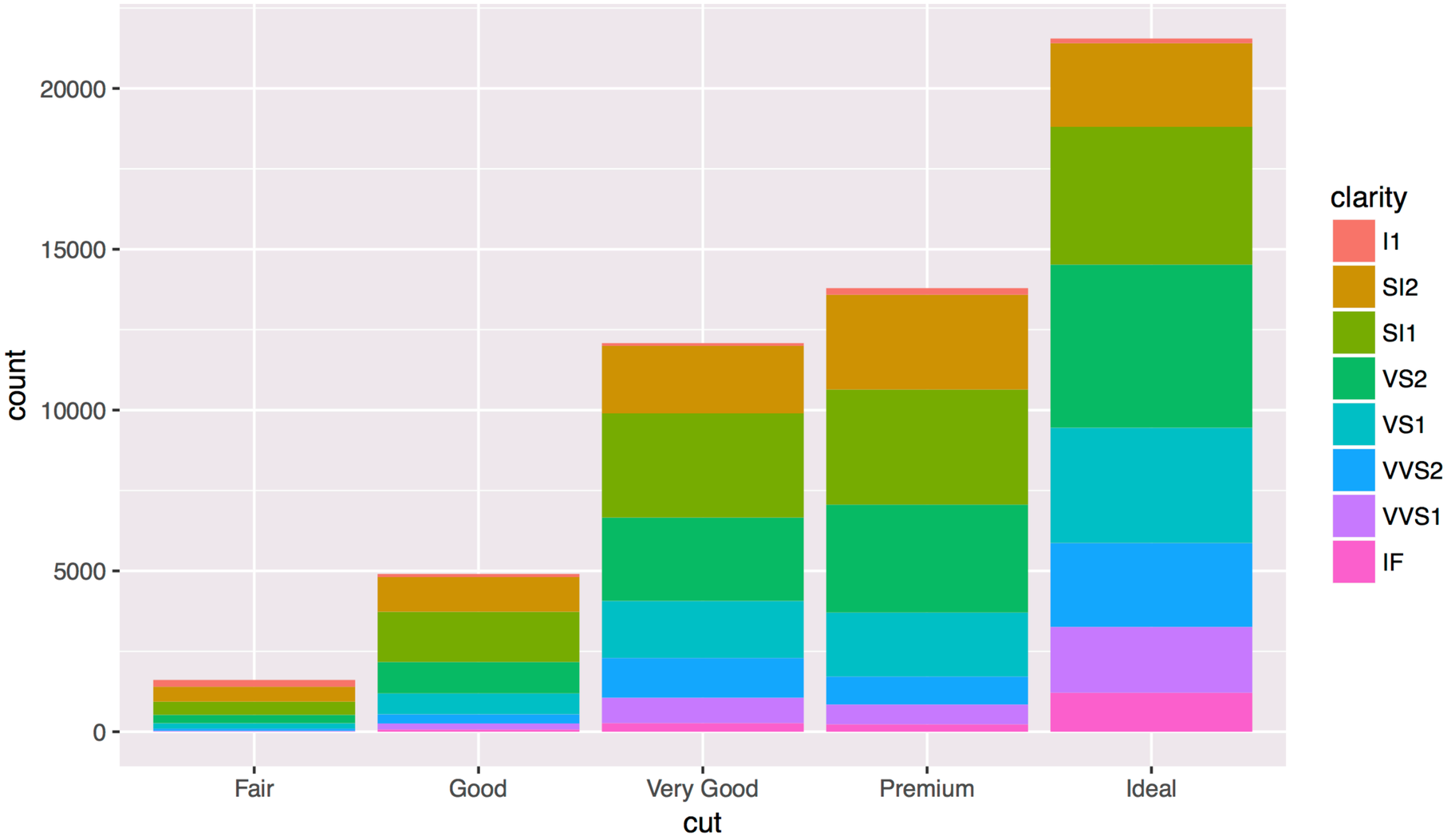
1. Pick a data set

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

2. Choose a geom to display cases

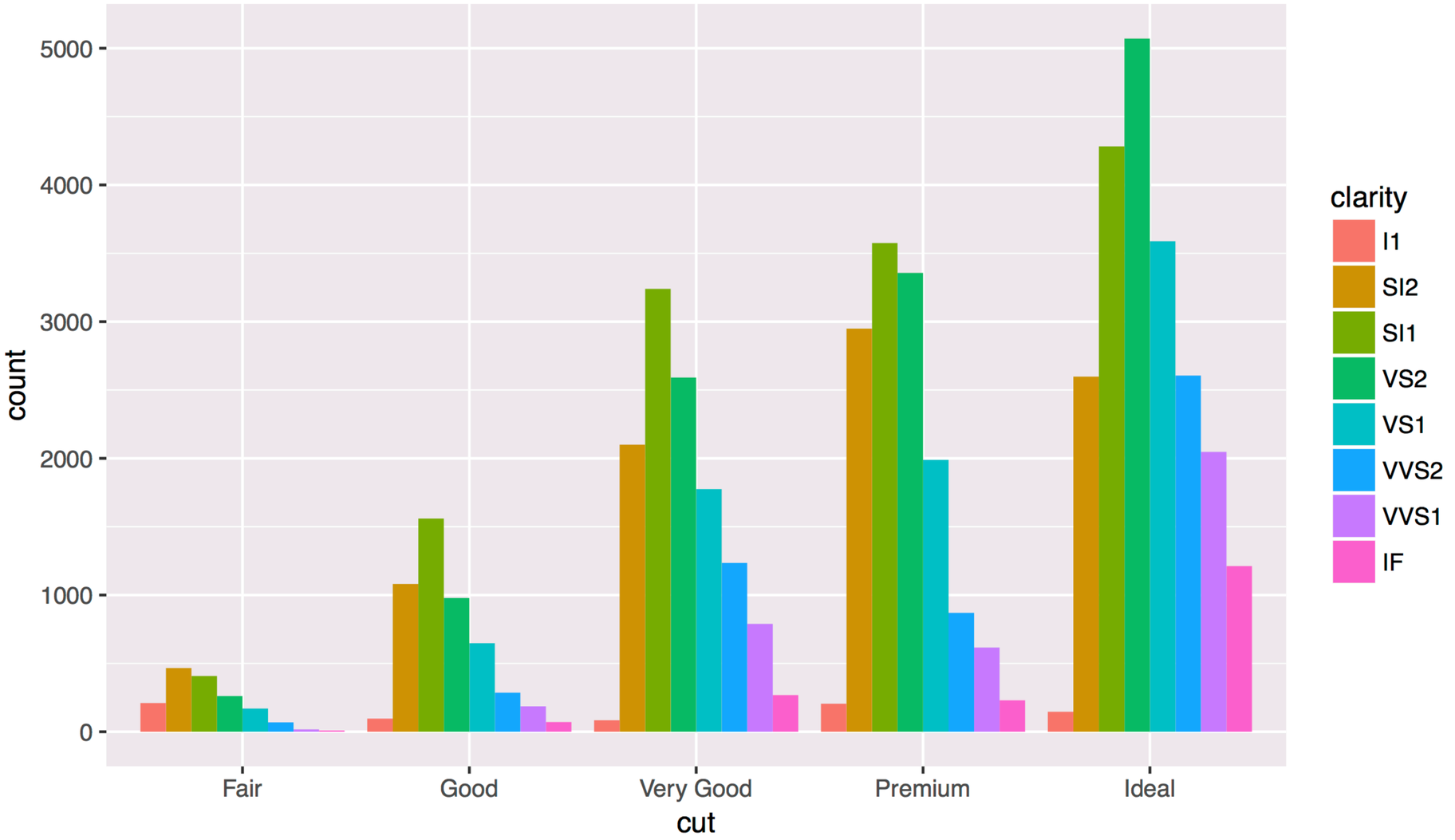
3. Map aesthetic properties to variables

What else?


20000
15000
10000
5000
0
count
Fair
Good
Very Good
Premium
Ideal
cut
clarity
I1
SI2
SI1
VS2
VS1
VVS2
VVS1
IF

Position Adjustments

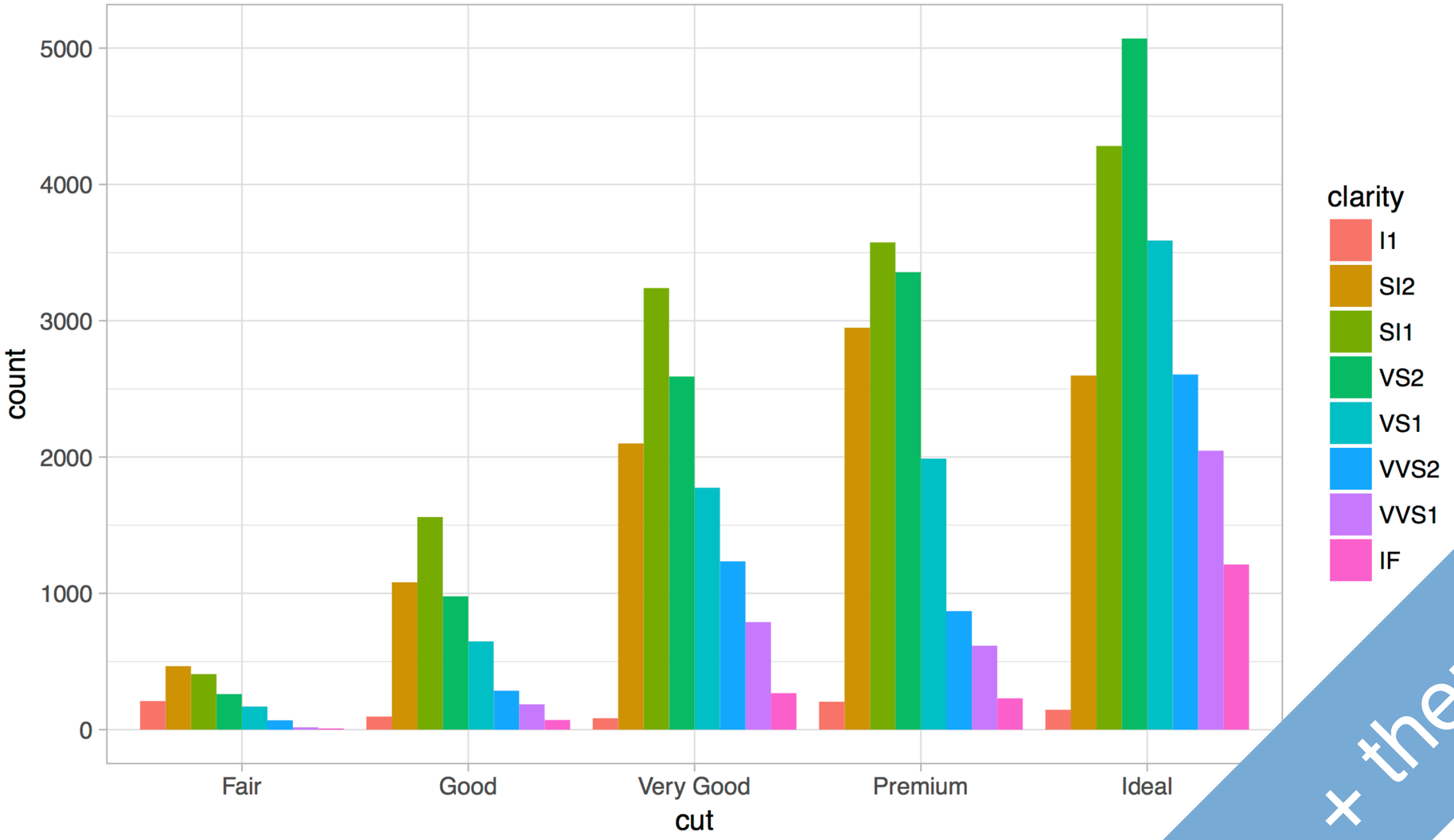
How overlapping objects are arranged



ggplot2

Themes

Visual appearance of non-data elements

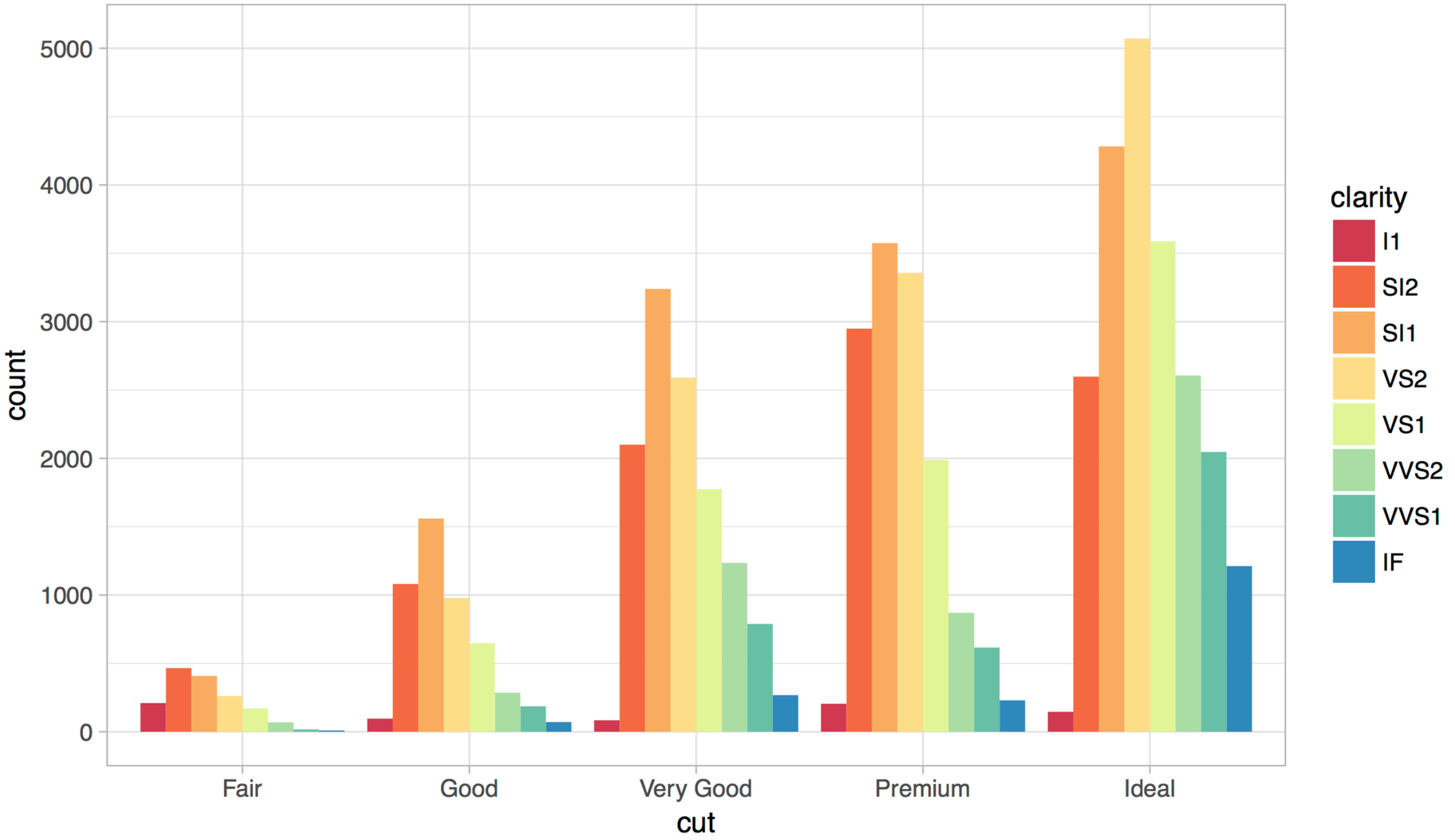


+ theme_bw()

ggplot2

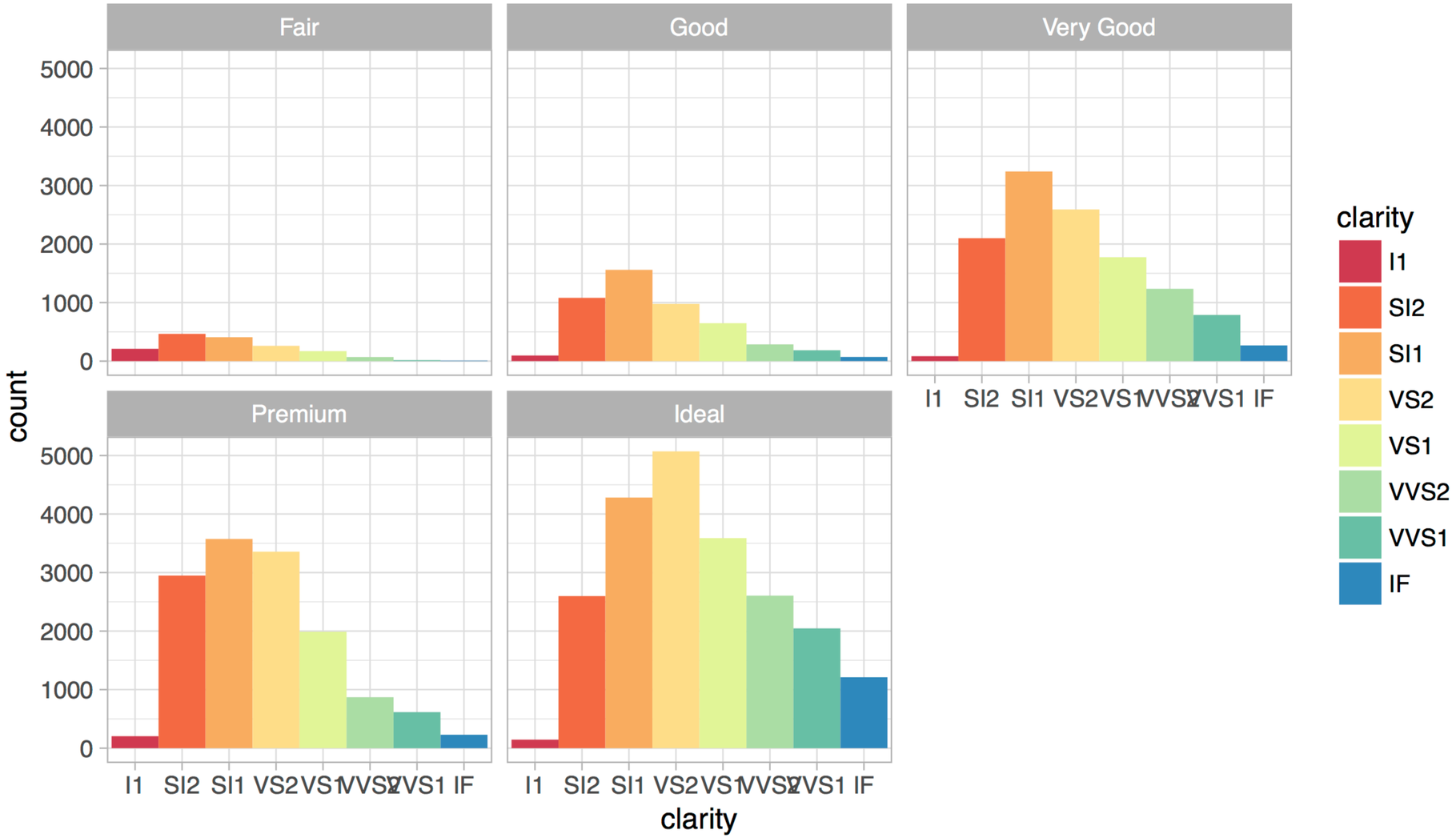
Scales

Customize color scales, other mappings

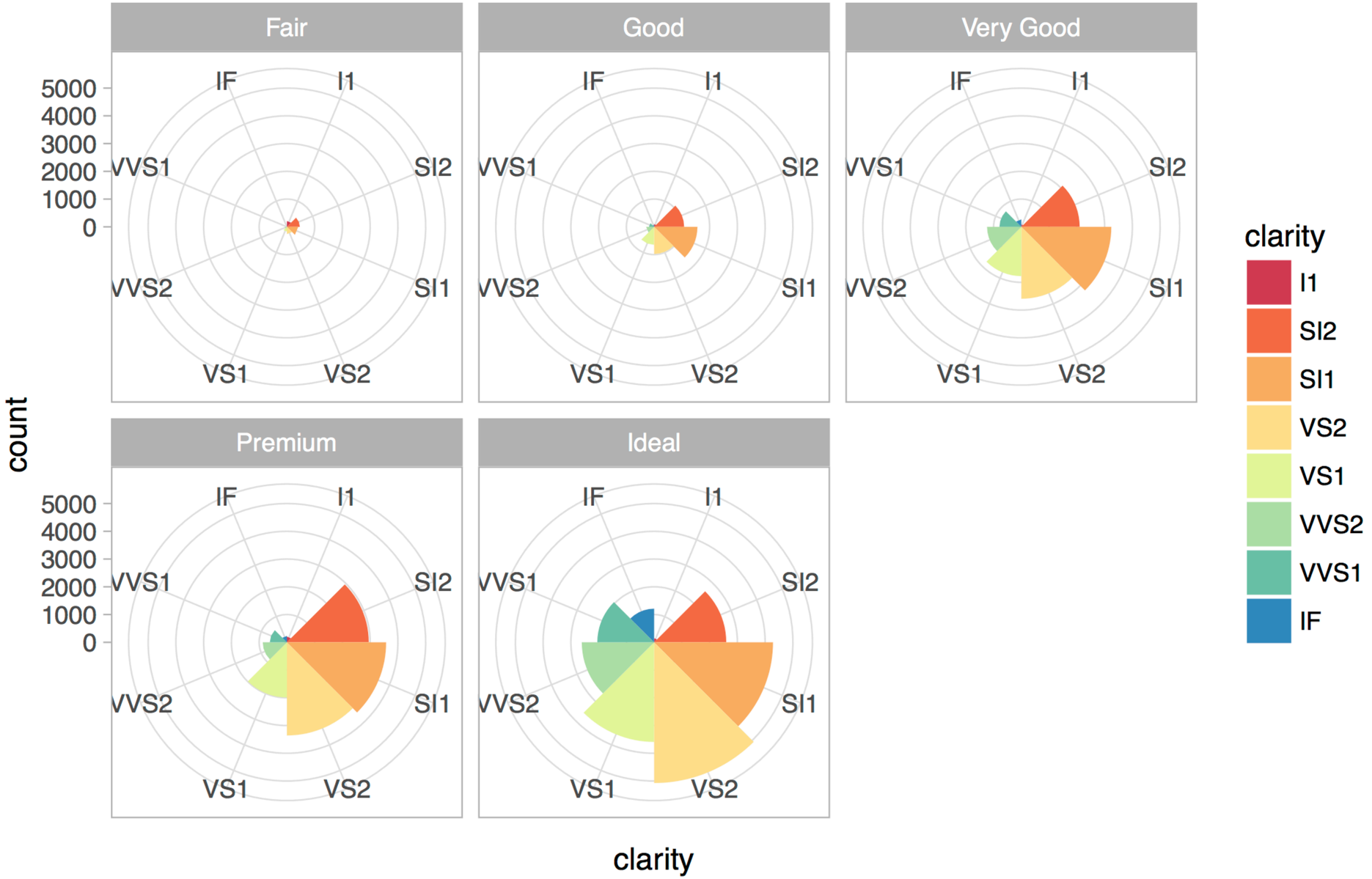


Facets

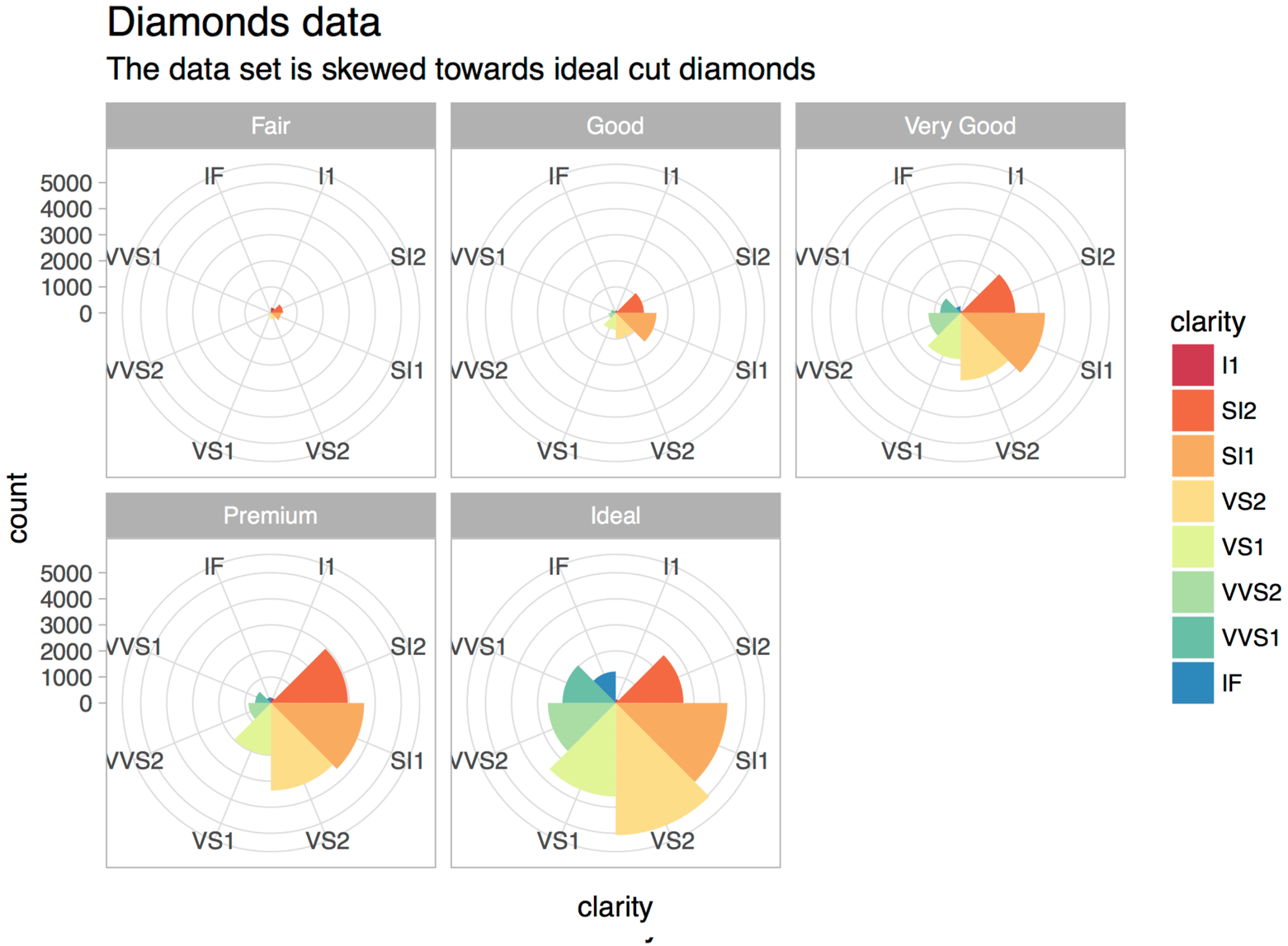
Subplots that display subsets of the data.



Coordinate systems



Titles and captions



A ggplot2 template

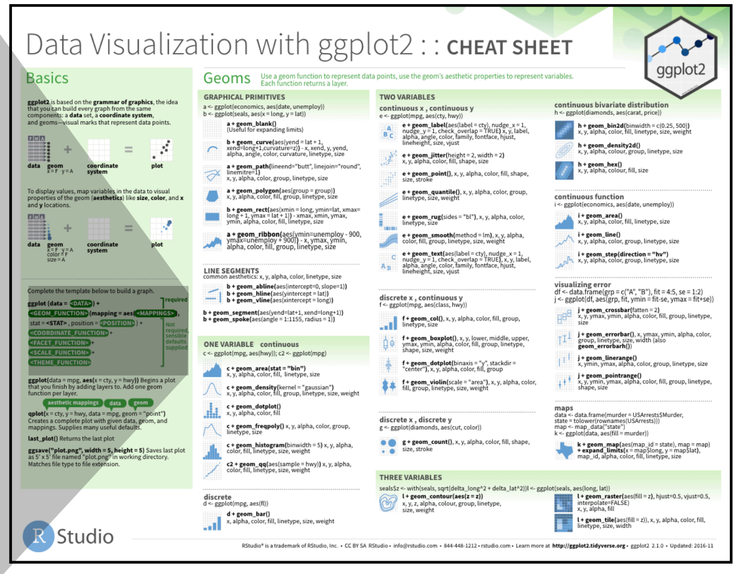
Make any plot by filling in the parameters of this template

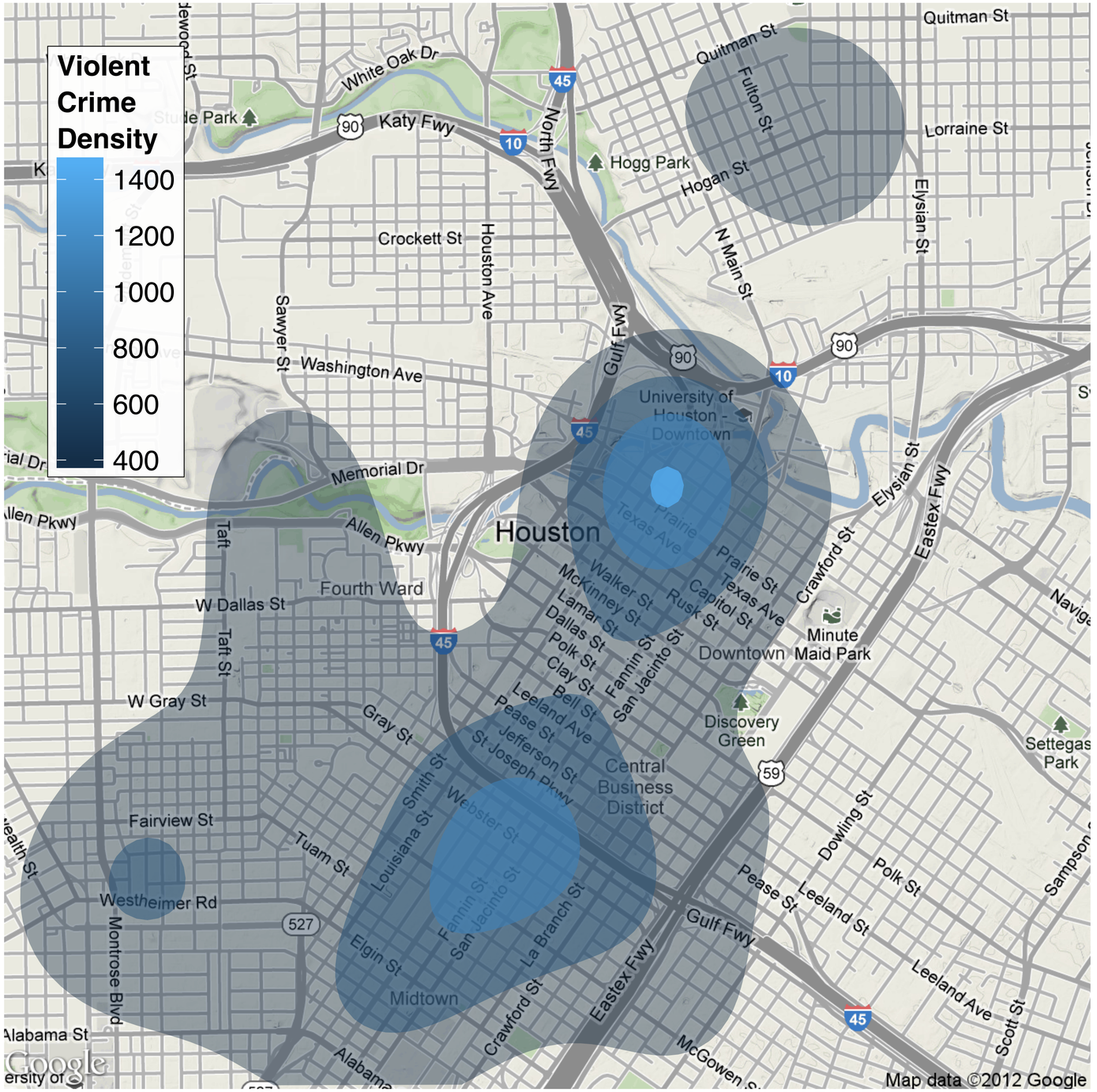
Complete the template below to build a graph.

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

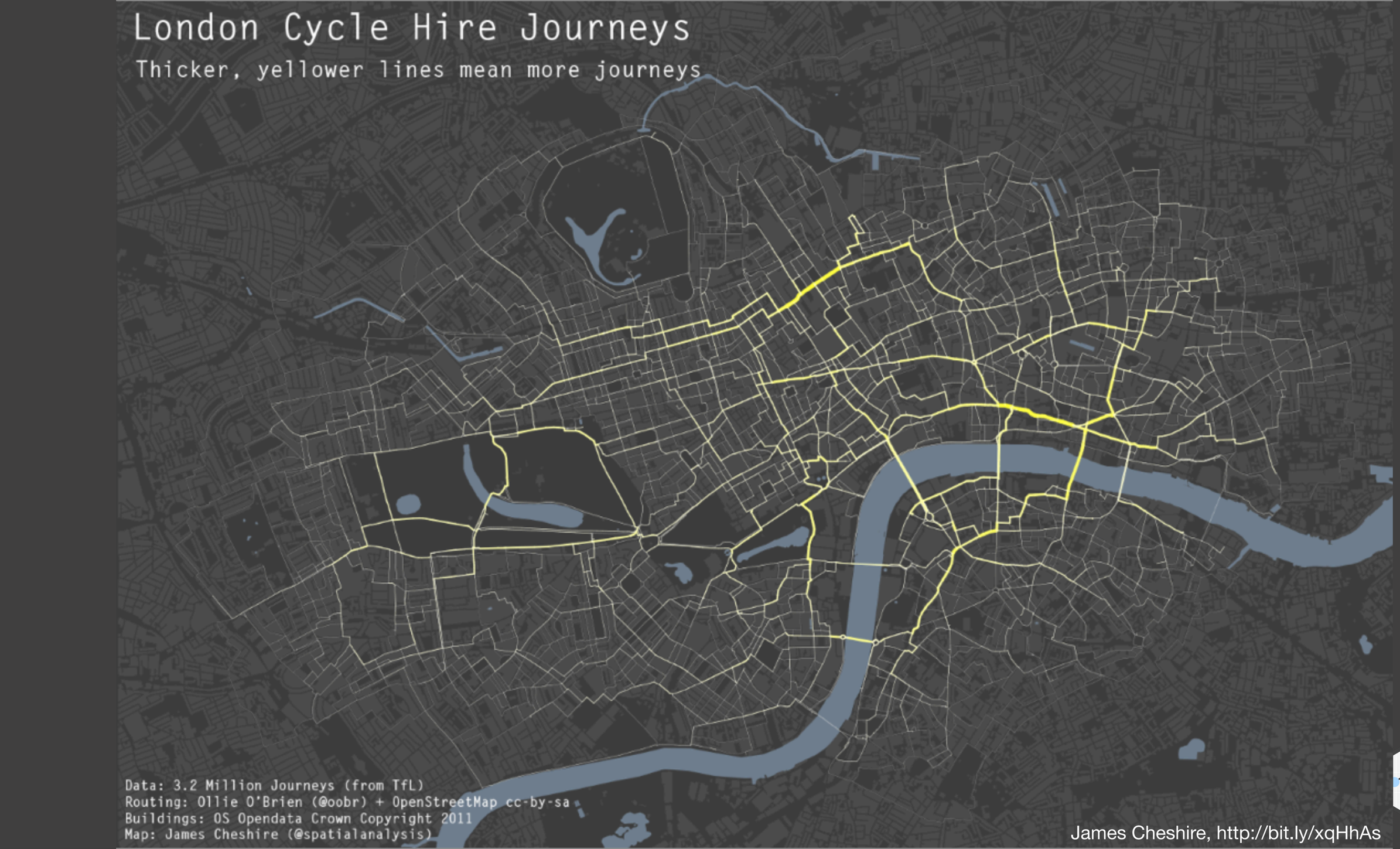
required

Not required, sensible defaults supplied





David Kahle, https://dl.dropbox.com/u/24648660/ggmap%20useR%202012.pdf



ggplot2

James Cheshire, http://bit.ly/xqHhAs

r4ds.had.co.nz

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r4ds.had.co.nz

R for Data Science

The ultimate resource for all of today

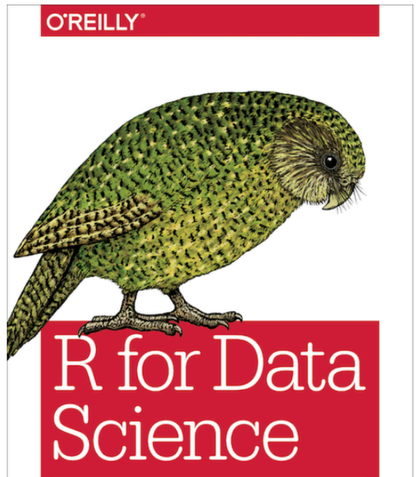
R for Data Science

Garrett Grolemund

Hadley Wickham

Welcome

This is the website for **"R for Data Science"**. This book will teach you how to do data science with R: You'll learn how to get your data into R, get it into the most useful structure, transform it, visualise it and model it. In this book, you will find a practicum of skills for data science. Just as a chemist learns how to clean test tubes and stock a lab, you'll learn how to clean data and draw plots—and many other things besides. These are the skills that allow data science to happen, and here you will find the best practices for doing each of these things with R. You'll learn how to use the grammar of graphics, literate programming, and reproducible research to save time. You'll also learn how to



ggplot2

Visualize Data with