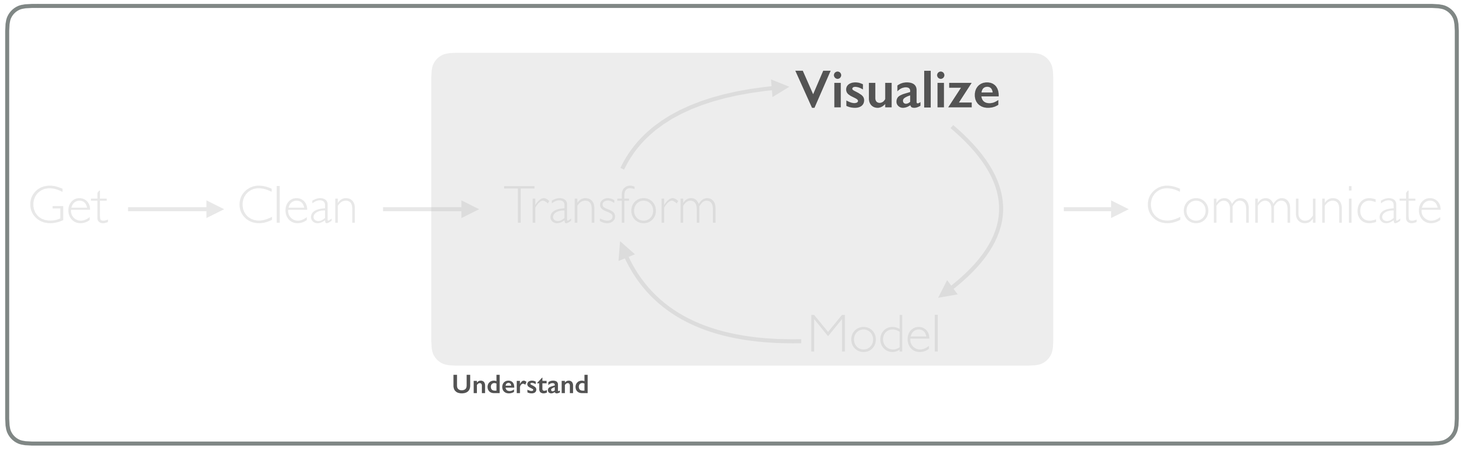
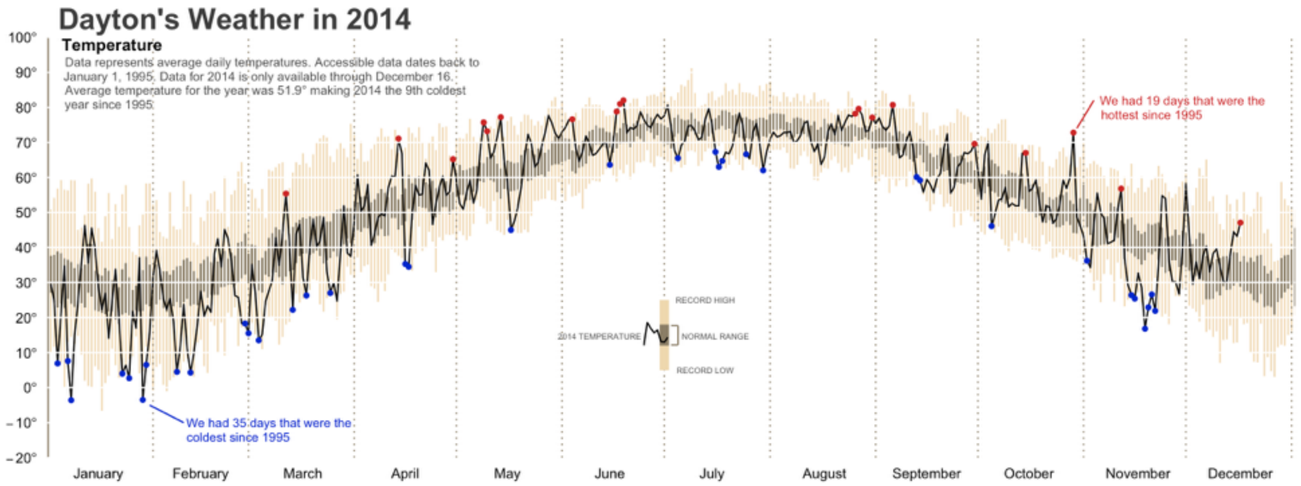
VISUALIZATION

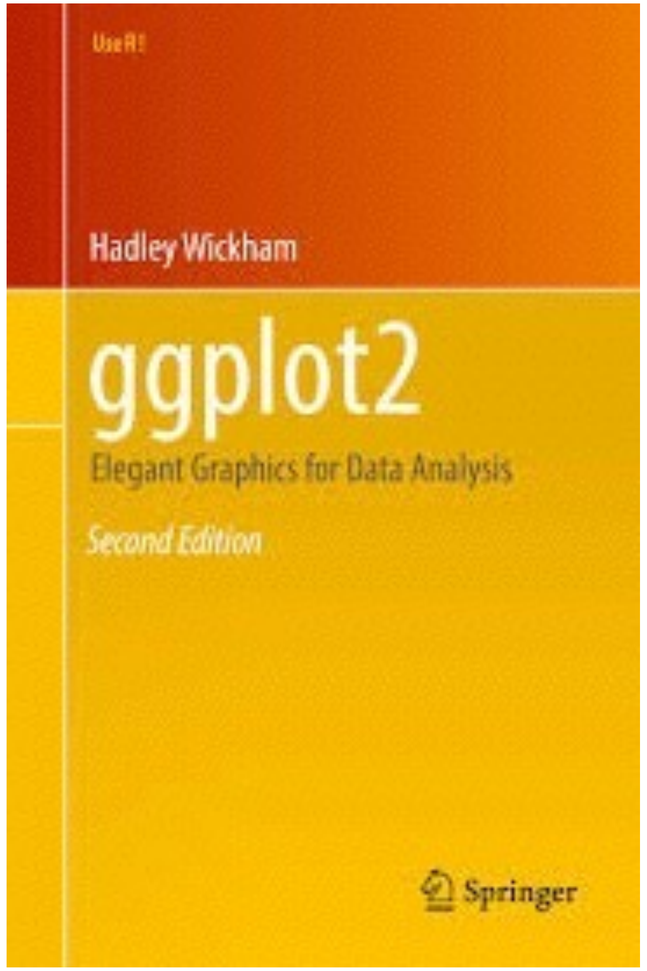


†A modified version of Hadley Wickham's analytic process

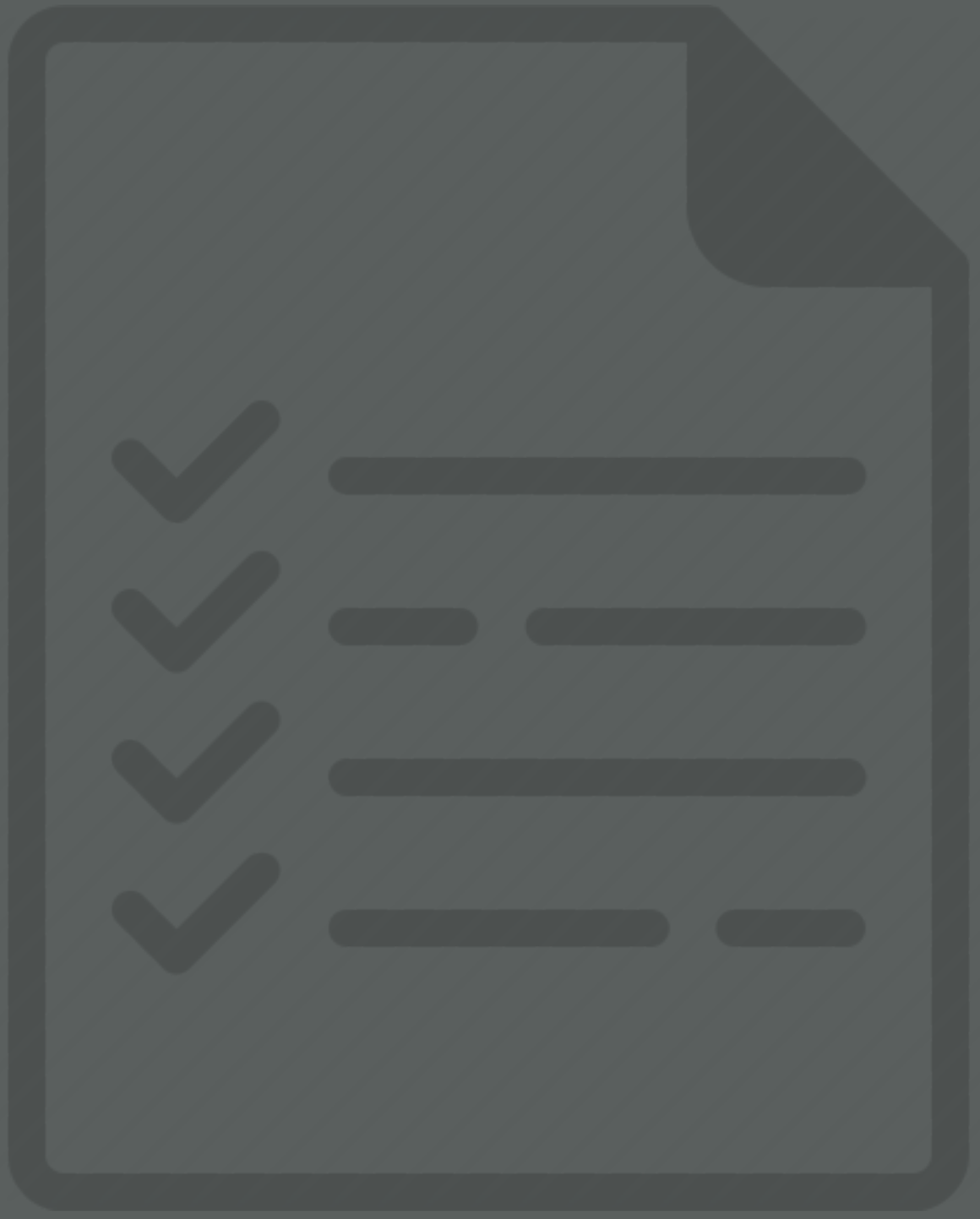
ggplot2

- R has several systems for making graphs
- `ggplot2` is the most elegant and versatile
- Implements the grammar of graphics theory behind data visualization





PREREQUISITES



PACKAGE PREREQUISITE

```
library(tidyverse)
#> Loading tidyverse: ggplot2
#> Loading tidyverse: tibble
#> Loading tidyverse: tidyr
#> Loading tidyverse: readr
#> Loading tidyverse: purrr
#> Loading tidyverse: dplyr
#> Conflicts with tidy packages ----------------------------------------
#> filter(): dplyr, stats
#> lag():    dplyr, stats
```

DATA PREREQUISITE

```
mpg
#> # A tibble: 234 × 11
#>   manufacturer model displ  year   cyl      trans   drv   cty   hwy    fl
#>          <chr> <chr> <dbl> <int> <int>      <chr> <chr> <int> <int> <chr>
#> 1         audi    a4   1.8  1999     4   auto(l5)     f    18    29     p
#> 2         audi    a4   1.8  1999     4 manual(m5)     f    21    29     p
#> 3         audi    a4   2.0  2008     4 manual(m6)     f    20    31     p
#> 4         audi    a4   2.0  2008     4   auto(av)     f    21    30     p
#> 5         audi    a4   2.8  1999     6   auto(l5)     f    16    26     p
#> 6         audi    a4   2.8  1999     6 manual(m5)     f    18    26     p
#> # ... with 228 more rows, and 1 more variables: class <chr>
```

*Type **`View(mpg)`** in the console for a spreadsheet view of the data*

YOUR TURN!

Is there a vignette for the **`tidyverse`** *package?*

Can you find additional documentation explaining the **`mpg`** *data set?*

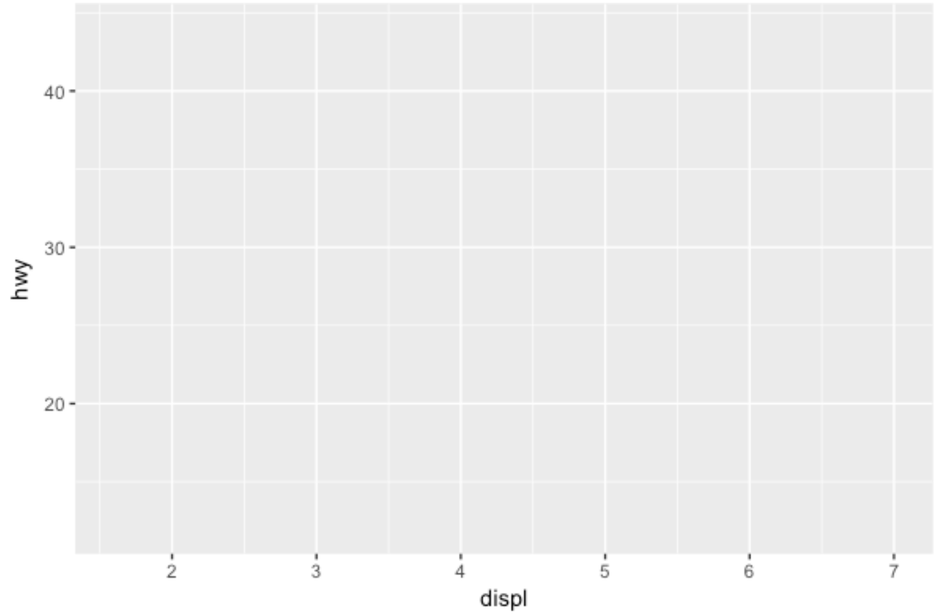
SOLUTION

```
# is there a vignette for the tidy verse package -> yes, “manifesto”
vignette(package = "tidyverse")


# additional documentation for the mpg data set
?mpg
```

CANVAS

LET'S CREATE OUR "CANVAS"

```
# left
ggplot(data = mpg)

# right
ggplot(data = mpg, aes(x = displ, y = hwy))
```

GEOMS

```
geom_abline       geom_histogram
geom_bar          geom_jitter
geom_bin2d        geom_label
geom_blank        geom_map
geom_boxplot      geom_path
geom_contour      geom_point
geom_count        geom_polygon
geom_hex          geom_quantile
geom_crossbar     geom_raster
geom_density      geom_ribbon
geom_density_2d   geom_rug
geom_dotplot      geom_segment
geom_errorharh    geom_smooth
geom_freqpoly     geom_violin
```

LETS ADD "GEOMS"

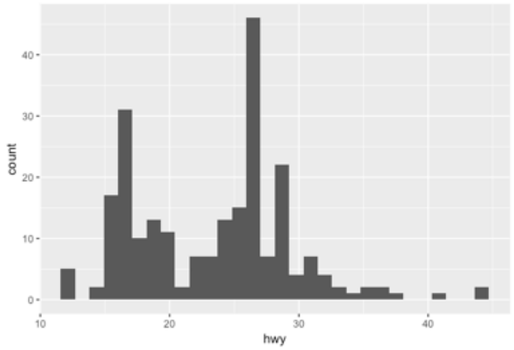
- We display data with geometric shapes
- ~ 30 built-in geoms (with many more offered by other pkgs)

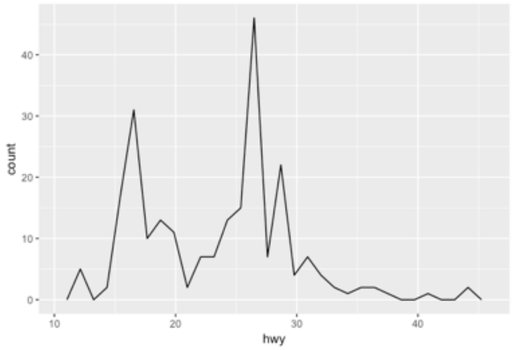
Type **`geom_ +`** *tab in the console*

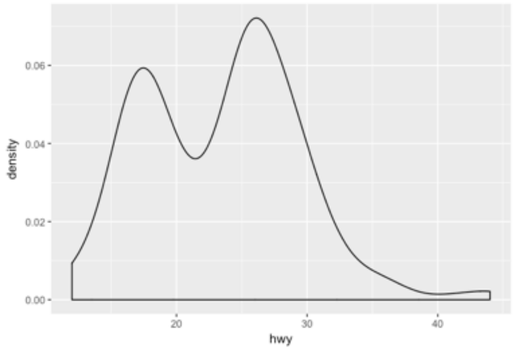
```
geom_abline      geom_histogram
geom_bar         geom_jitter
geom_bin2d       geom_label
geom_blank       geom_map
geom_boxplot     geom_path
geom_contour     geom_point
geom_count       geom_polygon
geom_hex         geom_quantile
geom_crossbar    geom_raster
geom_density     geom_ribbon
geom_density_2d  geom_rug
geom_dotplot     geom_segment
geom_errorharh   geom_smooth
geom_freqpoly    geom_violin
```

UNIVARIATE GEOMS

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

ggplot(data = mpg, aes(x = hwy)) +
  geom_freqpoly()

ggplot(data = mpg, aes(x = hwy)) +
  geom_density()
```



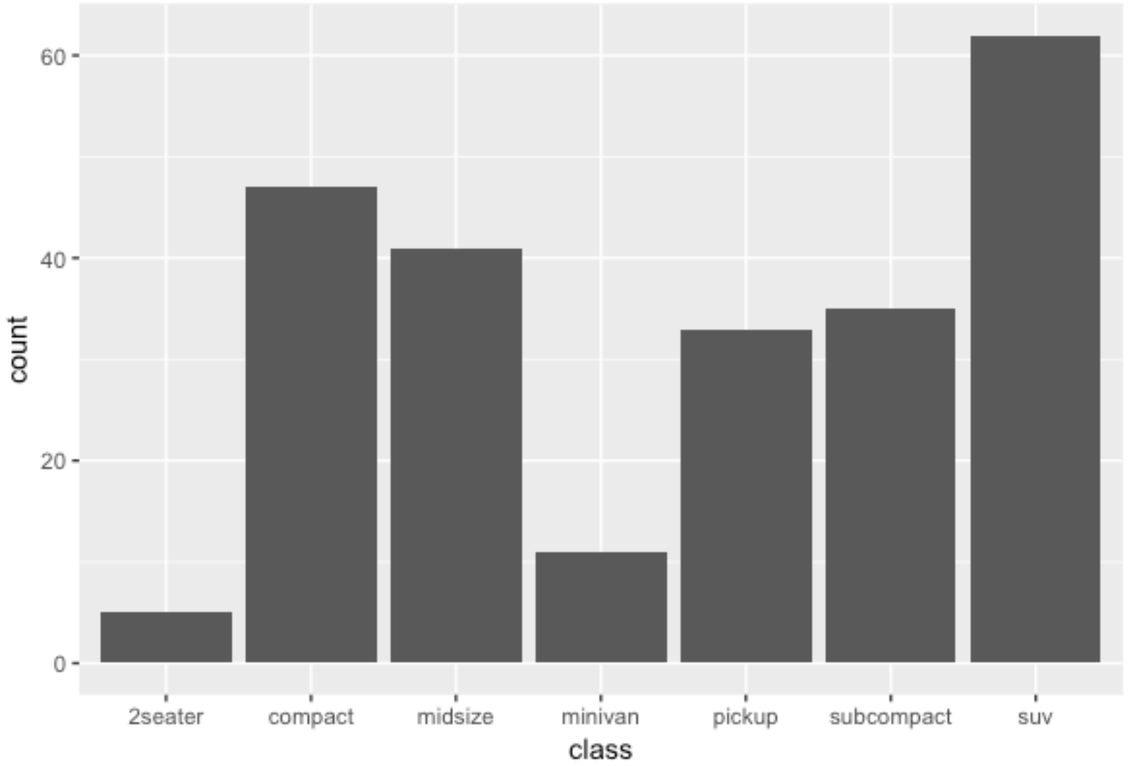




geom_abline
geom_bar
geom_bin2d
geom_blank
geom_boxplot
geom_contour
geom_count
geom_hex
geom_crossbar
geom_density
geom_density_2d
geom_dotplot
geom_errorharh
geom_freqpoly
geom_histogram
geom_jitter
geom_label
geom_map
geom_path
geom_point
geom_polygon
geom_quantile
geom_raster
geom_ribbon
geom_rug
geom_segment
geom_smooth
geom_violin

UNIVARIATE GEOMS

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



geom_abline
geom_bar
geom_bin2d
geom_blank
geom_boxplot
geom_contour
geom_count
geom_hex
geom_crossbar
geom_density
geom_density_2d
geom_dotplot
geom_errorharh
geom_freqpoly
geom_histogram
geom_jitter
geom_label
geom_map
geom_path
geom_point
geom_polygon
geom_quantile
geom_raster
geom_ribbon
geom_rug
geom_segment
geom_smooth
geom_violin

UNIVARIATE GEOMS

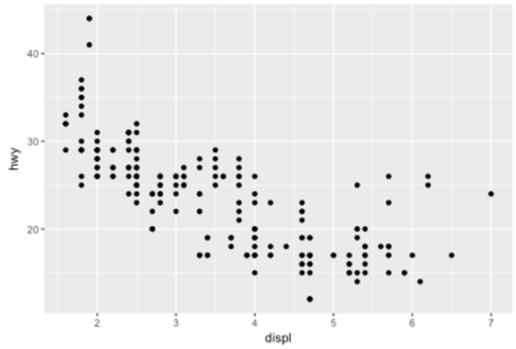
```
ggplot(data = mpg, aes(x = class)) +
  geom_bar()
```

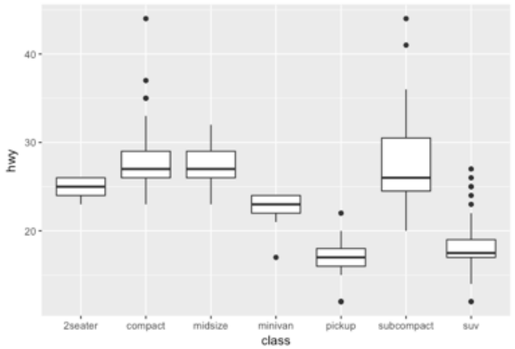
- This is called an **aes**thetic mapping argument
- Every geom requires a mapping argument
  - Some geoms require just one (x variable)
  - While other geoms require two (x & y variable)

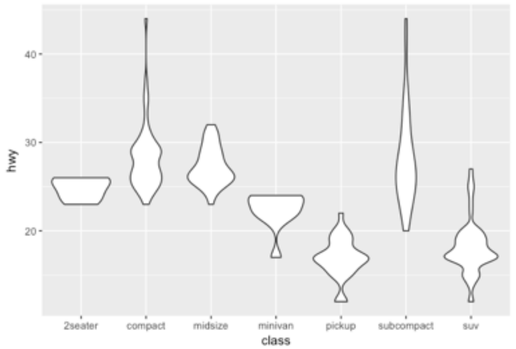
```
geom_abline       geom_histogram
geom_bar          geom_jitter
geom_bin2d        geom_label
geom_blank        geom_map
geom_boxplot      geom_path
geom_contour      geom_point
geom_count        geom_polygon
geom_hex          geom_quantile
geom_crossbar     geom_raster
geom_density      geom_ribbon
geom_density_2d   geom_rug
geom_dotplot      geom_segment
geom_errorharh    geom_smooth
geom_freqpoly     geom_violin
```

BIVARIATE GEOMS

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

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

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







geom_abline
geom_bar
geom_bin2d
geom_blank
geom_boxplot
geom_contour
geom_count
geom_hex
geom_crossbar
geom_density
geom_density_2d
geom_dotplot
geom_errorharh
geom_freqpoly
geom_histogram
geom_jitter
geom_label
geom_map
geom_path
geom_point
geom_polygon
geom_quantile
geom_raster
geom_ribbon
geom_rug
geom_segment
geom_smooth
geom_violin

YOUR TURN!

1. Create a chart that illustrates the distribution of the `cty` variable

2. Create a chart that shows the number of observations for each `manufacturer`

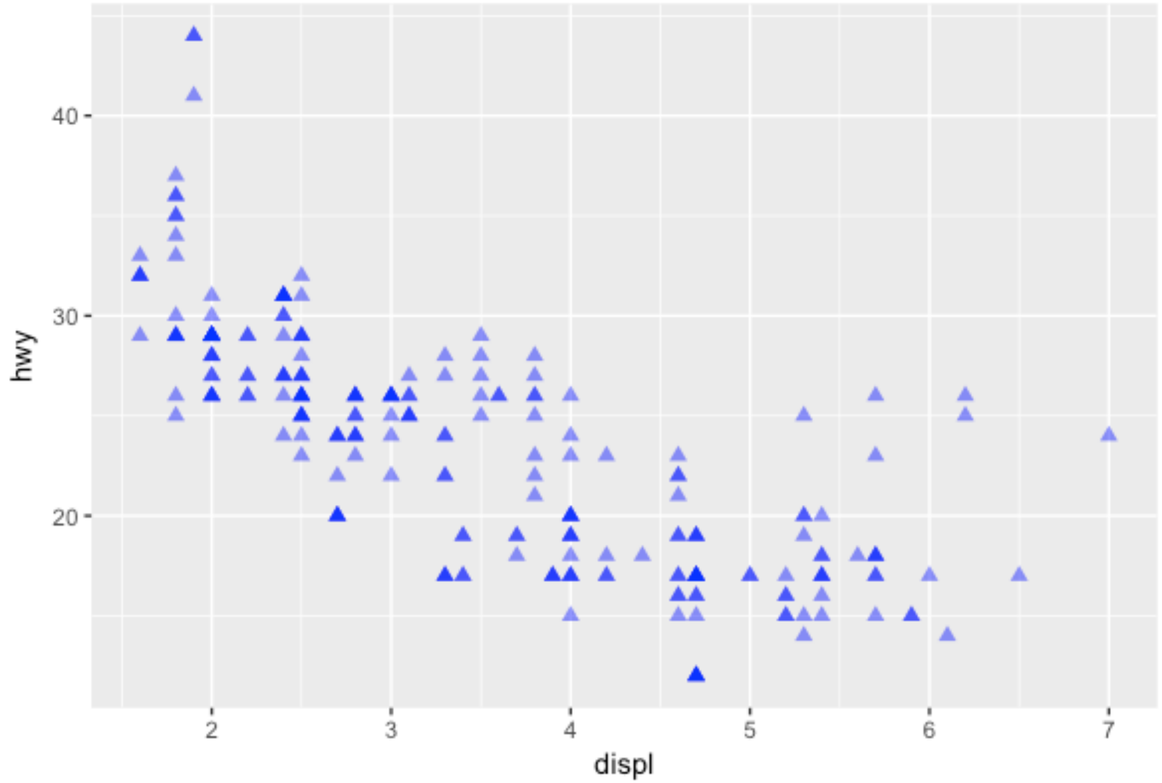
3. Create a scatter plot of `cty` vs `displ`

SOLUTION

```
# distribution of cty variable
ggplot(data = mpg, aes(x = cty)) +
  geom_histogram()


# number of observations for each manufacturer
ggplot(data = mpg, aes(x = manufacturer)) +
  geom_bar()


# scatter plot for cty vs displ
ggplot(data = mpg, aes(x = displ, y = cty)) +
  geom_point()
```

NON-MAPPING AESTHETICS

```
ggplot(data = mpg, aes(x = displ, y = hwy)) +
  geom_point(color = "blue", size = 2, shape = 17, alpha = .5)
```



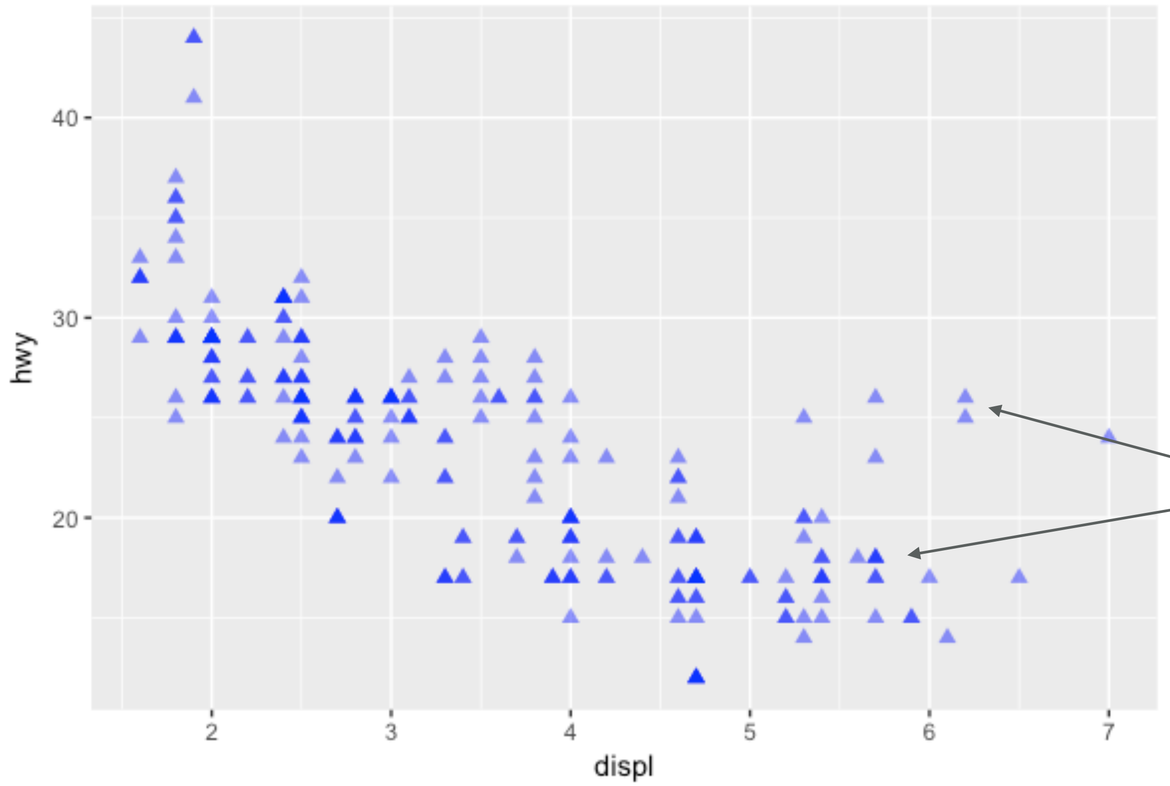
We can also change other visual aesthetics in our graphics

- color
- size
- sh△pe (0-25 **?pch**)
- opacity

Lots of color and sh◆pe options; just google and you'll find plenty of references

NON-MAPPING AESTHETICS

```
ggplot(data = mpg, aes(x = displ, y = hwy)) +
  geom_point(color = "blue", size = 2, shape = 17, alpha = .5)
```



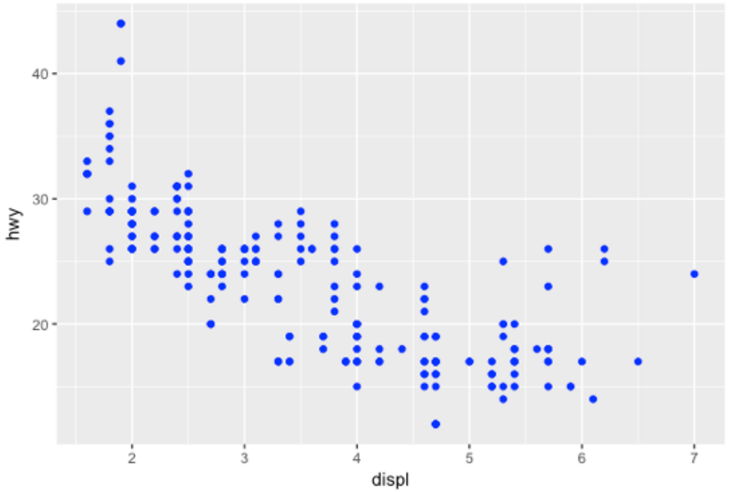
We can also change other visual aesthetics in our graphics

- color
- size
- sh△pe
- opacity

- Why are some points darker than others?
- Try **`geom_jitter`** in place of **`geom_point`**
- What do you think **`geom_jitter`** does?

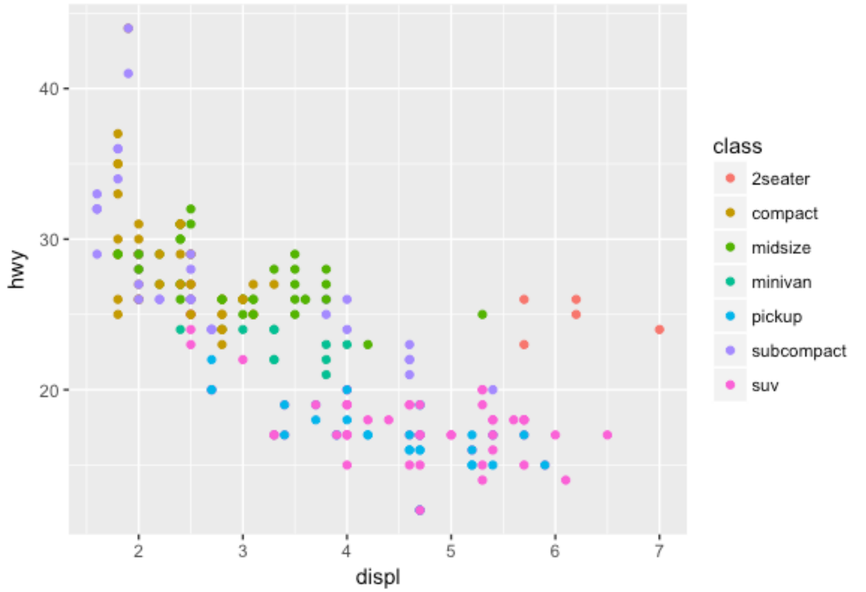
ADDING A 3RD DIMENSION

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



By moving the **`color`** argument to within `aes()`, we can map a 3rd variable to our plot

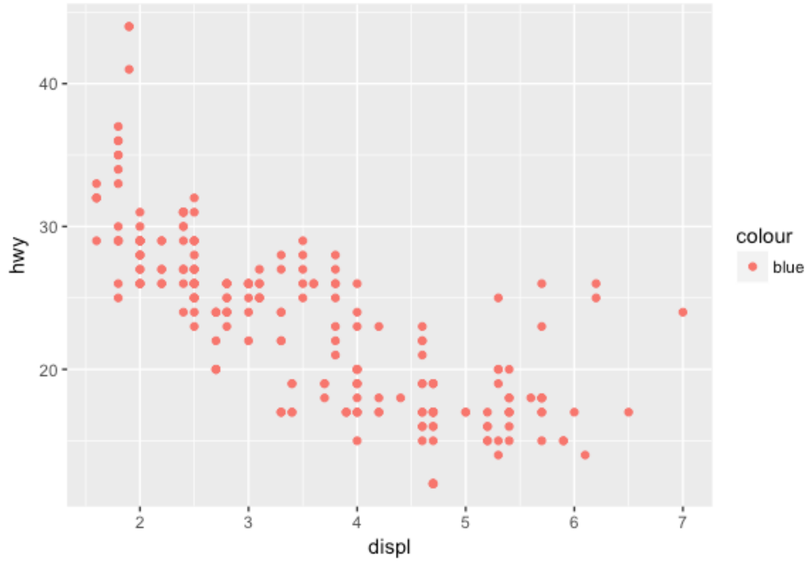
```
ggplot(data = mpg, aes(x = displ, y = hwy, color = class)) +
  geom_point()
```



ADDING A 3RD DIMENSION

A common error…what happened???

```
ggplot(data = mpg, aes(x = displ, y = hwy, color = “blue”)) +
  geom_point()
```



YOUR TURN!

1. Which variables in mpg are categorical? Which variables are continuous? (Hint: type `?mpg` to read the documentation for the dataset). How can you see this information when you run mpg?

2. Map a continuous variable to `color`, `size`, and `shape`. How do these aesthetics behave differently for categorical vs. continuous variables?

3. What happens if you map the same variable to multiple aesthetics?

4. What does the `stroke` aesthetic do? What shapes does it work with? (Hint: use `?geom_point`)

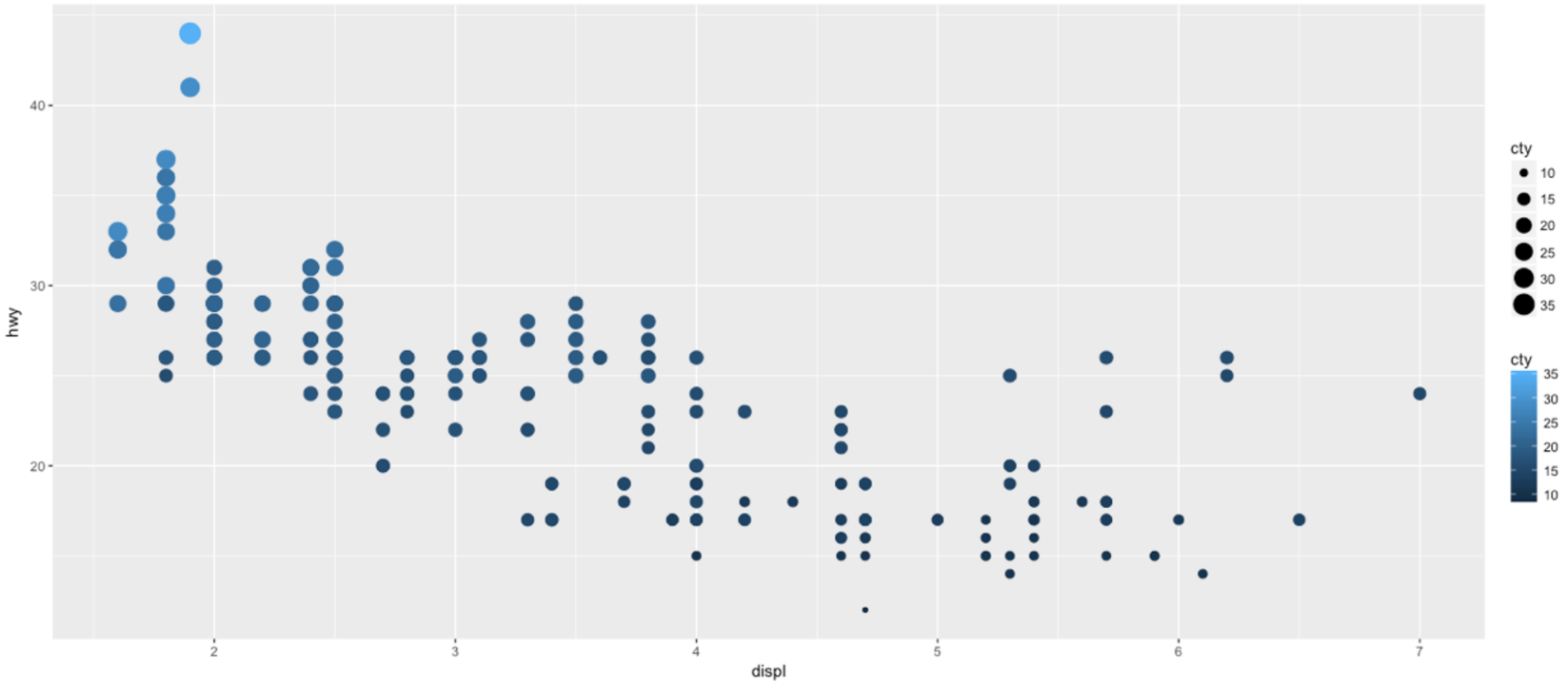
5. What happens if you map an aesthetic to something other than a variable name, like `aes(colour = displ < 5)`?

SOLUTION

```
# 1. which variables are continuous vs categorical
?mpg

mpg
# A tibble: 234 × 11
   manufacturer      model displ  year   cyl      trans   drv   cty   hwy    fl   class
          <chr>      <chr> <dbl> <int> <int>      <chr> <chr> <int> <int> <chr>   <chr>
1          audi         a4   1.8  1999     4   auto(l5)     f    18    29     p compact
2          audi         a4   1.8  1999     4 manual(m5)     f    21    29     p compact
3          audi         a4   2.0  2008     4 manual(m6)     f    20    31     p compact
4          audi         a4   2.0  2008     4   auto(av)     f    21    30     p compact
5          audi         a4   2.8  1999     6   auto(l5)     f    16    26     p compact
6          audi         a4   2.8  1999     6 manual(m5)     f    18    26     p compact
7          audi         a4   3.1  2008     6   auto(av)     f    18    27     p compact
8          audi a4 quattro   1.8  1999     4 manual(m5)     4    18    26     p compact
9          audi a4 quattro   1.8  1999     4   auto(l5)     4    16    25     p compact
10         audi a4 quattro   2.0  2008     4 manual(m6)     4    20    28     p compact
```

SOLUTION

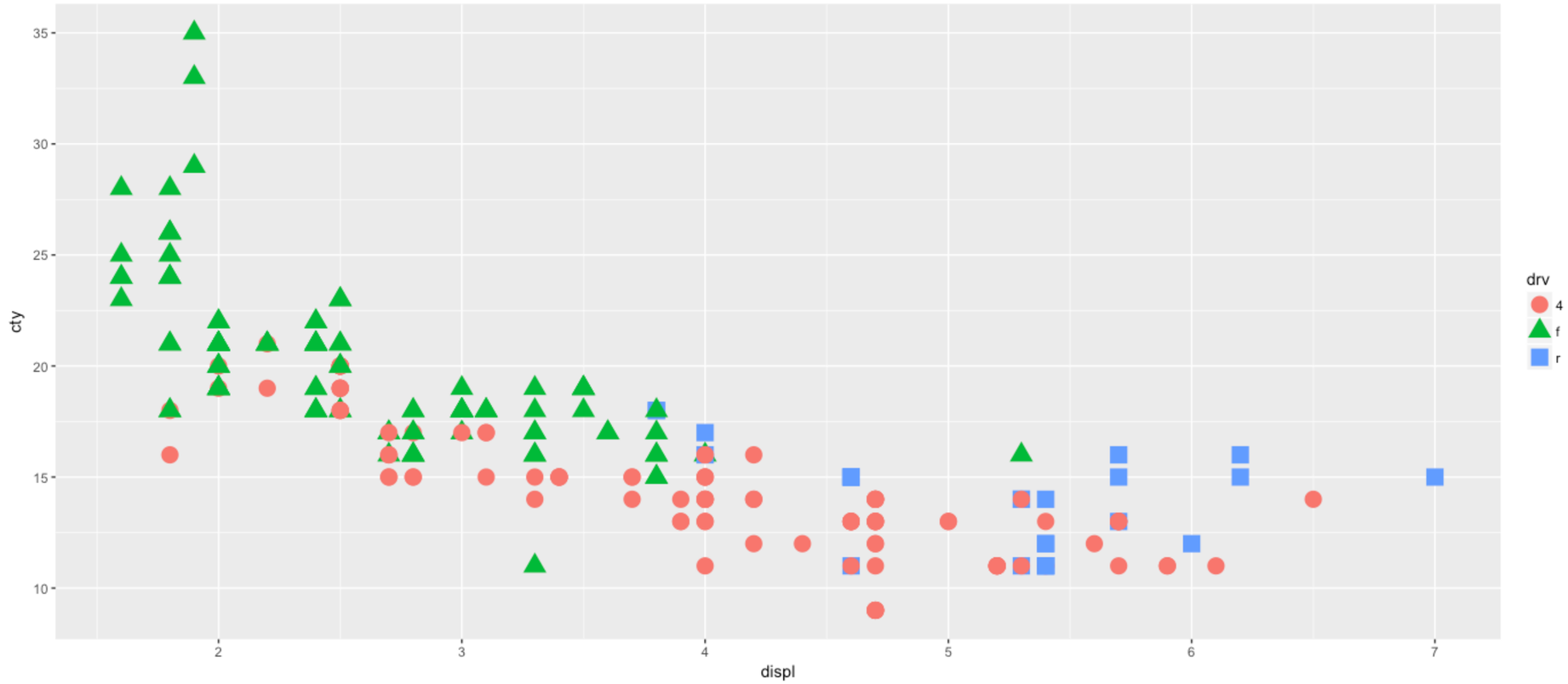
```
# 2. Map a continuous variable to color, size, and shape. How do these aesthetics behave
#    differently for categorical vs. continuous variables?
ggplot(mpg, aes(displ, hwy, color = cty, size = cty)) +
  geom_point()
```



Error: A continuous variable can not be mapped to shape

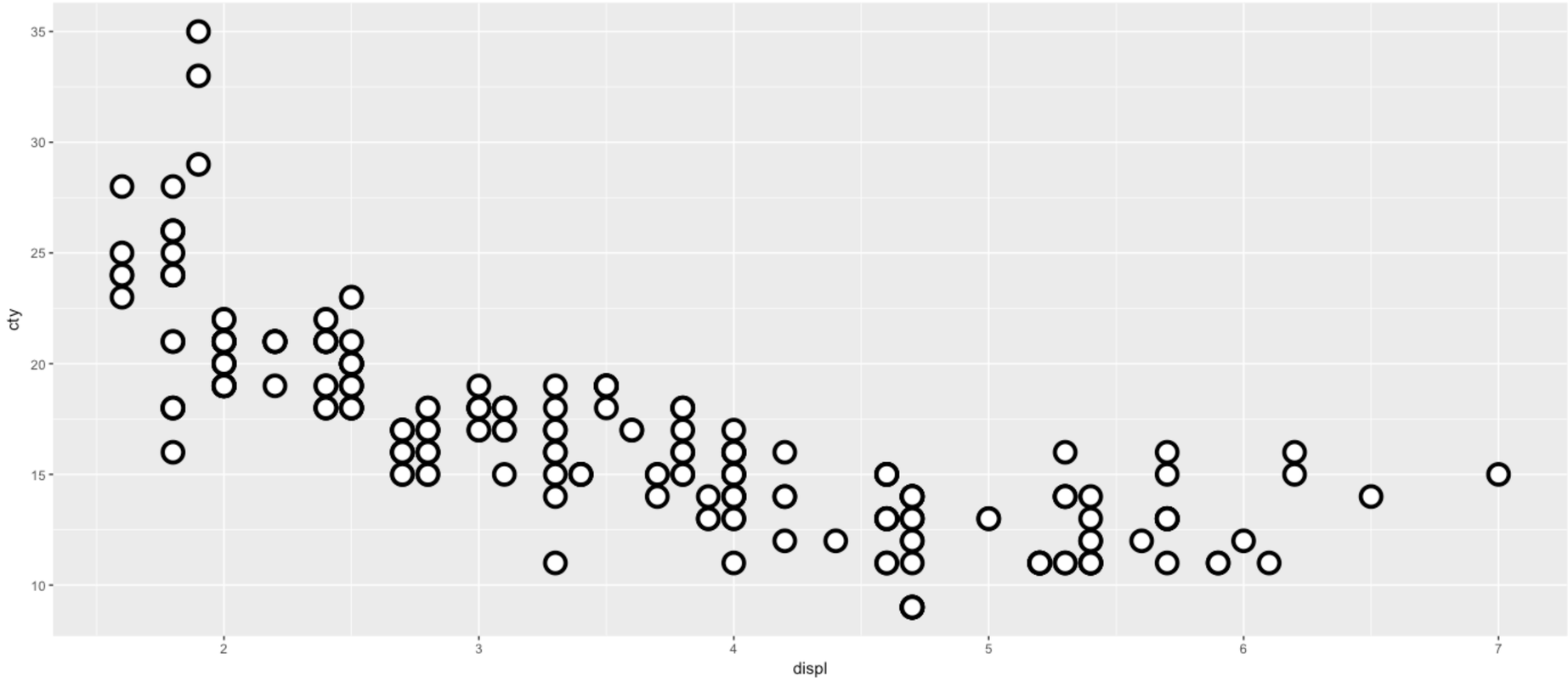
SOLUTION

```
# 3. What happens if you map the same variable to multiple aesthetics?
ggplot(mpg, aes(displ, cty, color = drv, shape = drv)) +
  geom_point()
```



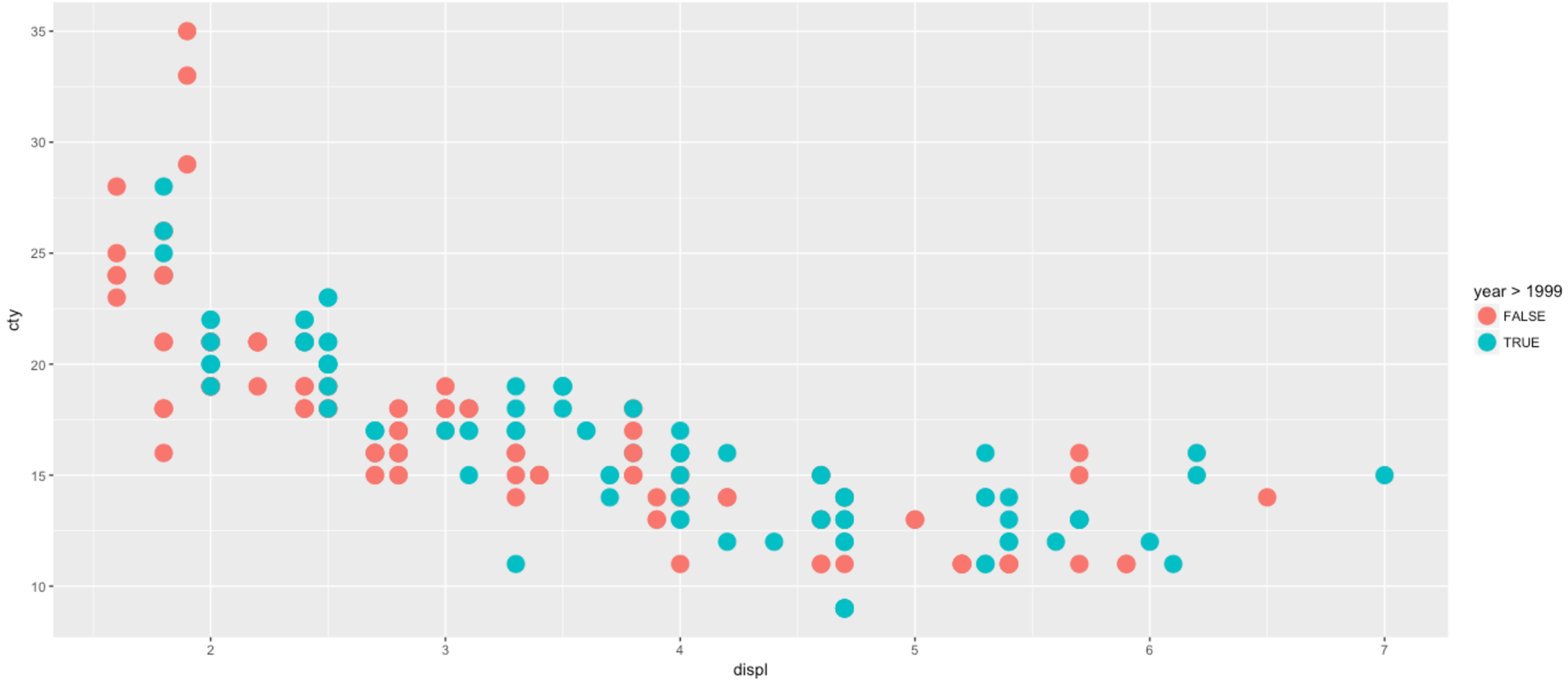
SOLUTION

```
# 4. What does the stroke aesthetic do? What shapes does it work with?
ggplot(mpg, aes(displ, cty)) +
  geom_point(shape = 21, colour = "black", fill = "white", size = 5, stroke = 2)
```



SOLUTION

```
# 5. What happens if you map an aesthetic to something other than a variable name, like
#    aes(colour = displ < 5)
ggplot(mpg, aes(displ, cty)) +
  geom_point(shape = 21, colour = "black", fill = "white", size = 5, stroke = 2)
```

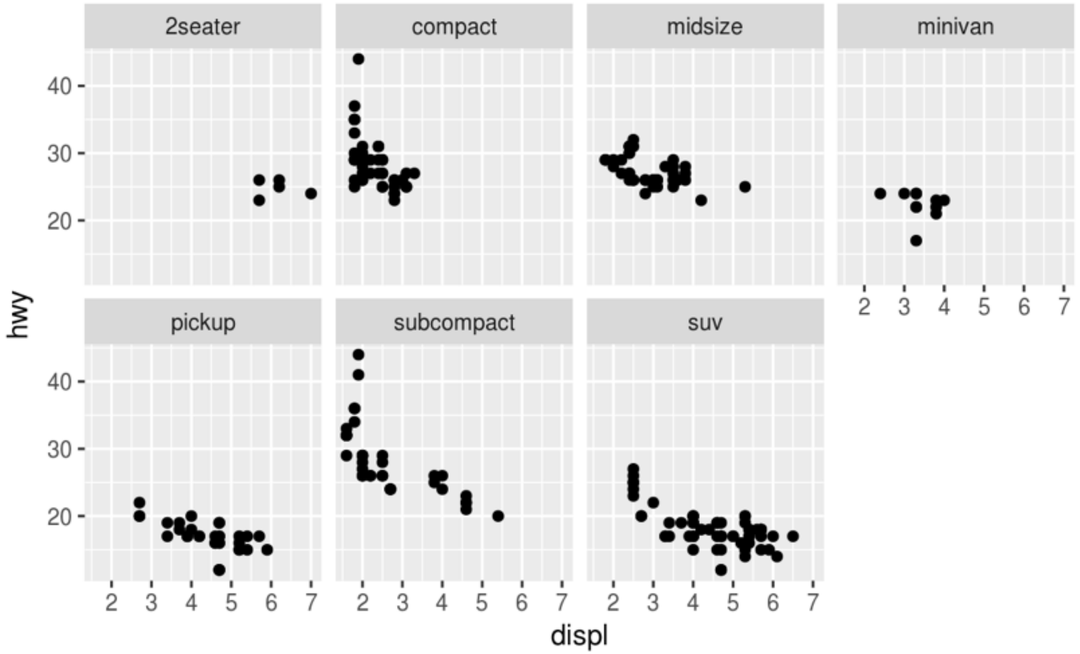


FACETS

FACETS = SMALL MULTIPLES

- The `facet` functions provide a simple way to create small multiples
  - `facet_wrap`: primarily used to create small multiples based on a single variable
  - `facet_grid`: primarily used to create a small multiples grid based on two variables

```
ggplot(data = mpg, aes(x = displ, y = hwy)) +
  geom_point() +
  facet_wrap(~ class, nrow = 2)
```

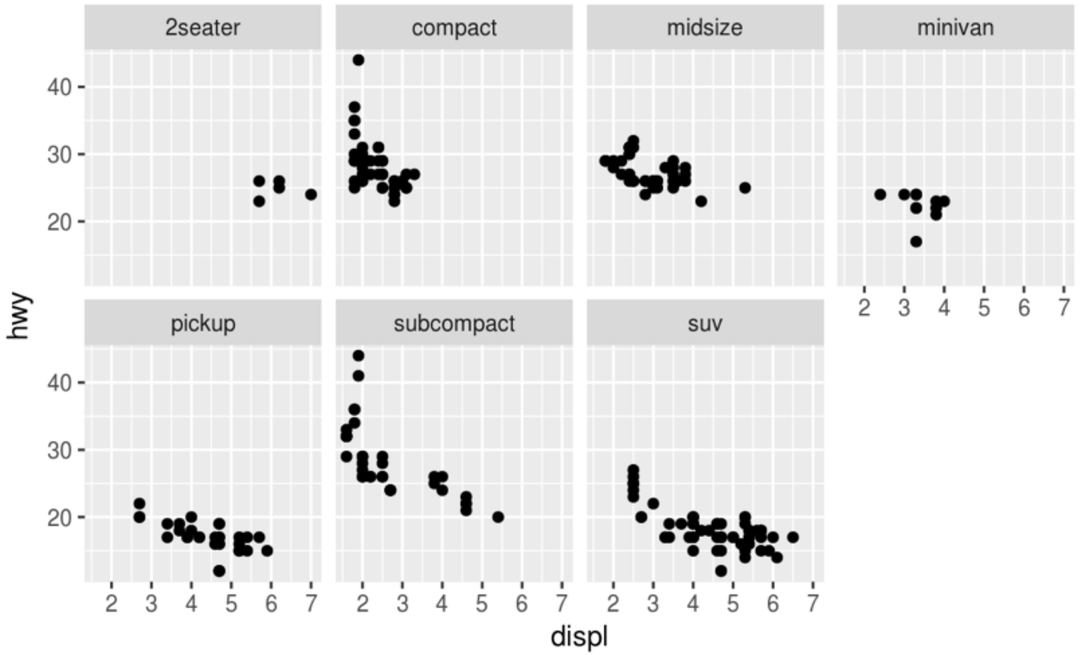


FACETS = SMALL MULTIPLES

- The `facet` functions provide a simple way to create small multiples
  - `facet_wrap`: primarily used to create small multiples based on a single variable
  - `facet_grid`: primarily used to create a small multiples grid based on two variables

```
ggplot(data = mpg, aes(x = displ, y = hwy)) +
  geom_point() +
  facet_wrap(~ class, nrow = 2)
```

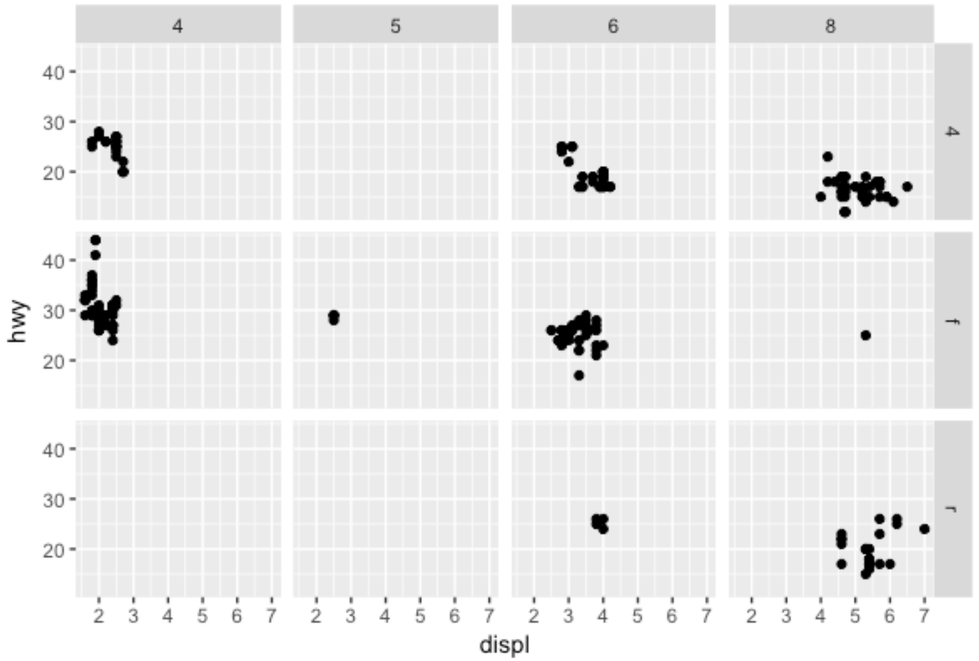
- use `nrow` or `ncol` to specify dimensions
- `?facet_wrap` to see other arguments to control the output



FACETS = SMALL MULTIPLES

- The `facet` functions provide a simple way to create small multiples
  - `facet_wrap`: primarily used to create small multiples based on a single variable
  - `facet_grid`: primarily used to create a small multiples grid based on two variables

```
ggplot(data = mpg, aes(x = displ, y = hwy)) +
  geom_point() +
  facet_grid(drv ~ cyl)
```

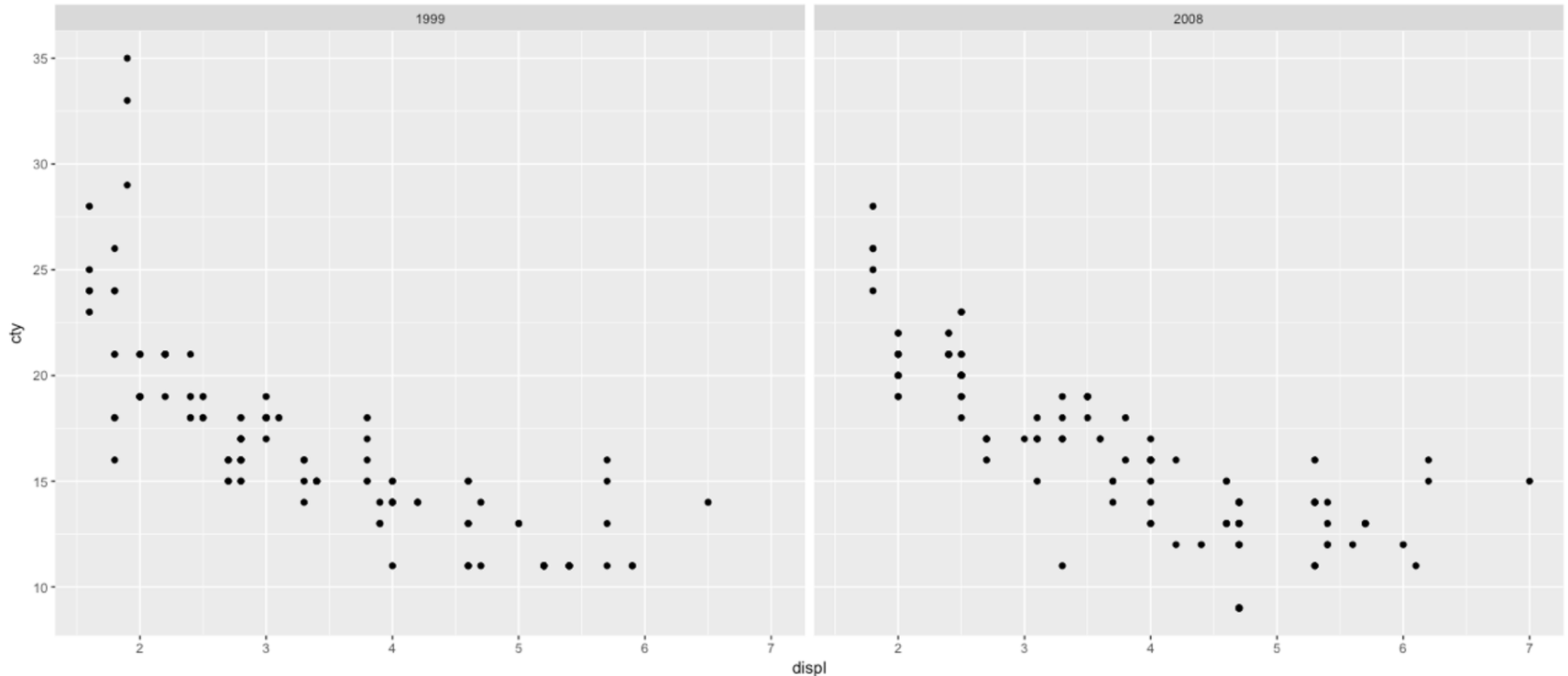


YOUR TURN!

1. Create a scatter plot of `displ` vs `cty` facetted by `year`.
2. Create a scatter plot of `displ` vs `cty` facetted by `year` and `cyl`.
3. How does placement within `facet_grid(cyl ~ year)` affect the output?
4. How does `facet_grid(cyl ~ year)` differ from `facet_grid(~ year + cyl)`?
5. What do the `scales` and `space` arguments do?

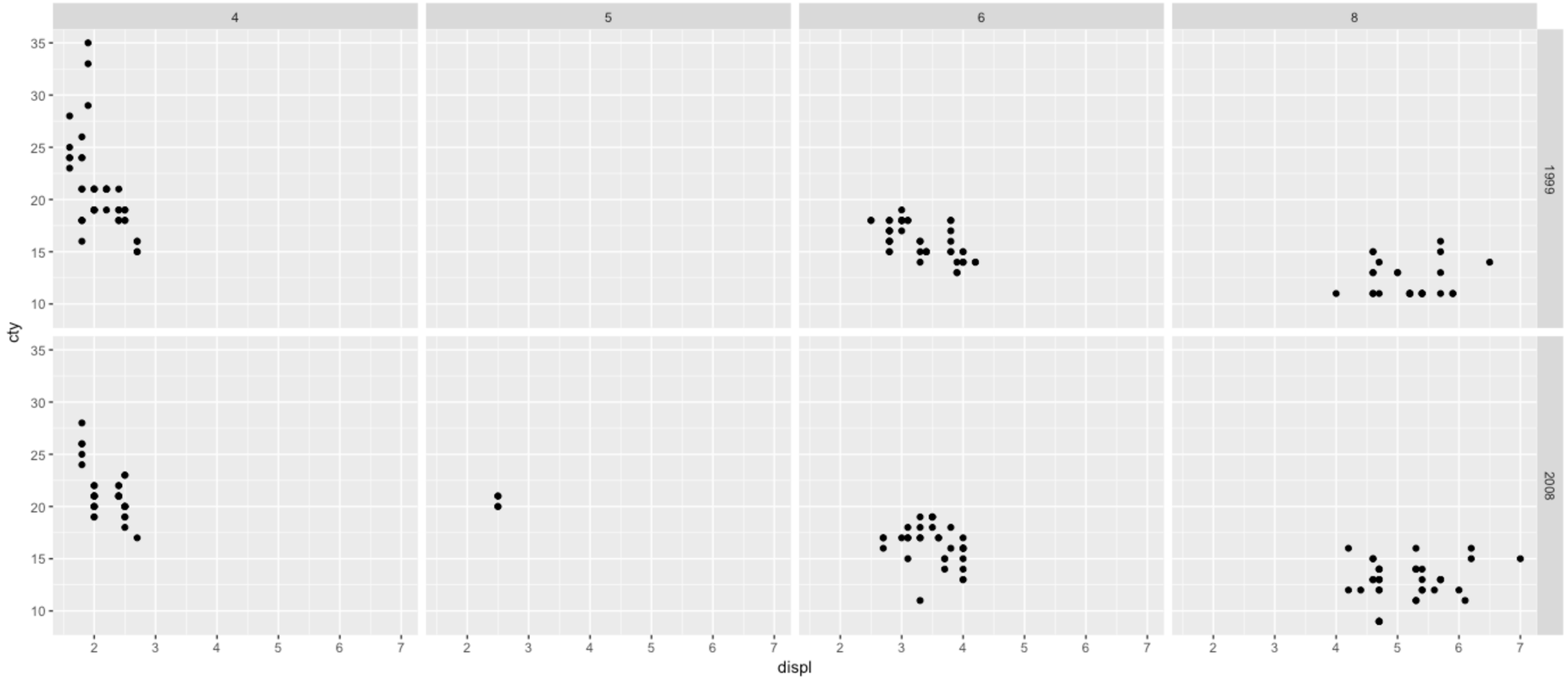
SOLUTION

```
# 1. Create a scatter plot of displ vs cty facetted by year.
ggplot(mpg, aes(displ, cty)) +
  geom_point() +
  facet_wrap(~ year)
```



SOLUTION

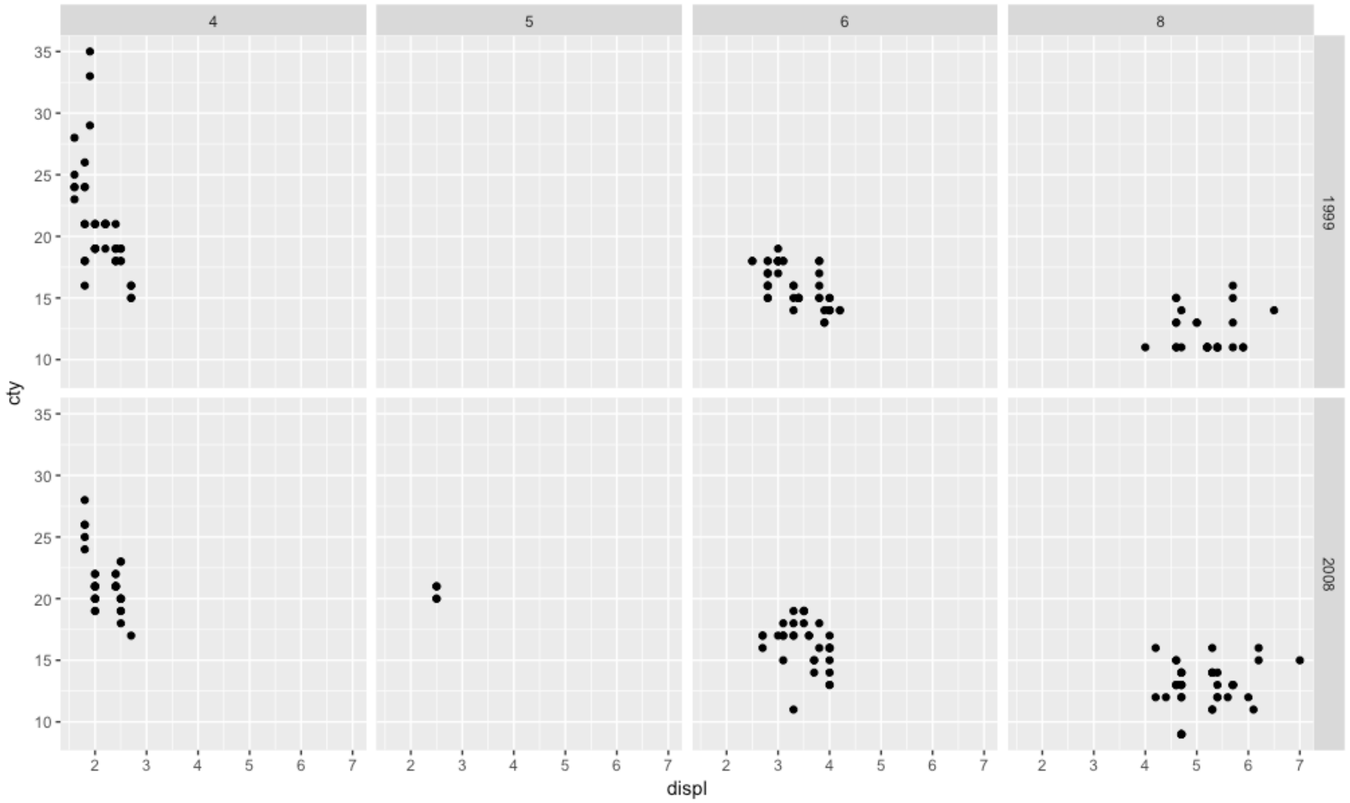
```
# 2. Create a scatter plot of displ vs cty facetted by year and cyl
ggplot(mpg, aes(displ, cty)) +
  geom_point() +
  facet_grid(year ~ cyl)
```



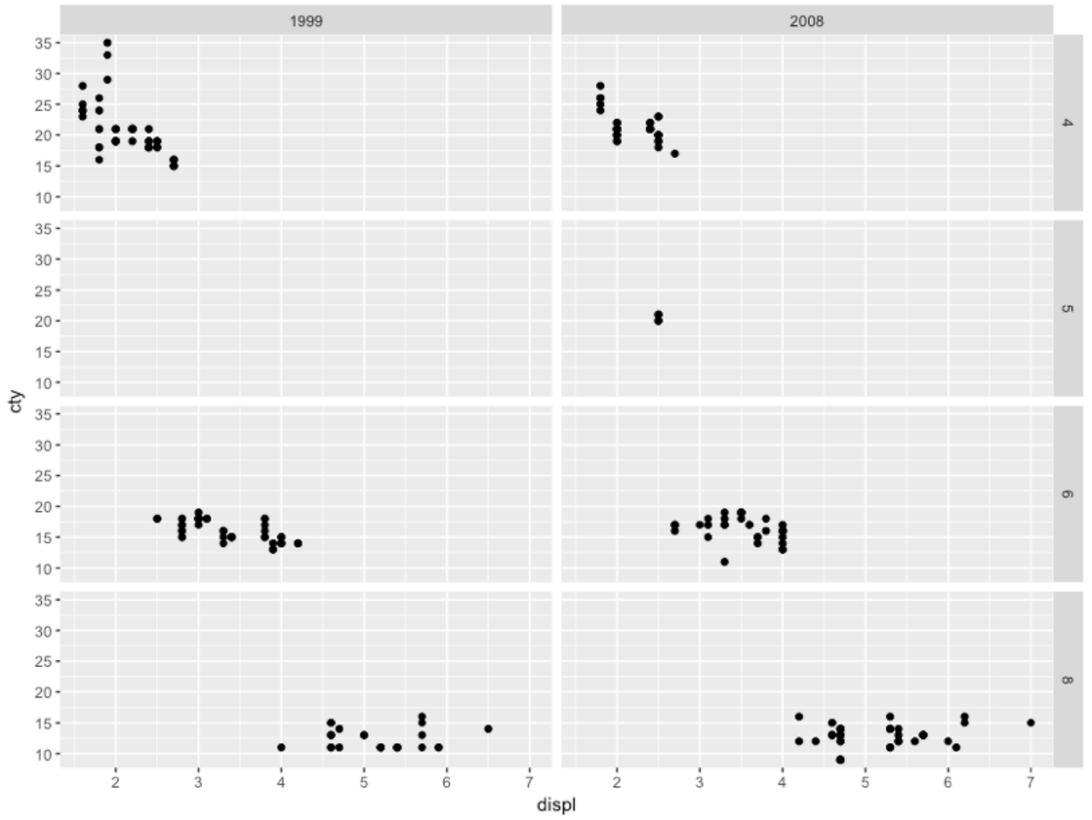
SOLUTION

```
# 3. How does placement within facet_grid(cyl ~ year) affect the output?
```

facet_grid(year ~ cyl)

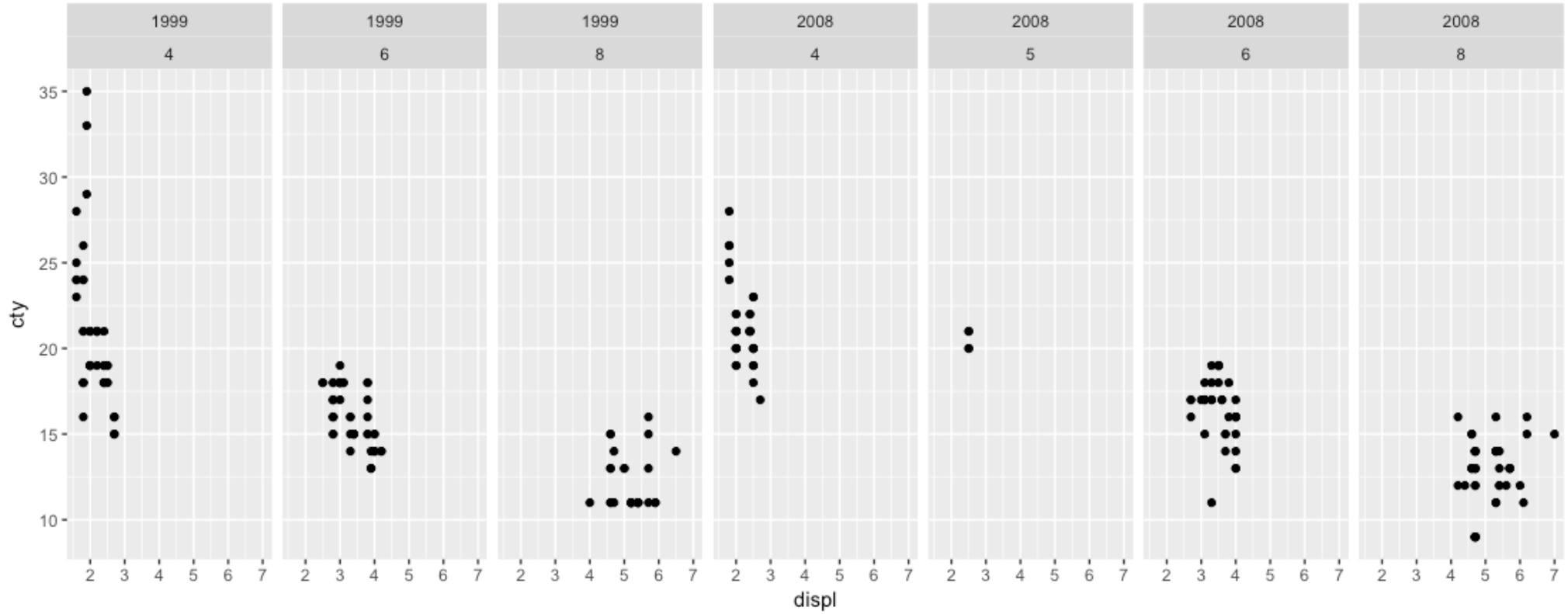


facet_grid(cyl ~ year)



SOLUTION

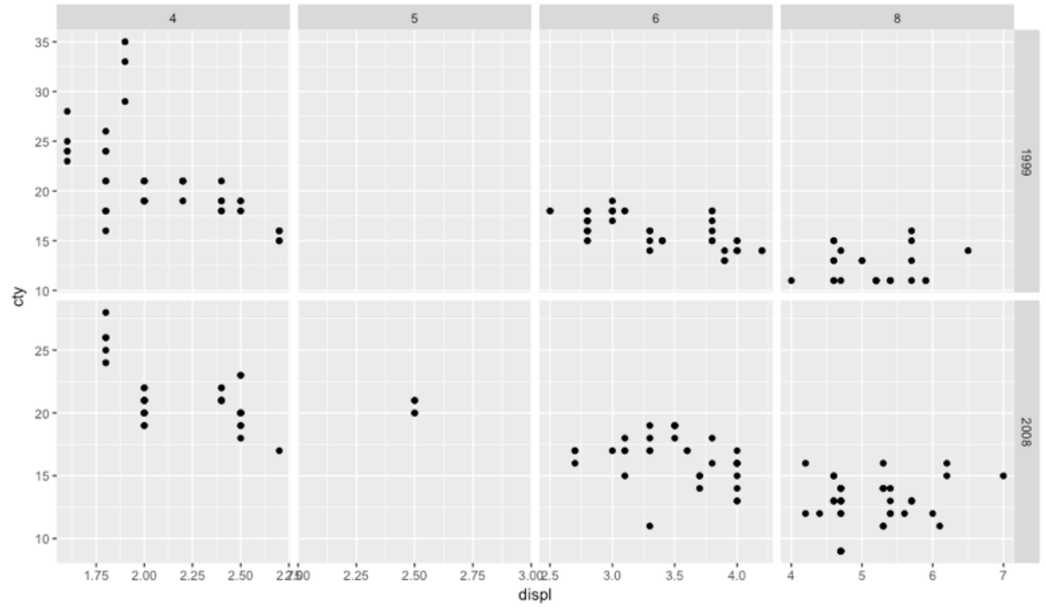
```
# 4. How does facet_grid(cyl ~ year) differ from facet_grid(~ year + cyl)?
ggplot(mpg, aes(displ, cty)) +
  geom_point() +
  facet_grid(~ year + cyl)
```



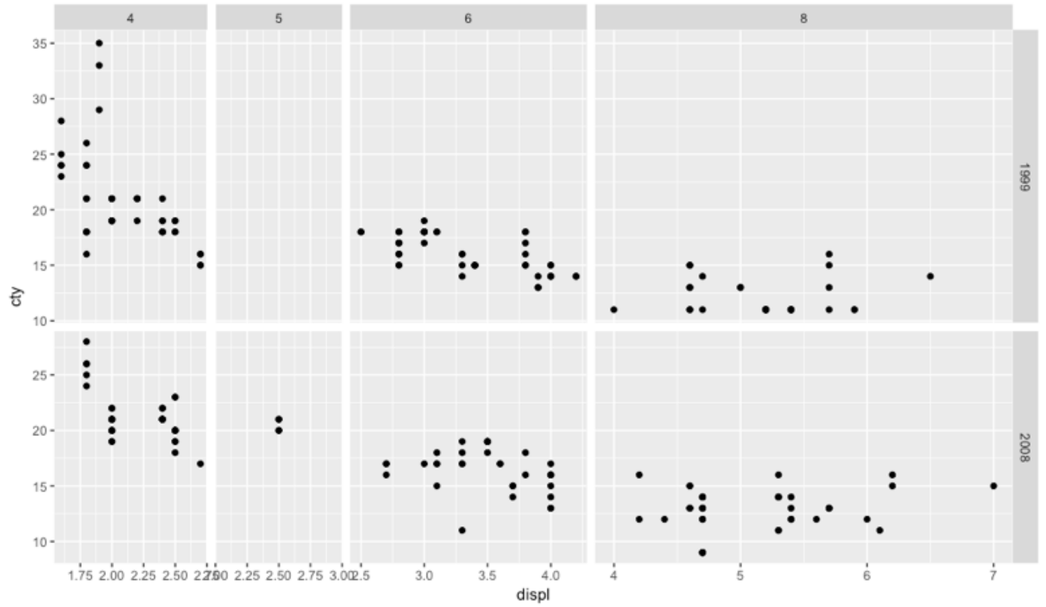
SOLUTION

```
# 5. What do the scales and space arguments do
```

```
ggplot(mpg, aes(displ, cty)) +
  geom_point() +
  facet_grid(year ~ cyl, scales = "free")
```



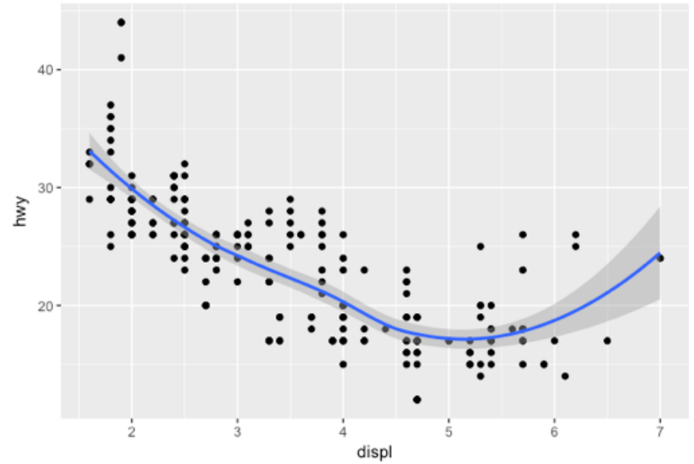

```
ggplot(mpg, aes(displ, cty)) +
  geom_point() +
  facet_grid(year ~ cyl, scales = "free", space = "free")
```



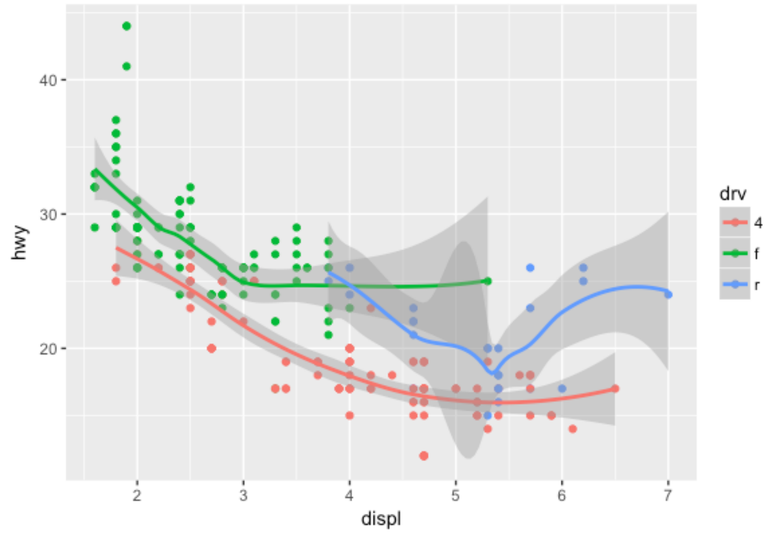
OVERPLOTTING

LAYERING HELPS DISPLAY PATTERNS

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

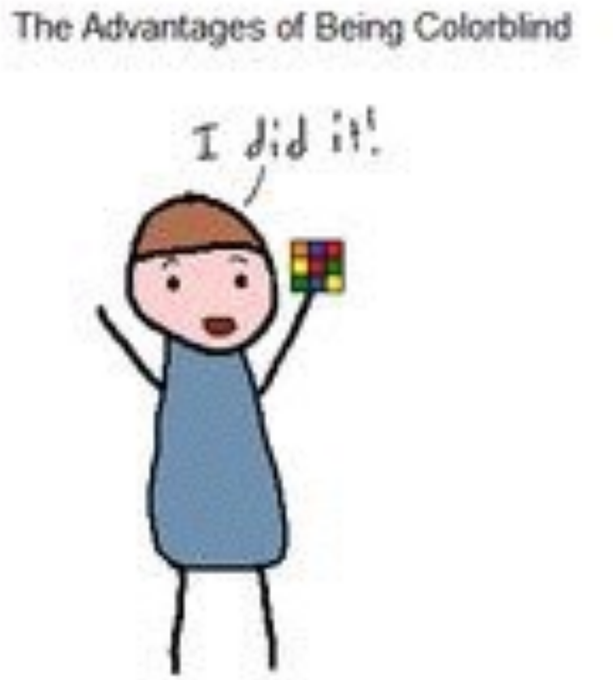



```
ggplot(data = mpg, aes(x = displ, y = hwy, color = drv)) +
  geom_point() +
  geom_smooth()
```



LAYERING HELPS DISPLAY PATTERNS

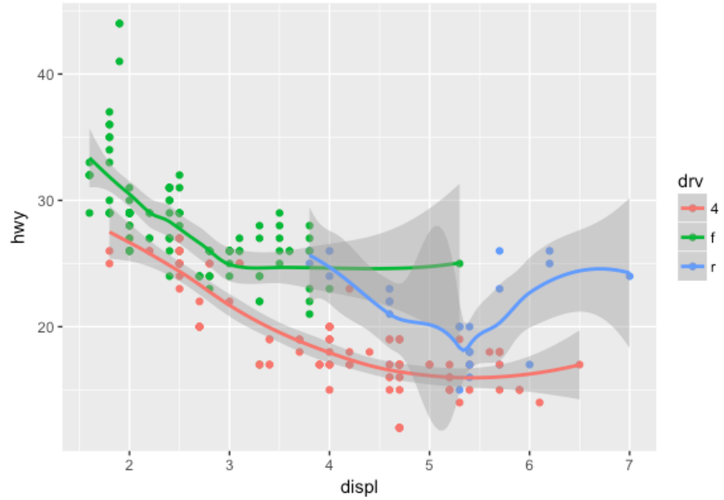
```
ggplot(data = mpg, aes(x =
  geom_point() +
  geom_smooth()
```



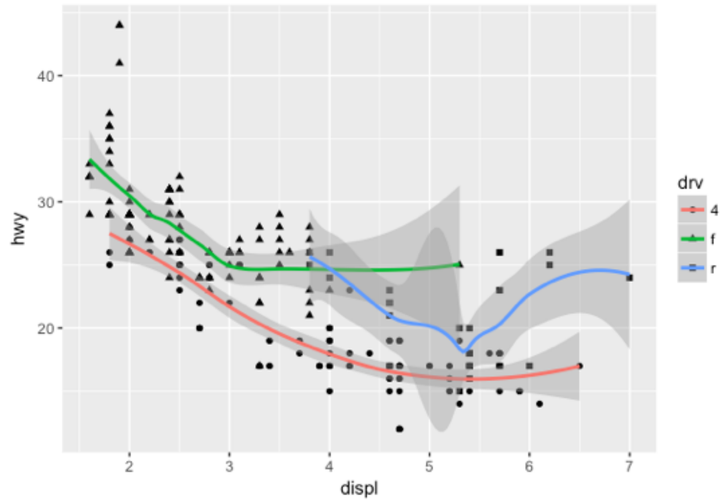

```
ggplot(data = mpg, aes(x =
  geom_point() +
  geom_smooth()
```

LAYERING HELPS DISPLAY PATTERNS

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



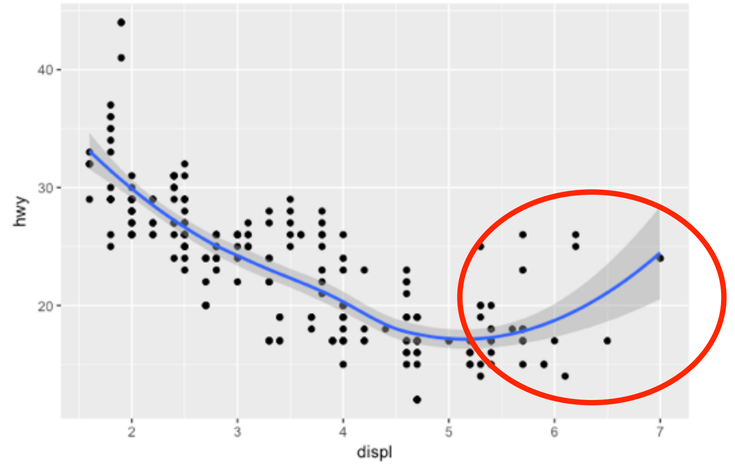

```
ggplot(data = mpg, aes(x = displ, y = hwy)) +
  geom_point(aes(shape = drv)) +
  geom_smooth(aes(color = drv))
```



`aes` mapping can be done in `ggplot()` or `geom_xx()`

LAYERING HELPS ID ABNORMALITIES

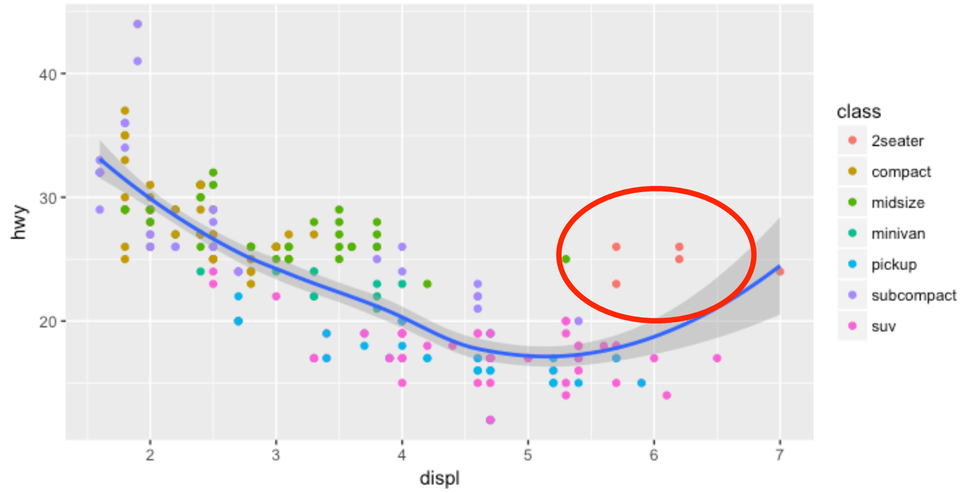
```
ggplot(data = mpg, aes(x = displ, y = hwy)) +
  geom_point() +
  geom_smooth()
```



What's driving this upward swing?

LAYERING HELPS ID ABNORMALITIES

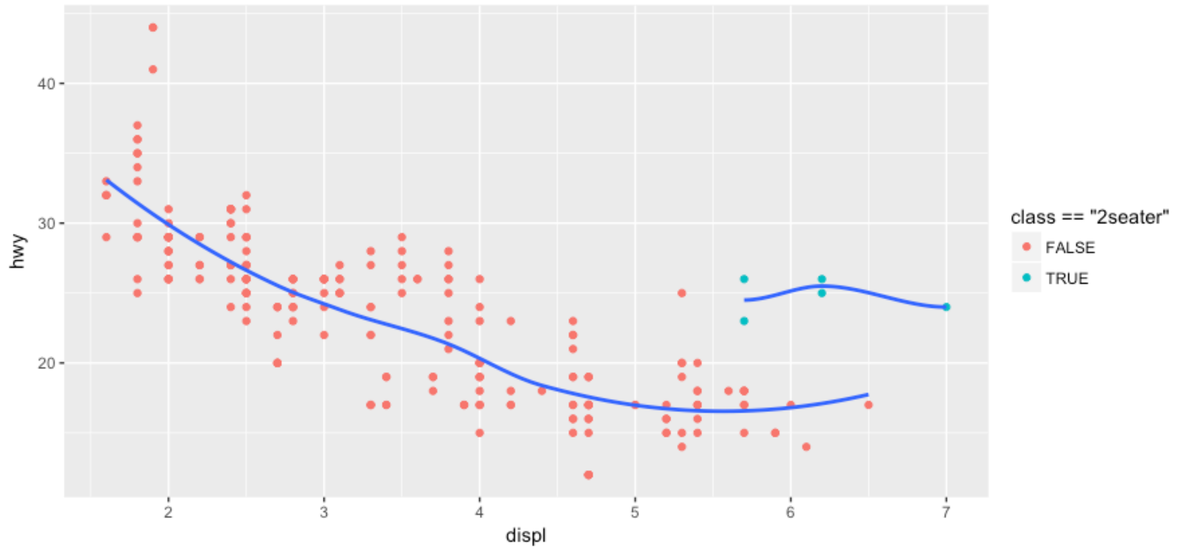
```
ggplot(data = mpg, aes(x = displ, y = hwy)) +
  geom_point(aes(color = class)) +
  geom_smooth()
```



Looks like it could be the 2 seaters but we need to verify

LAYERING HELPS ID ABNORMALITIES

```
ggplot(data = mpg, aes(x = displ, y = hwy)) +
        geom_point(aes(color = class == "2seater")) +
        geom_smooth(data = filter(mpg, class == "2seater"), se = FALSE) +
        geom_smooth(data = filter(mpg, class != "2seater"), se = FALSE)
```



YOUR TURN!

1. Over plot:

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

   with `geom_jitter(width = .2, alpha = .5)`

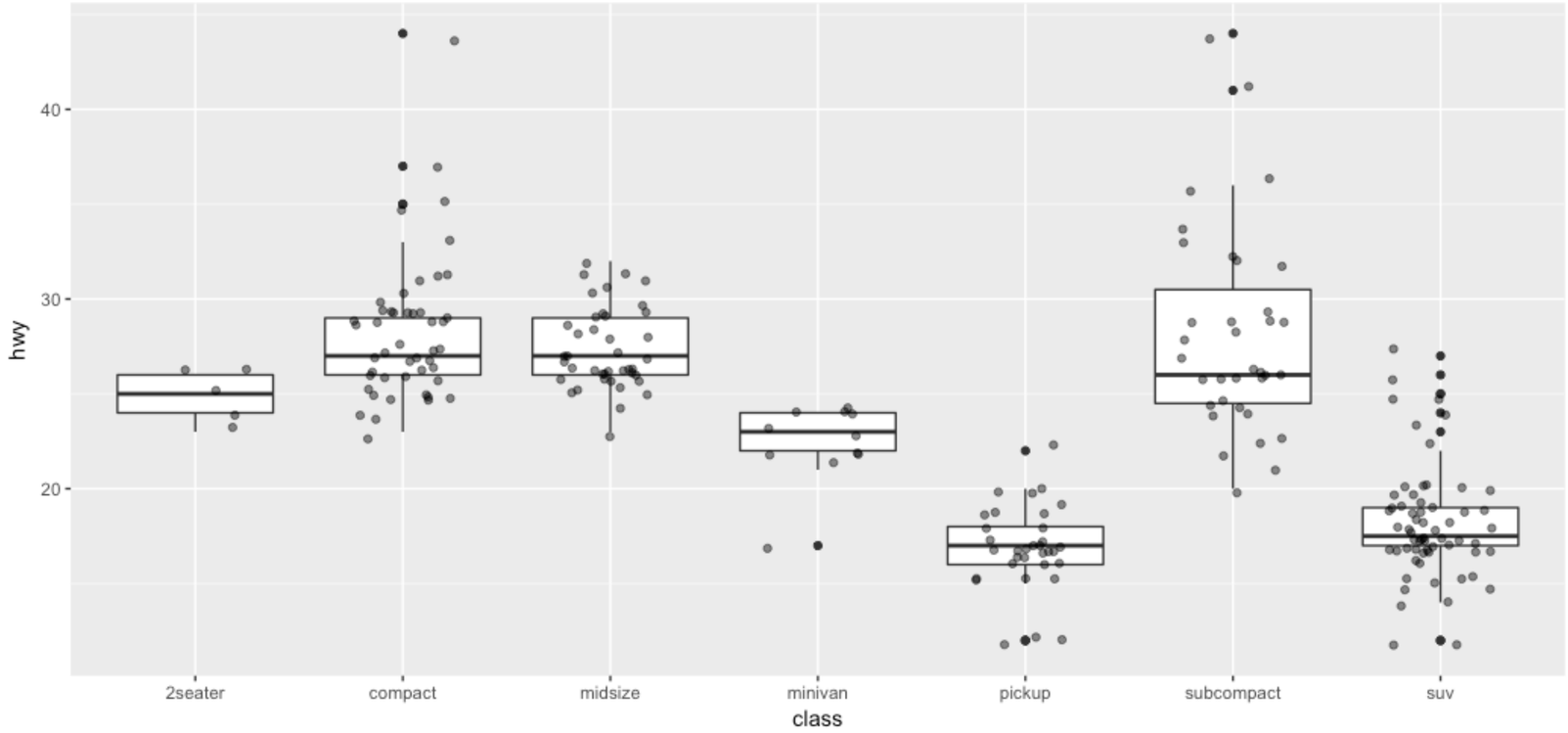
2. If you add `geom_rug()` to

```
ggplot(data = mpg, aes(x = displ, y = cty)) +
        geom_smooth()
```

   what does this tell you?

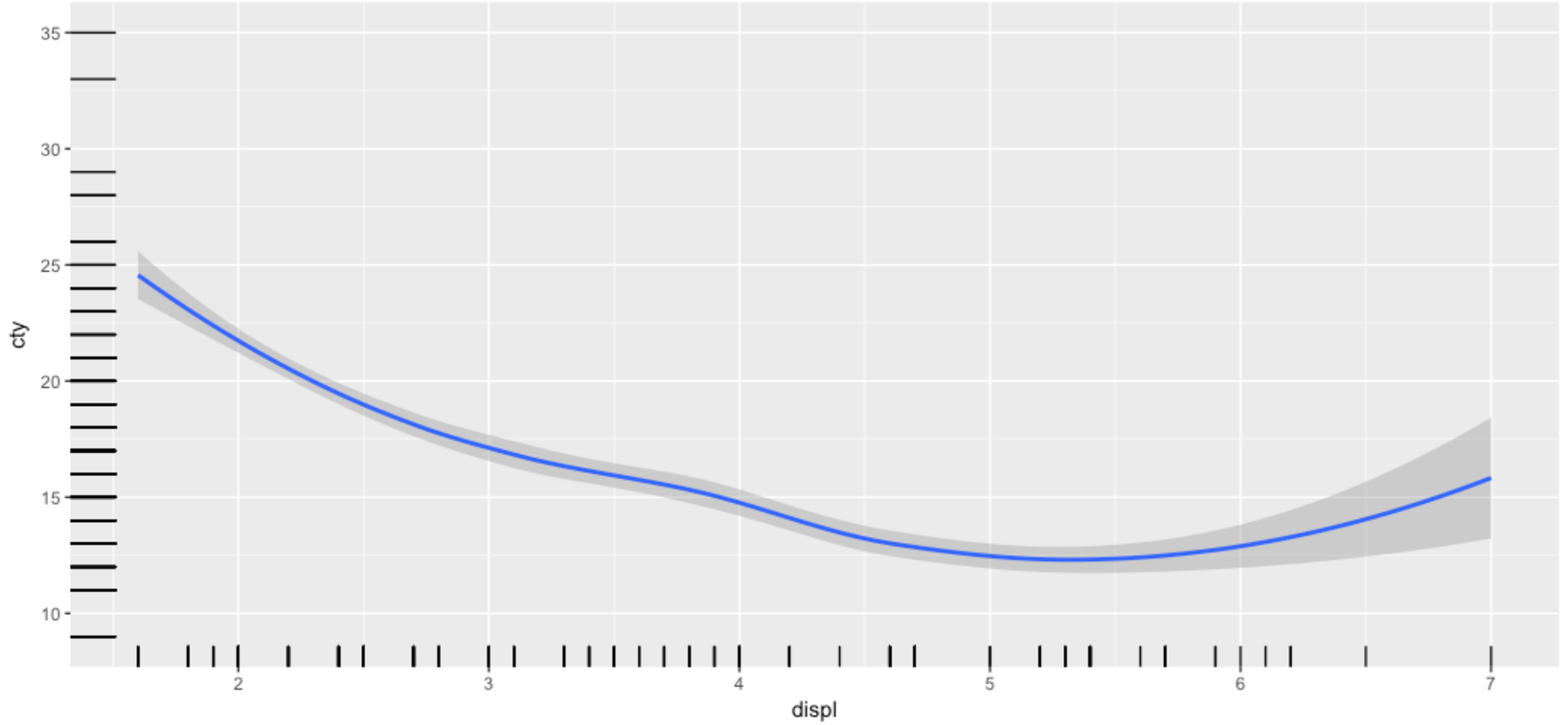
SOLUTION

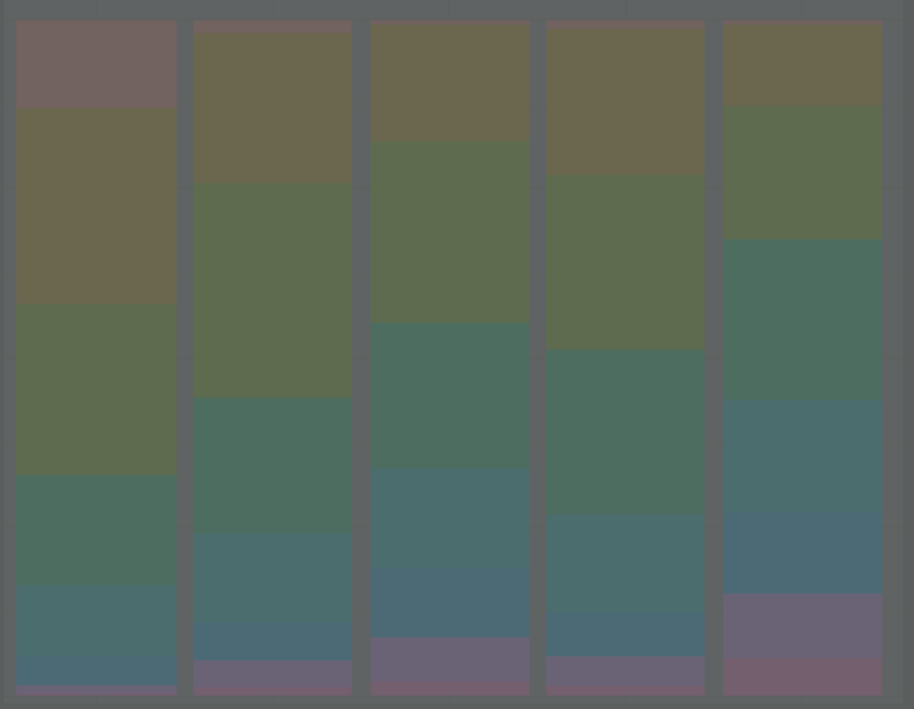
```
# 1. Overplot boxplot with jitter
ggplot(mpg, aes(class, hwy)) +
  geom_boxplot() +
  geom_jitter(width = .25, alpha = .5)
```



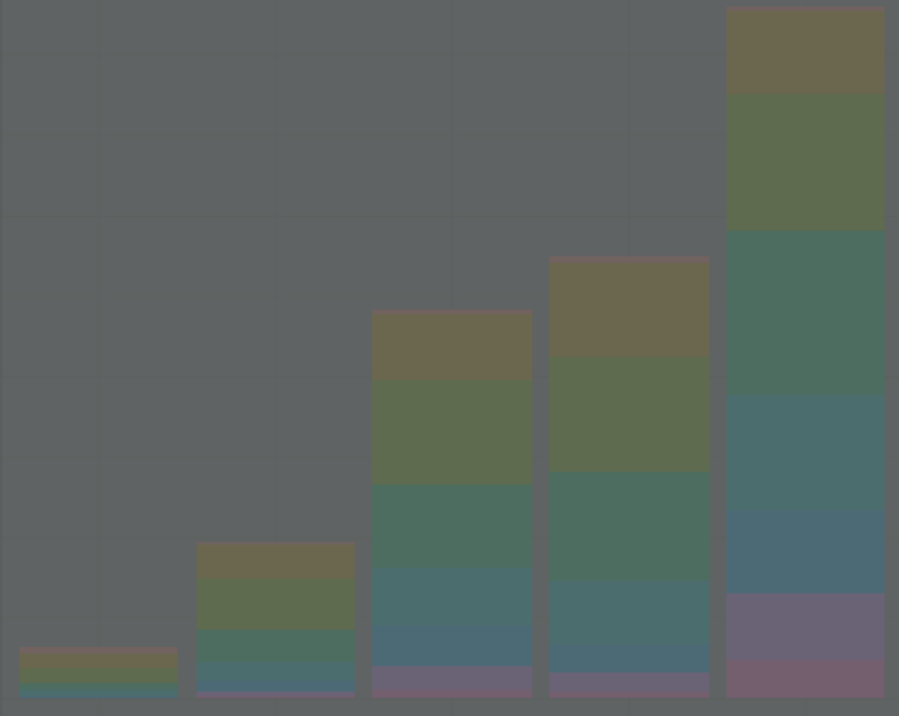
SOLUTION

```
# 2. add geom_rug to smoother
ggplot(mpg, aes(displ, cty)) +
  geom_smooth() +
  geom_rug()
```





POSITIONING



BAR CHARTS

- All `geoms` have a position argument but rarely will you need to adjust it
- `geom_bar` and a few others benefit from its use though:
  - `position = "stack"` (default)
  - `position = "fill"`
  - `position = "dodge"`

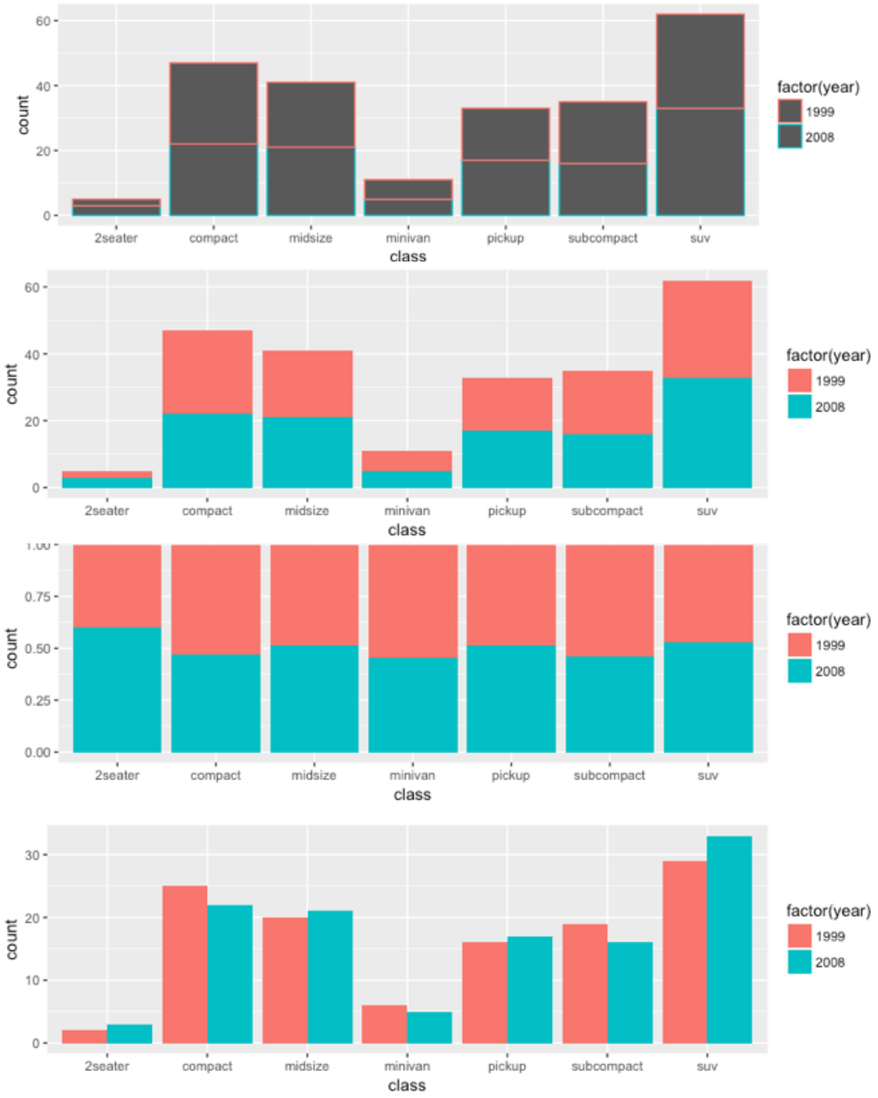
BAR CHARTS

```
ggplot(data = mpg, aes(class, color = factor(year))) +
  geom_bar()
```

```
ggplot(data = mpg, aes(class, fill = factor(year))) +
  geom_bar()
```

```
ggplot(data = mpg, aes(class, fill = factor(year))) +
  geom_bar(position = “fill”)
```

```
ggplot(data = mpg, aes(class, fill = factor(year))) +
  geom_bar(position = “dodge”)
```

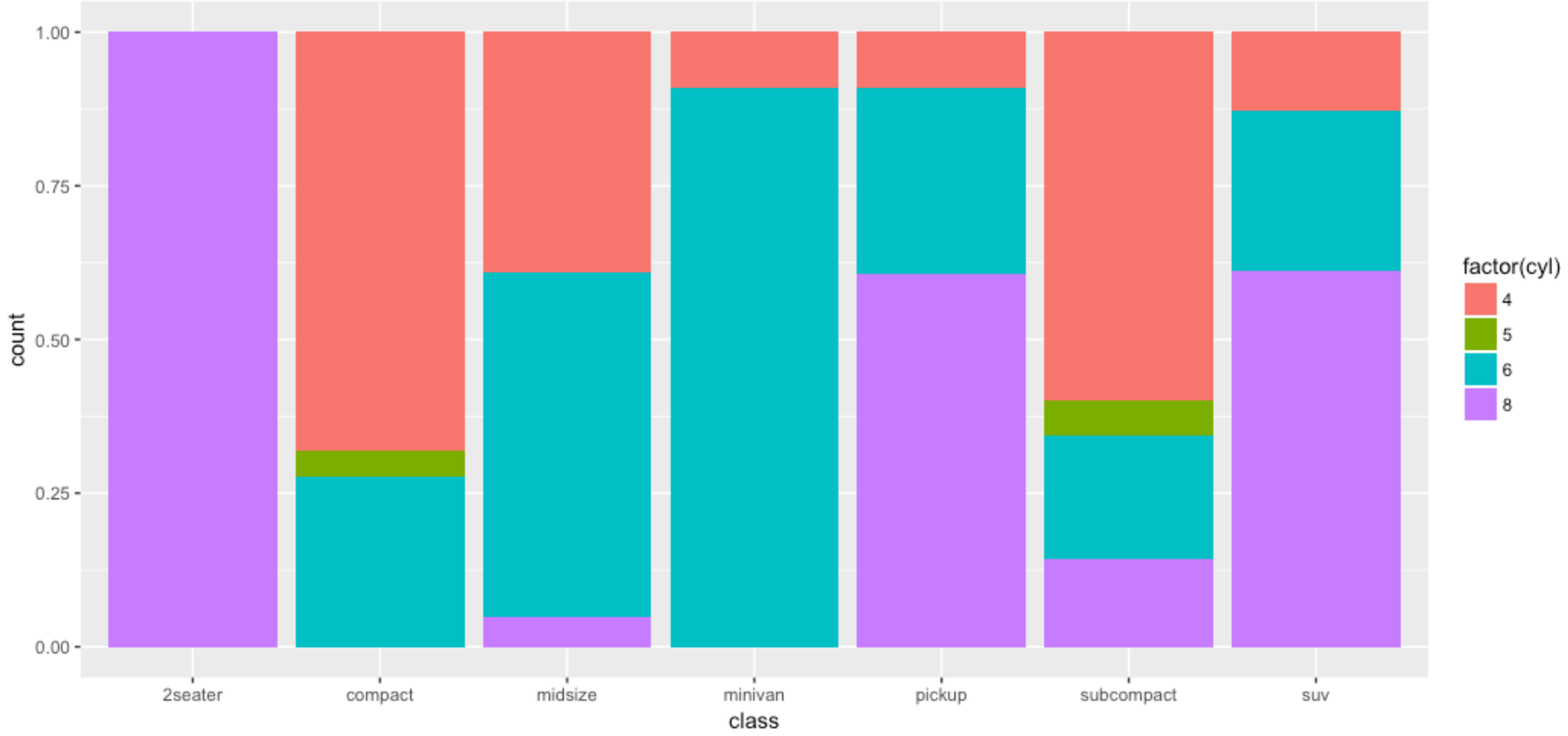


YOUR TURN!

Use `geom_bar` and the different `position` arguments to assess how the `cyl` variable is distributed within each `class`.

SOLUTION

```
# One potential solution
ggplot(mpg, aes(class, fill = factor(cyl))) +
  geom_bar(position = "fill")
```



COORDINATE SYSTEM

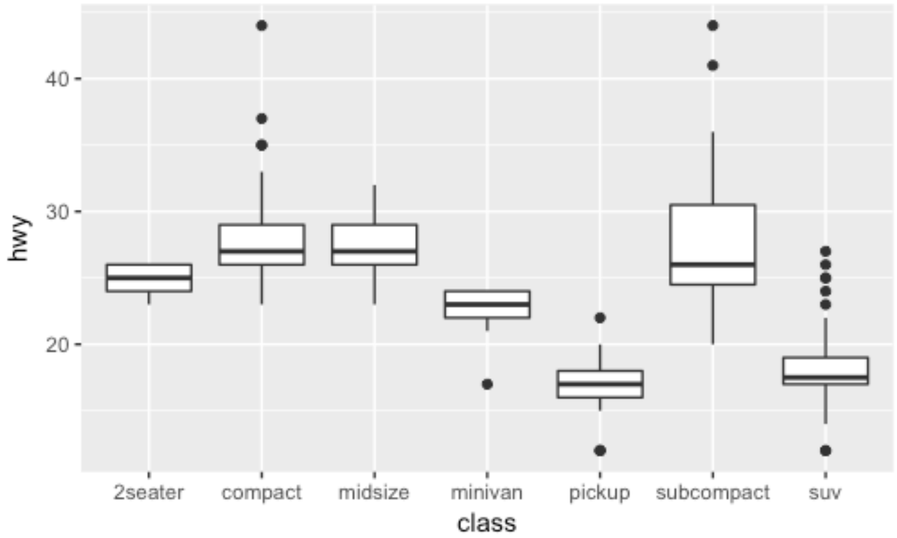
MANIPULATING YOUR COORDINATES

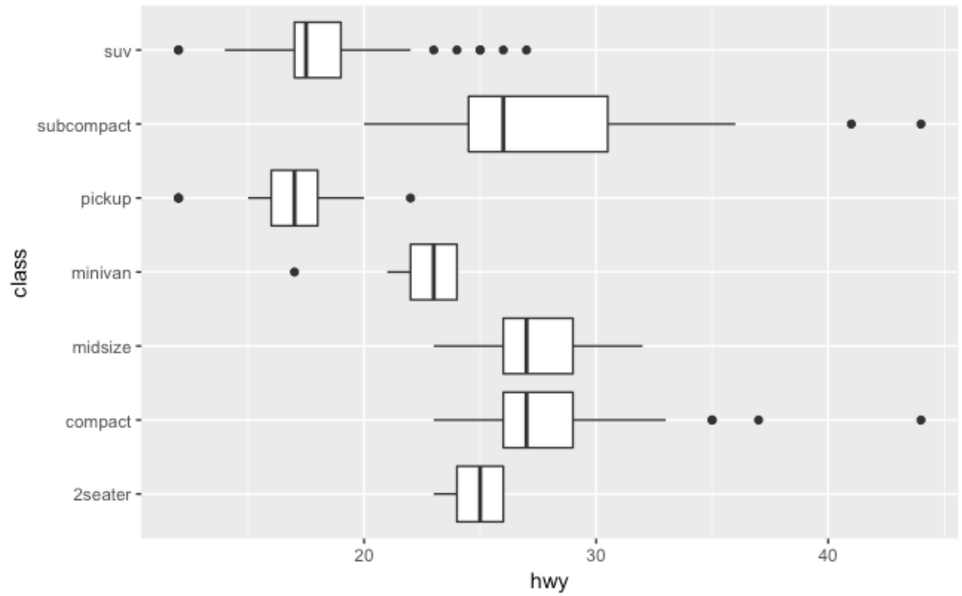
- There are *many* options to manipulate and adjust the coordinate system but some basic ones include:

MANIPULATING YOUR COORDINATES

- There are *many* options to manipulate and adjust the coordinate
  - **flipping the coordinates**

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

# bottom
ggplot(data = mpg, aes(x = class, y = hwy)) +
  geom_boxplot() +
  coord_flip()
```

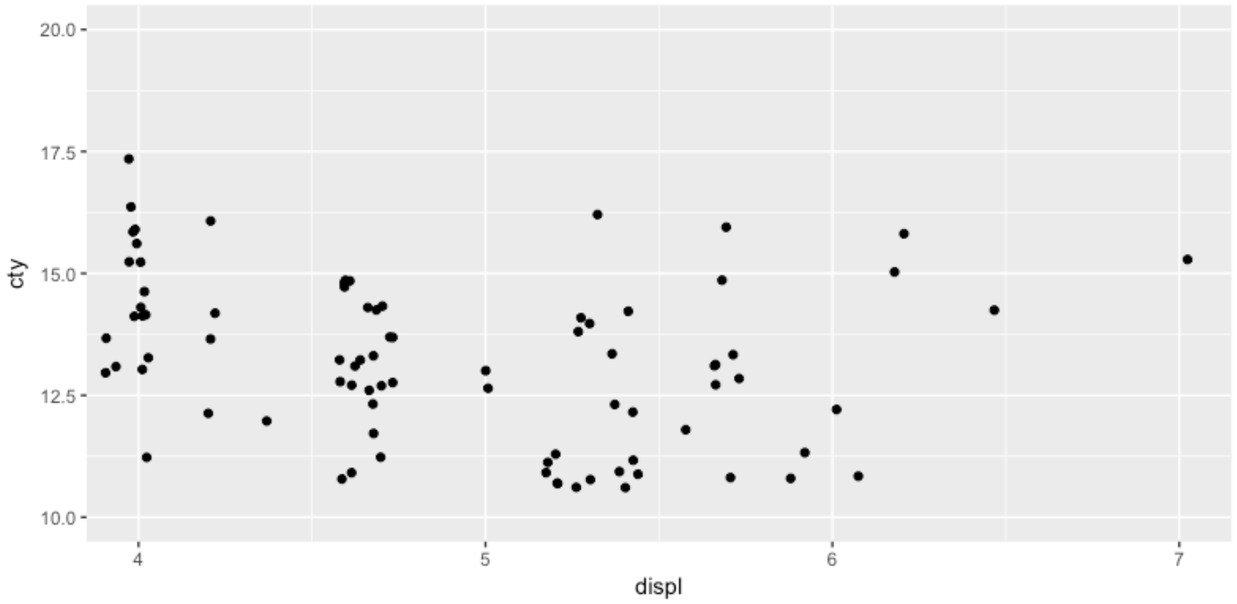




MANIPULATING YOUR COORDINATES

- There are *many* options to manipulate and adjust the coordinate system but some basic ones include:
  - **zooming in or out**

```
ggplot(data = mpg, aes(x = displ, y = cty)) +
  geom_jitter() +
  coord_cartesian(xlim = c(4, 7), ylim = c(10, 20))
```



MANIPULATING YOUR COORDINATES

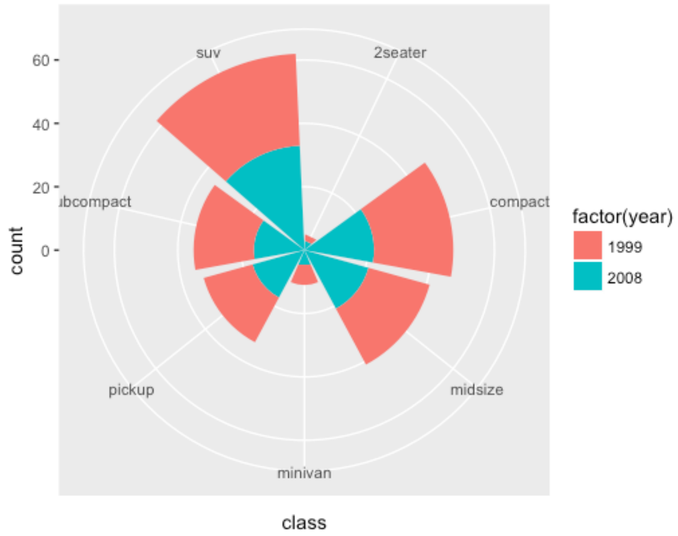
- There are *many* options to manipulate and adjust the coordinate system but some basic ones include:
  - **formatting axes and labels**

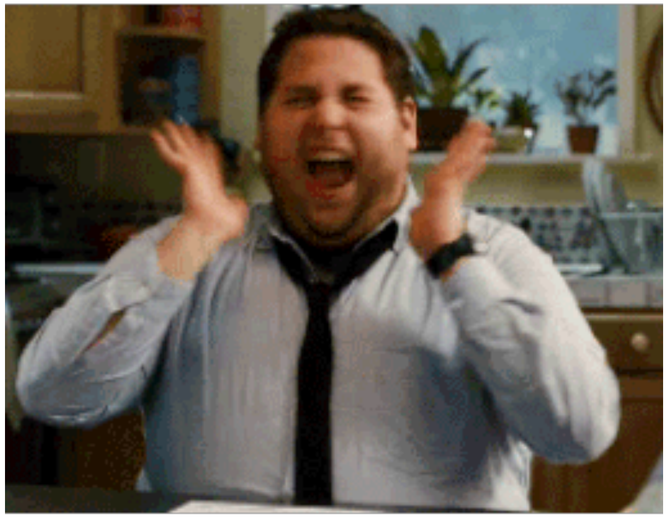
```
ggplot(data = txhousing, aes(x = volume, y = median)) +
        geom_point(alpha = .25) +
        scale_y_continuous(name = "Median Sales Price", labels = scales::dollar) +
        scale_x_log10(name = "Total Sales Volume", labels = scales::comma) +
        ggtitle("Texas Housing Sales",
                subtitle = "Sales data from 2000-2010 provided by the TAMU real estate center")
```

MANIPULATING YOUR COORDINATES

- There are *many* options to manipulate and adjust the coordinate system but some basic ones include:
  - ~~creating pie charts~~

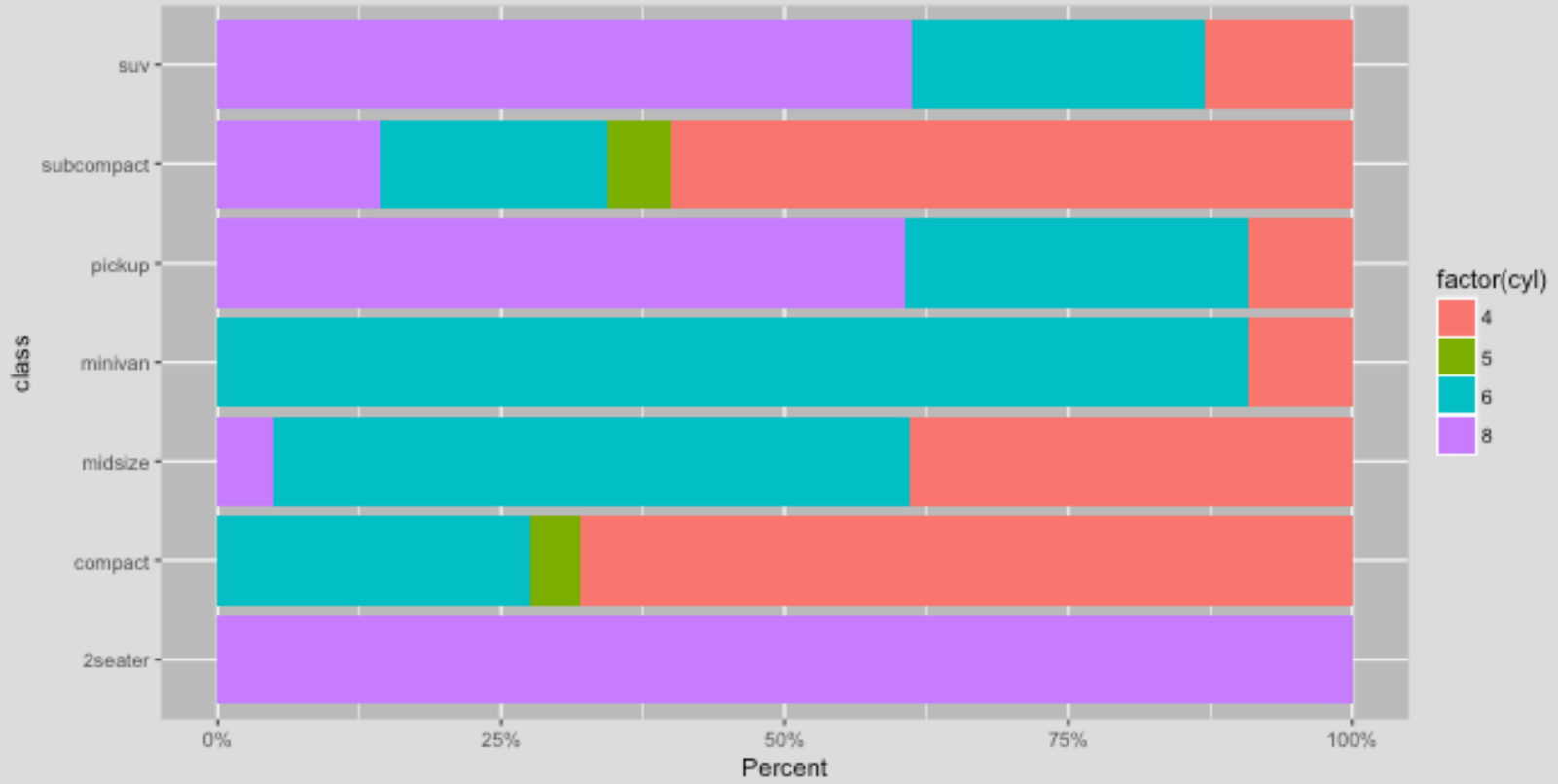
```
ggplot(data = mpg, aes(class, fill = factor(year))) +
        geom_bar() +
        coord_polar()
```





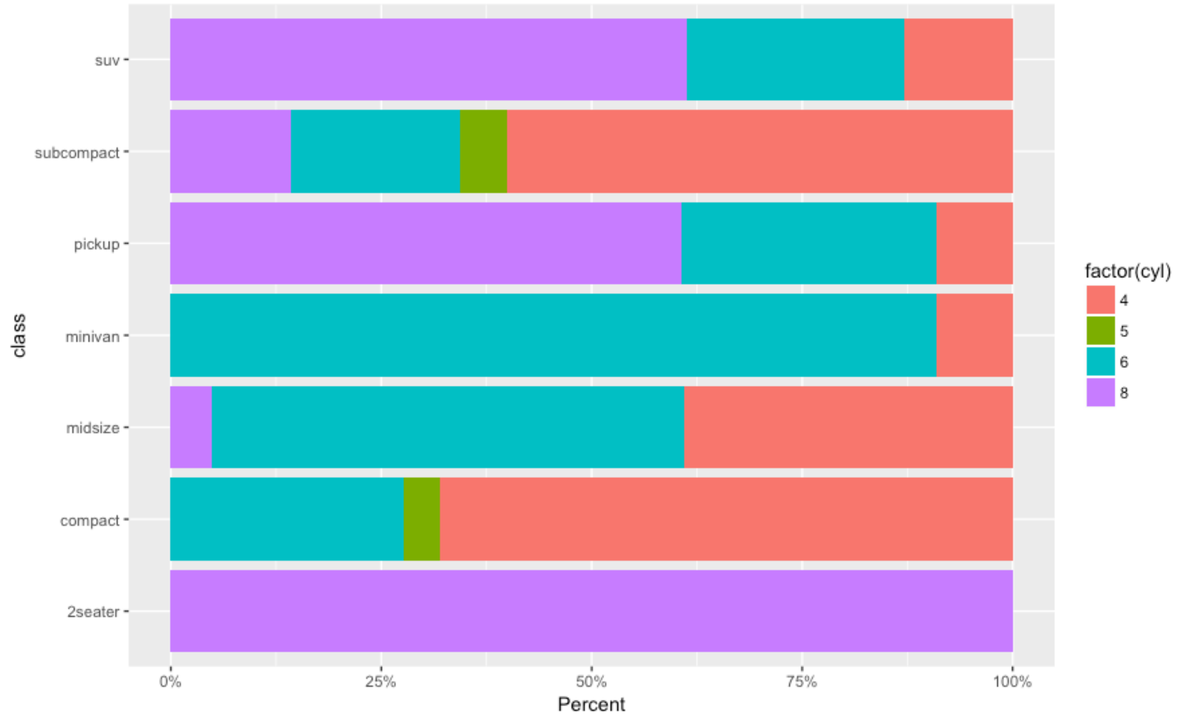
YOUR TURN!

How close can you get to re-creating this?



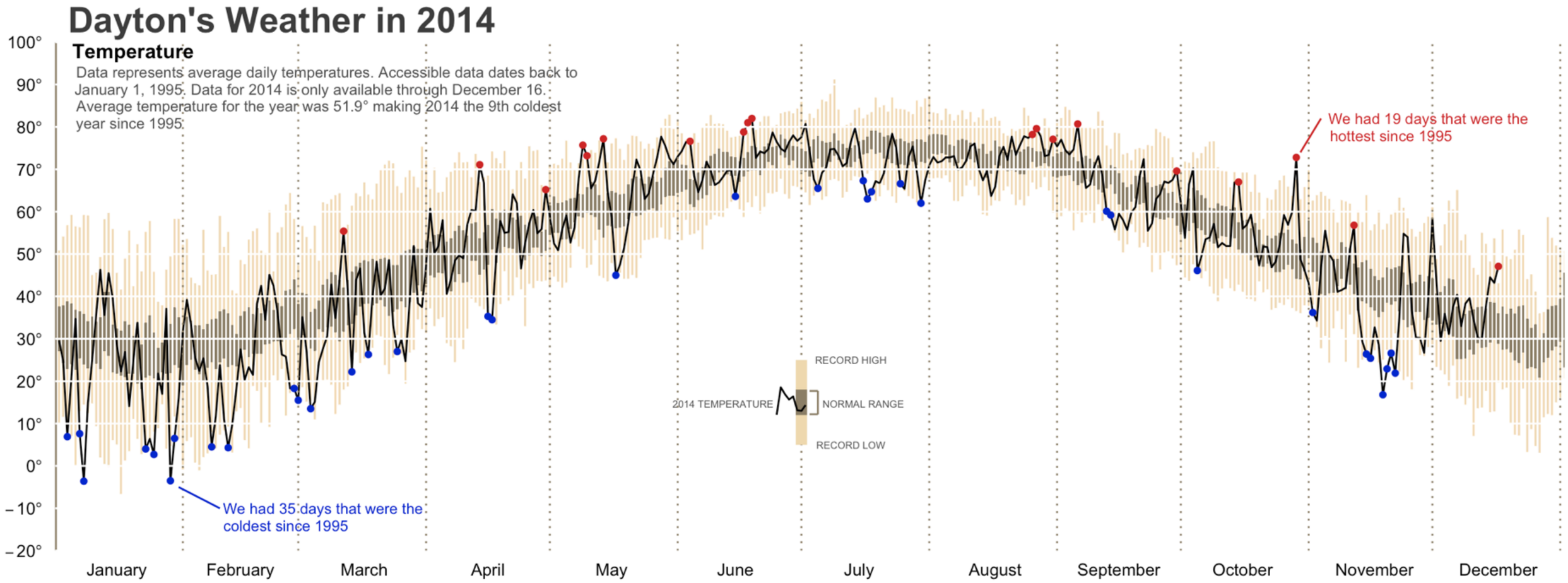
SOLUTION

```
ggplot(data = mpg, aes(class, fill = factor(cyl))) +
       geom_bar(position = "fill") +
       scale_y_continuous(name = "Percent", labels = scales::percent) +
       coord_flip()
```



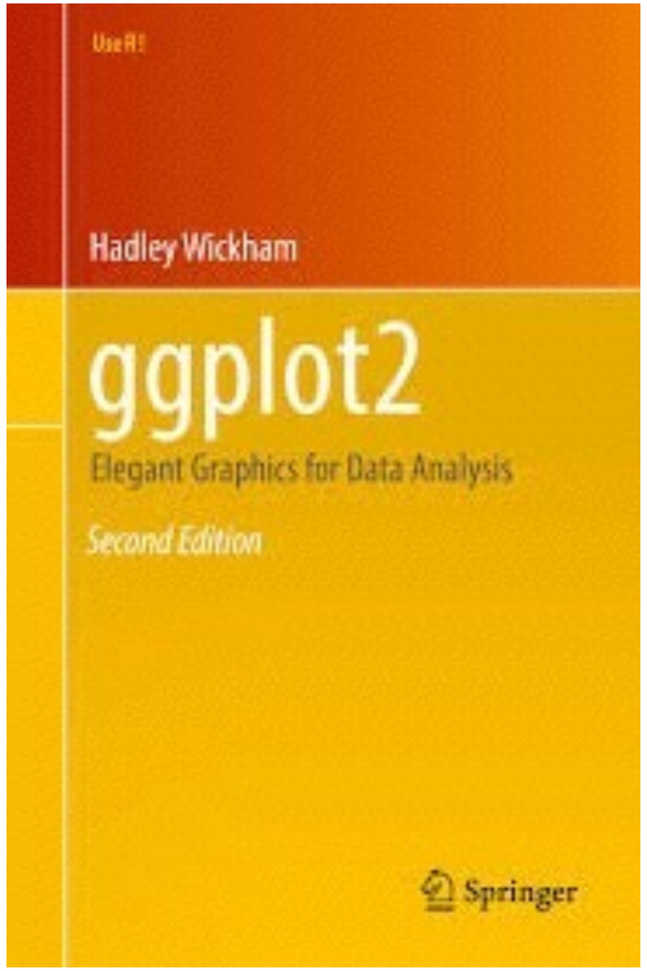
SO LITTLE TIME!

SEE LAYERING IN ACTION



https://rpubs.com/bradleyboehmke/weather_graphic

LEARN MORE


UseR!
Hadley Wickham
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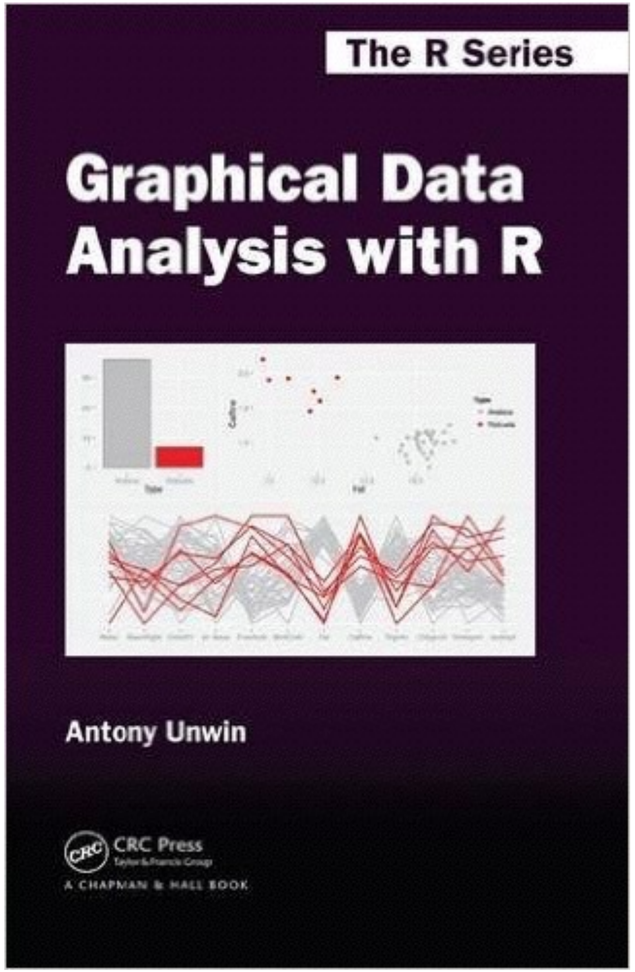
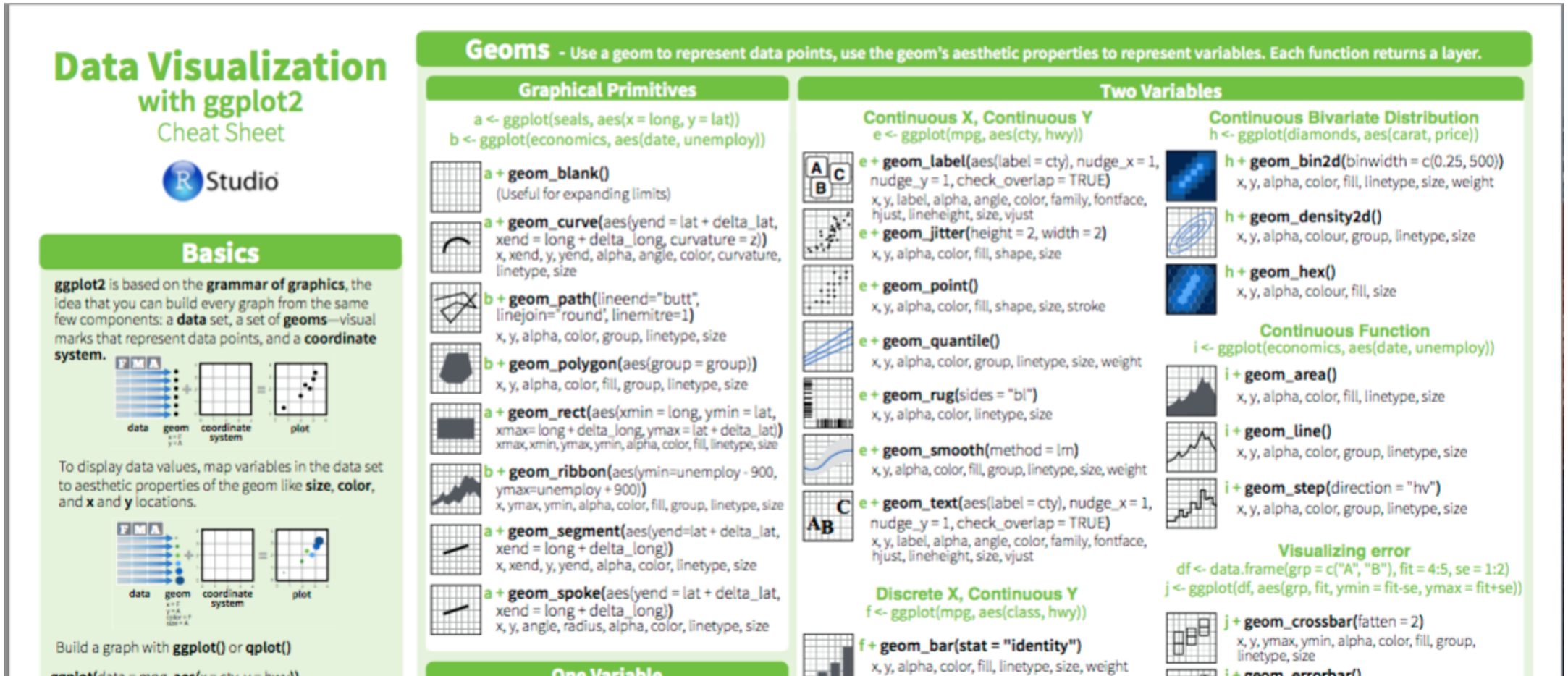
Elegant Graphics for Data Analysis
Second Edition
Springer


R Graphics Cookbook
O'REILLY


The R Series
Graphical Data Analysis with R
Antony Unwin
CRC Press
A CHAPMAN & HALL BOOK

LEVERAGE HELP AS YOU'RE LEARNING

Help >> Cheatsheets >> Data Visualization with ggplot2



Data Visualization with ggplot2 Cheat Sheet

RStudio

Basics

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

To display data values, map variables in the data set to aesthetic properties of the geom like **size**, **color**, and **x** and **y** locations.

Build a graph with **ggplot()** or **qplot()**

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

Graphical Primitives

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

a + **geom_blank()**
(Useful for expanding limits)

a + **geom_curve**(aes(yend = lat + delta_lat, xend = long + delta_long, curvature = z))
x, xend, y, yend, alpha, angle, color, curvature, linetype, size

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

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

a + **geom_rect**(aes(xmin = long, ymin = lat, xmax= long + delta_long, ymax = lat + delta_lat))
xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size

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

a + **geom_segment**(aes(yend=lat + delta_lat, xend = long + delta_long))
x, xend, y, yend, alpha, color, linetype, size

a + **geom_spoke**(aes(yend = lat + delta_lat, xend = long + delta_long))
x, y, angle, radius, alpha, color, linetype, size

One Variable

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_bar(stat = "identity")**
x, y, alpha, color, fill, linetype, size, weight

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()**

WHAT TO REMEMBER

FUNCTIONS TO REMEMBER

Operator/Function	Description
`ggplot()`	Initializes a ggplot object (creates the blank canvas)
`aes()`	Creates aesthetic mappings
`geom_xx`	Geometric shapes to plot the data
`color, shape, size, alpha, etc`	Aesthetic parameters
`facet_wrap, facet_grid`	Create small multiples
`position`	Position argument (primarily used with bar charts)
`coord_xx`	Functions to adjust the coordinate system
`scale_xx`	Functions to adjust x and y axis