Introduction to the tidyverse: A very brief introduction to `ggplot2()`

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Prerequisites

```
library(tidyverse)
```

```
## ── Attaching packages ─────────────────────────────────────── tidyverse 1.2.1 ──
```

```
## ✔ ggplot2 2.2.1.9000     ✔ purrr   0.2.4
## ✔ tibble  1.4.2          ✔ dplyr   0.7.4
## ✔ tidyr   0.8.0          ✔ stringr 1.3.0
## ✔ readr   1.1.1          ✔ forcats 0.2.0
```

```
## Warning: package 'tibble' was built under R version 3.4.3
```

```
## Warning: package 'tidyr' was built under R version 3.4.3
```

```
## Warning: package 'stringr' was built under R version 3.4.3
```

```
## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
```

Example data: the `mpg` data frame

```
mpg
```

```
## # A tibble: 234 x 11
##    manufacturer model    displ  year   cyl trans   drv     cty   hwy
##    <chr>        <chr>    <dbl> <int> <int> <chr>   <chr> <int> <int>
##  1 audi         a4         1.80  1999     4 auto(l… f        18    29
##  2 audi         a4         1.80  1999     4 manual… f        21    29
##  3 audi         a4         2.00  2008     4 manual… f        20    31
##  4 audi         a4         2.00  2008     4 auto(a… f        21    30
##  5 audi         a4         2.80  1999     6 auto(l… f        16    26
##  6 audi         a4         2.80  1999     6 manual… f        18    26
##  7 audi         a4         3.10  2008     6 auto(a… f        18    27
##  8 audi         a4 quat…   1.80  1999     4 manual… 4        18    26
##  9 audi         a4 quat…   1.80  1999     4 auto(l… 4        16    25
## 10 audi         a4 quat…   2.00  2008     4 manual… 4        20    28
## # ... with 224 more rows, and 1 more variable: class <chr>
```

Example data: the `mpg` data frame

Among the variables in `mpg` are:

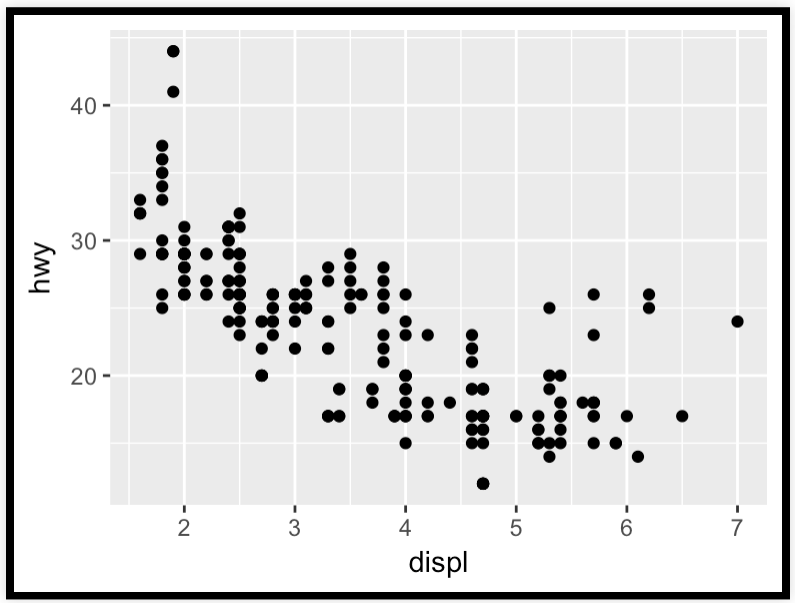
1. `displ`, a car's engine size, in litres.
2. `hwy`, a car's fuel efficiency on the highway, in miles per gallon (mpg). A car with a low fuel efficiency consumes more fuel than a car with a high fuel efficiency when they travel the same distance.

Creating a ggplot

To plot `mpg`, run this code to put `displ` on the x-axis and `hwy` on the y-axis:

Creating a ggplot

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



Arguments

`ggplot()` creates a coordinate system that you can add layers to. The first argument of `ggplot()` is the dataset to use in the graph. So `ggplot(data = mpg)` creates an empty graph, but it's not very interesting so I'm not going to show it here.

Arguments

You complete your graph by adding one or more layers to `ggplot()`. The function `geom_point()` adds a layer of points to your plot, which creates a scatterplot. ggplot2 comes with many geom functions that each add a different type of layer to a plot.

Arguments

Each geom function in ggplot2 takes a `mapping` argument. This defines how variables in your dataset are mapped to visual properties. The `mapping` argument is always paired with `aes()`, and the `x` and `y` arguments of `aes()` specify which variables to map to the x and y axes. ggplot2 looks for the mapped variable in the `data` argument, in this case, `mpg`.

A graphing template

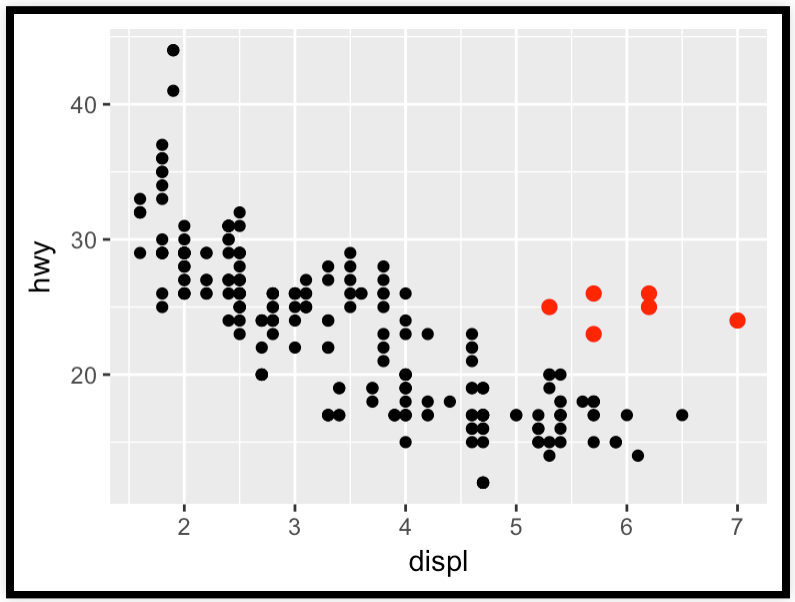
```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(mapping = aes(<MAPPINGS>))
```

Aesthetic mappings

In the plot below, one group of points (highlighted in red) seems to fall outside of the linear trend. These cars have a higher mileage than you might expect. How can you explain these cars?

Aesthetic mappings

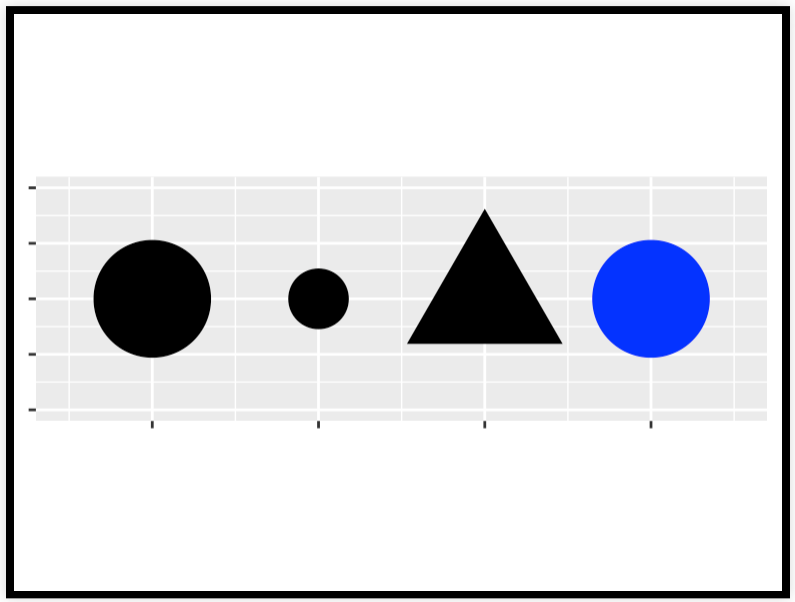
```
## Warning: package 'bindrcpp' was built under R version 3.4.4
```



Arguments

You can add a third variable, like `class`, to a two dimensional scatterplot by mapping it to an **aesthetic**. An aesthetic is a visual property of the objects in your plot. Aesthetics include things like the size, the shape, or the color of your points.

Arguments

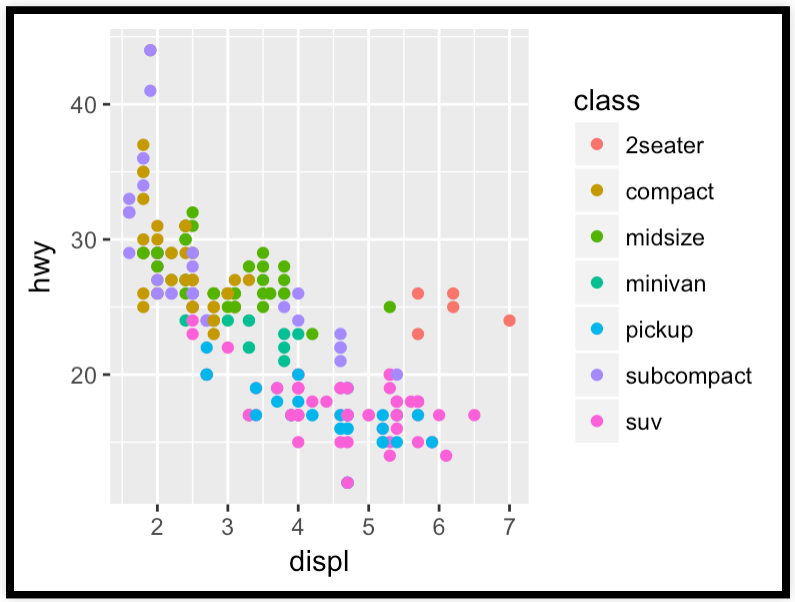


Arguments

You can convey information about your data by mapping the aesthetics in your plot to the variables in your dataset. For example, you can map the colors of your points to the `class` variable to reveal the class of each car.

Arguments

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



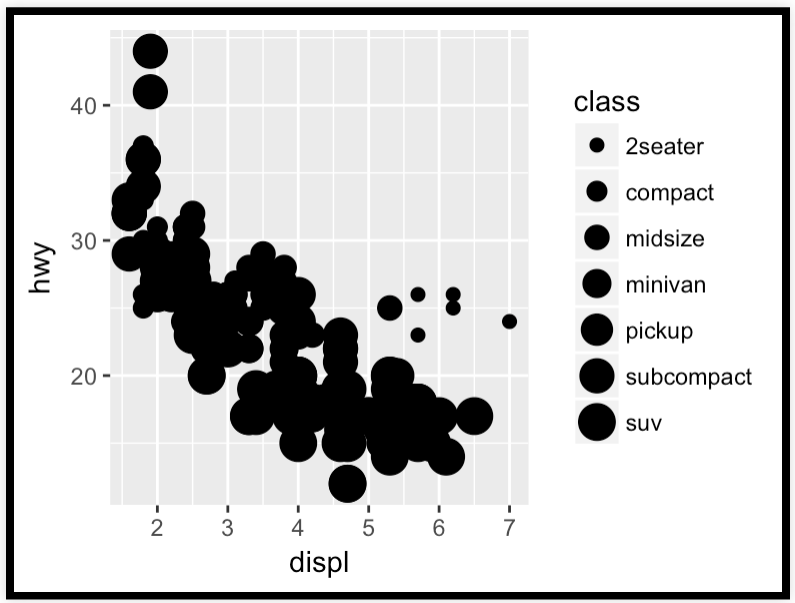
Arguments

In the above example, we mapped `class` to the color aesthetic, but we could have mapped `class` to the size aesthetic in the same way. In this case, the exact size of each point would reveal its class affiliation. We get a *warning* here, because mapping an unordered variable (`class`) to an ordered aesthetic (`size`) is not a good idea.

Arguments

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

```
## Warning: Using size for a discrete variable is not advised.
```

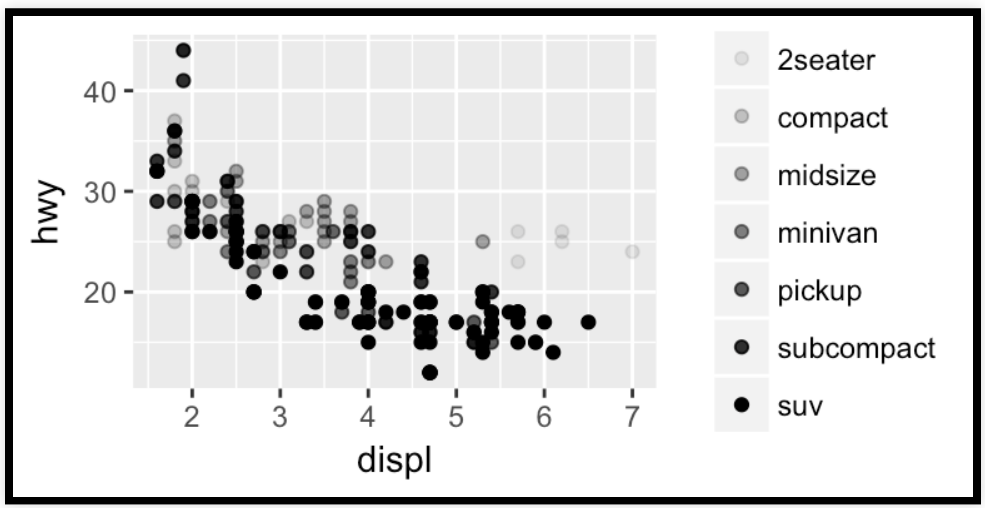


Arguments

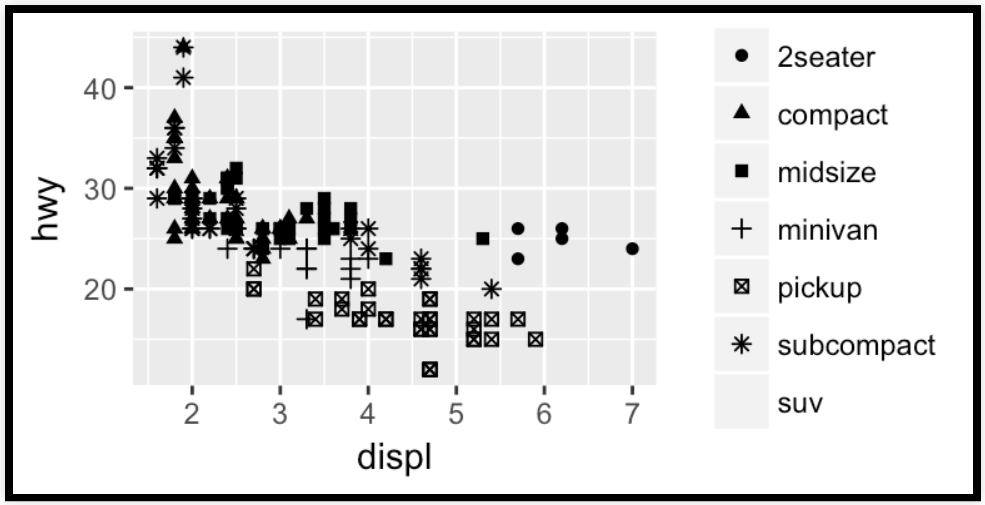
Or we could have mapped `class` to the *alpha* aesthetic, which controls the transparency of the points, or the shape of the points.

Arguments

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




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

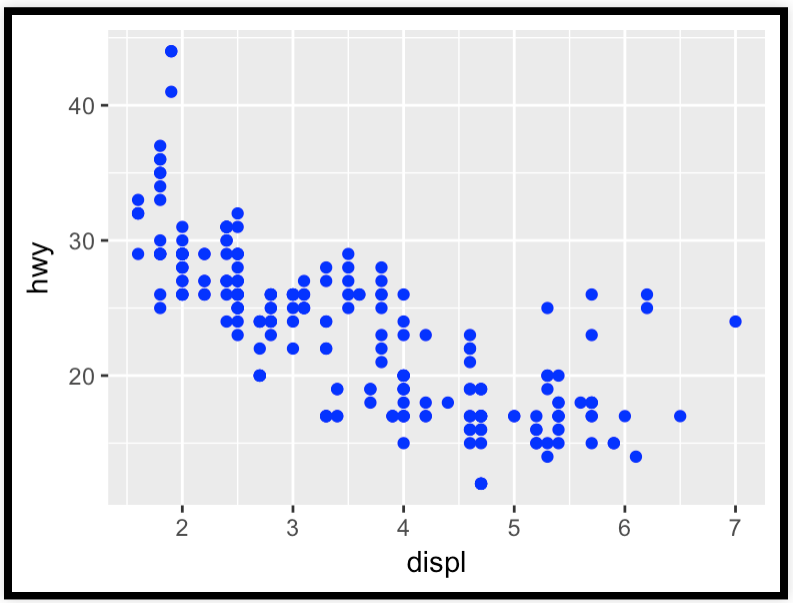

hwy
40
30
20
2
3
4
5
6
7
displ
2seater
compact
midsize
minivan
pickup
subcompact
suv

Arguments

You can also *set* the aesthetic properties of your geom manually. For example, we can make all of the points in our plot blue:

Arguments

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



Arguments

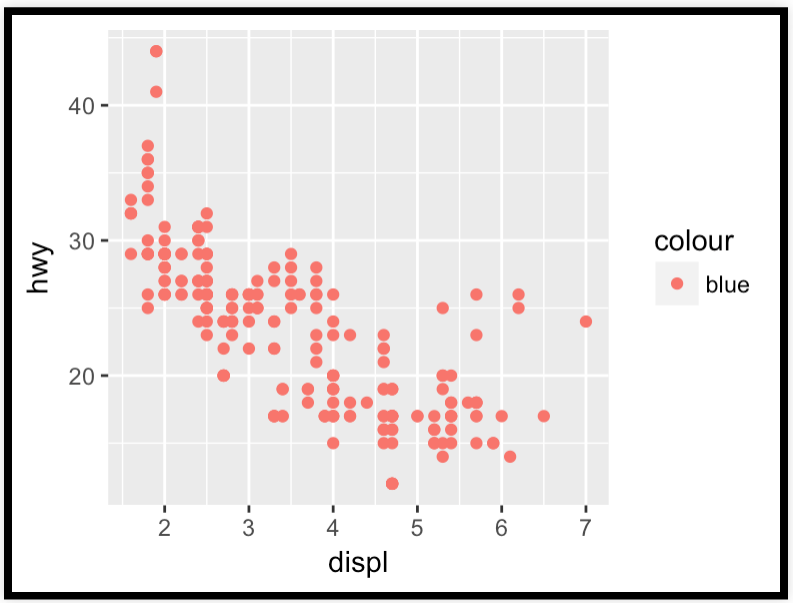
Here, the color doesn't convey information about a variable, but only changes the appearance of the plot. To set an aesthetic manually, set the aesthetic by name as an argument

of your geom function; i.e. it goes *outside* of `aes()`. You'll need to pick a value that makes sense for that aesthetic:

Exercises

1. What's gone wrong with this code? Why are the points not blue?

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



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

Facets

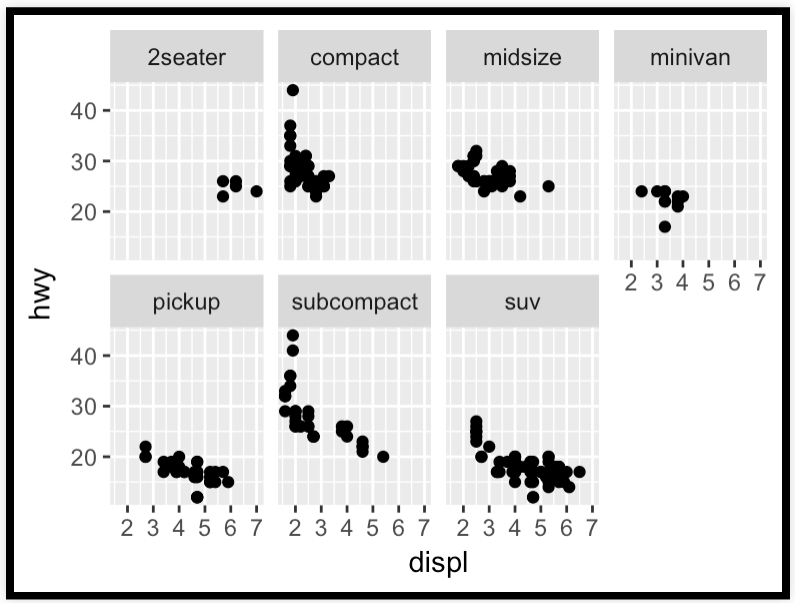
One way to add additional variables is with aesthetics. Another way, particularly useful for categorical variables, is to split your plot into **facets**, subplots that each display one subset of the data.

Facets

To facet your plot by a single variable, use `facet_wrap()`. The first argument of `facet_wrap()` should be a formula, which you create with ~ followed by a variable name (here "formula" is the name of a data structure in R, not a synonym for "equation"). The variable that you pass to `facet_wrap()` should be discrete.

Facets

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

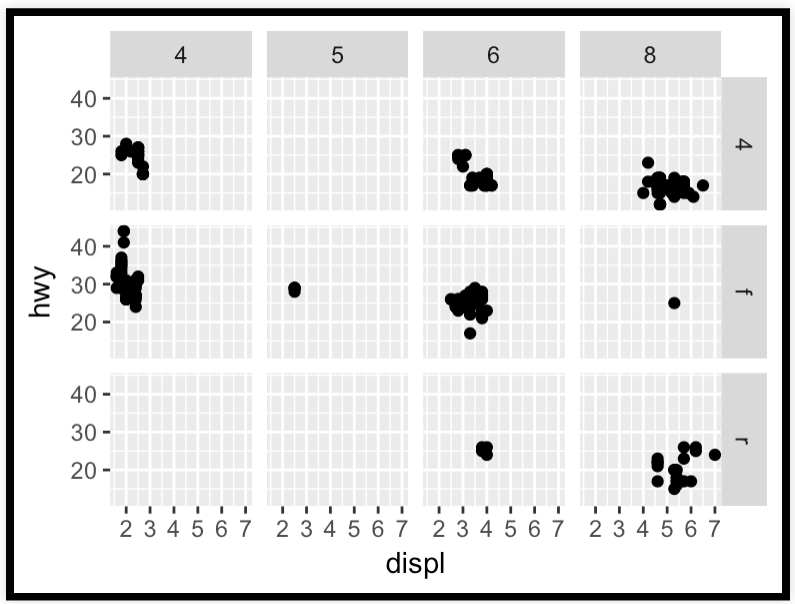


Facets

To facet your plot on the combination of two variables, add `facet_grid()` to your plot call. The first argument of `facet_grid()` is also a formula. This time the formula should contain two variable names separated by a ~.

Facets

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



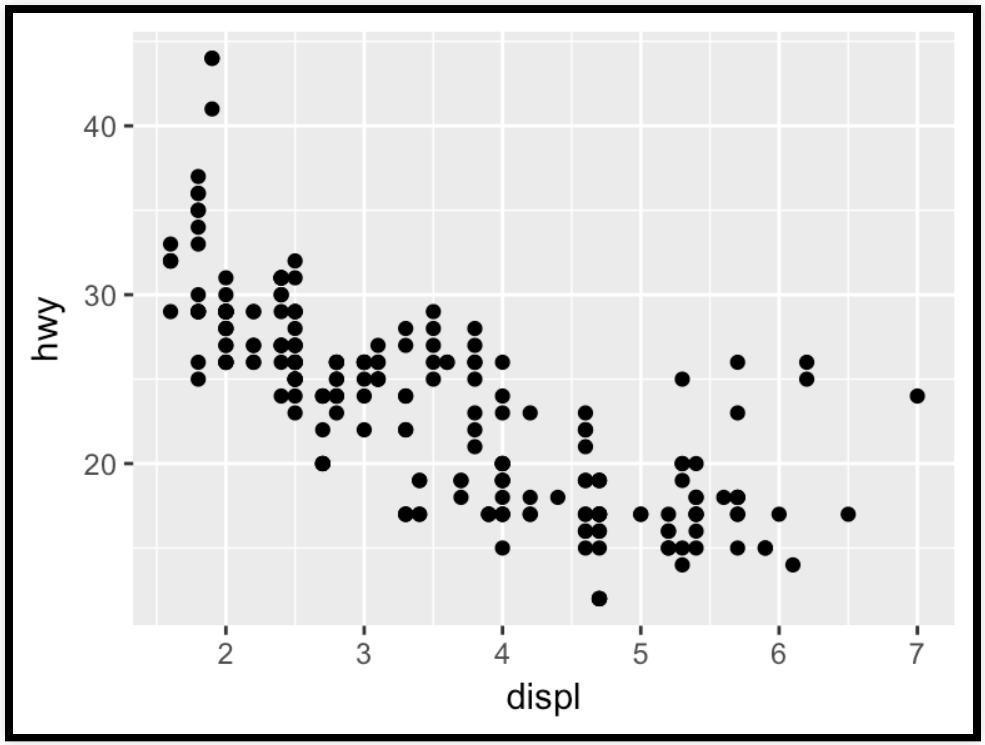
Facets

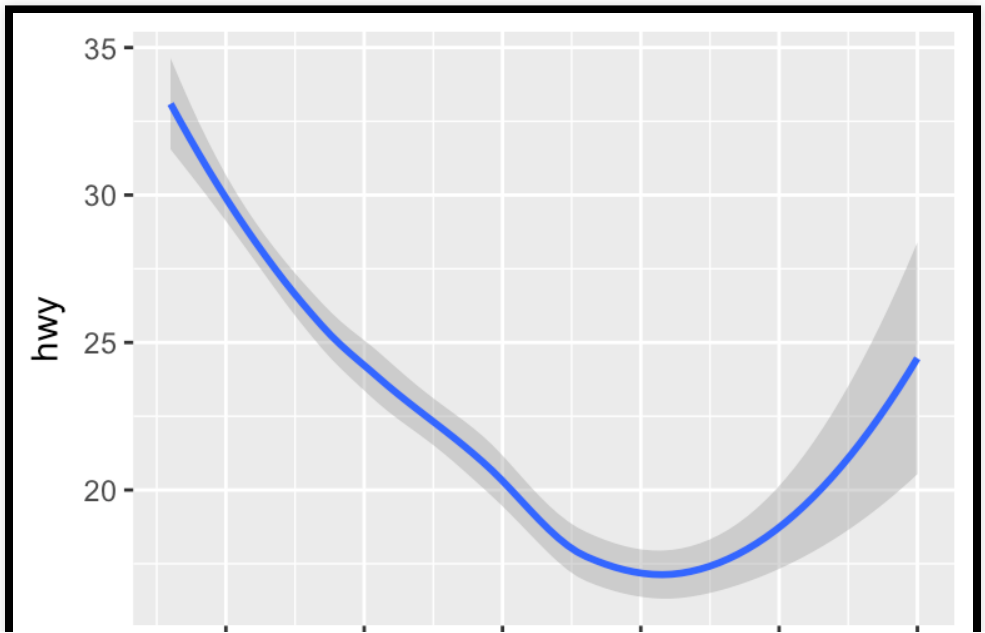
If you prefer to not facet in the rows or columns dimension, use a `.` instead of a variable name, e.g. `+ facet_grid(. ~ cyl)`. is section:

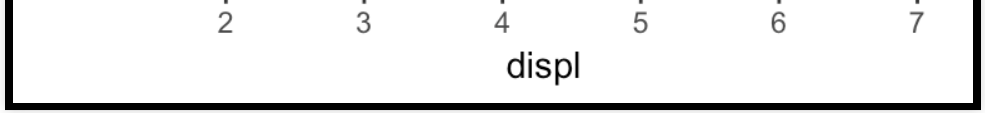
```r
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy)) +
  facet_wrap(~ class, nrow = 2)
```

Geometric objects

How are these two plots similar?


hwy
40
30
20
2
3
4
5
6
7
displ


hwy
35
30
25
20


2
3
4
5
6
7
displ

Geometric objects

Both plots contain the same x variable, the same y variable, and both describe the same data. But the plots are not identical. Each plot uses a different visual object to represent the data. In ggplot2 syntax, we say that they use different **geoms**.

Geometric objects

A **geom** is the geometrical object that a plot uses to represent data. People often describe plots by the type of geom that the plot uses. For example, bar charts use bar geoms, line charts use line geoms, boxplots use boxplot geoms, and so on. Scatterplots break the trend; they use the point geom. As we see above, you can use different geoms to plot the same data. The plot on the left uses the point geom, and the plot on the right uses the smooth geom, a smooth line fitted to the data.

Geometric objects

To change the geom in your plot, change the geom function that you add to `ggplot()`. For instance, to make the plots above, you can use this code:

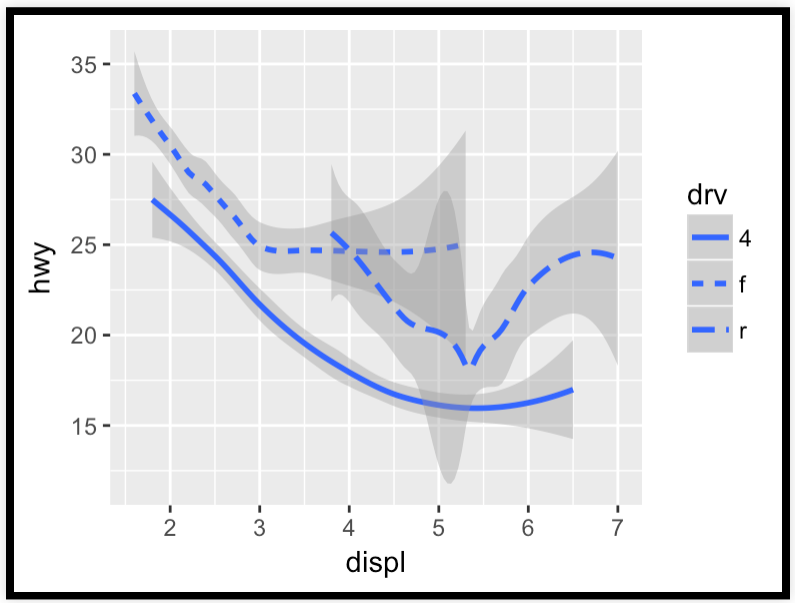
```
# left
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy))

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

Geometric objects

Every geom function in ggplot2 takes a `mapping` argument. However, not every aesthetic works with every geom. You could set the shape of a point, but you couldn't set the "shape" of a line. On the other hand, you *could* set the linetype of a line. `geom_smooth()` will draw a different line, with a different linetype, for each unique value of the variable that you map to linetype.

Geometric objects

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

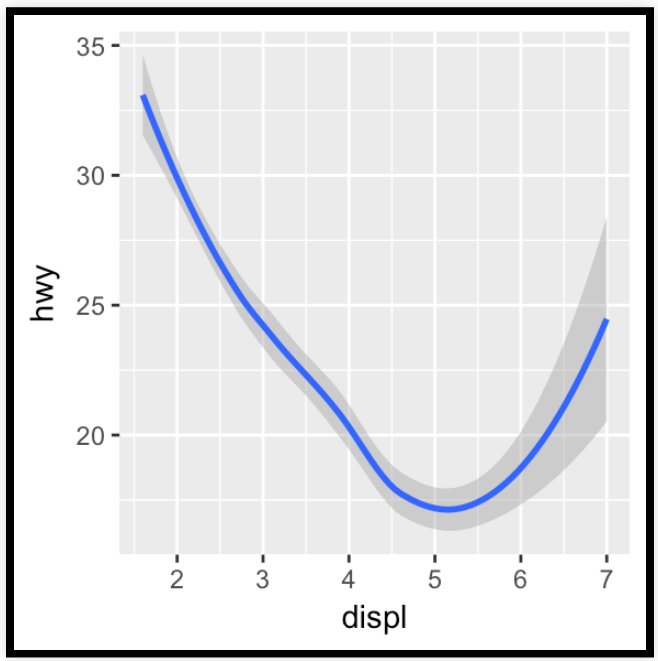


Geometric objects

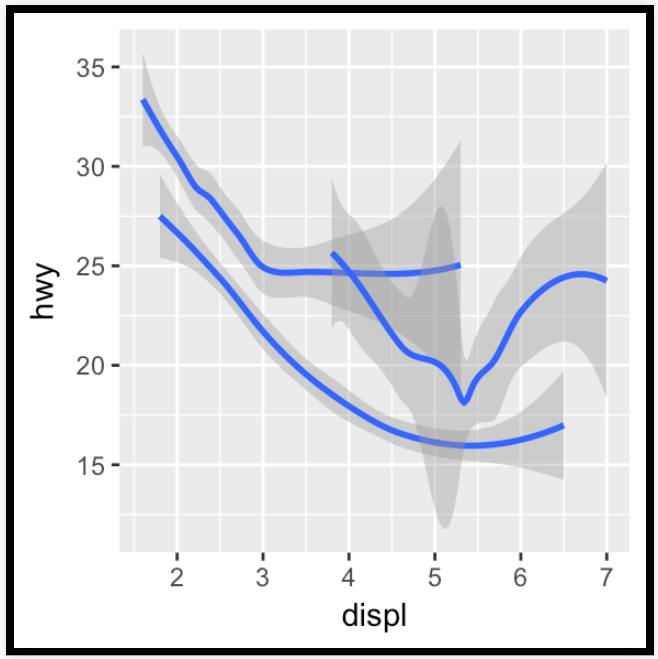
Here `geom_smooth()` separates the cars into three lines based on their `drv` value, which describes a car's drivetrain. One line describes all of the points with a `4` value, one line describes all of the points with an `f` value, and one line describes all of the points with an `r` value. Here, `4` stands for four-wheel drive, `f` for front-wheel drive, and `r` for rear-wheel drive.

Geometric objects

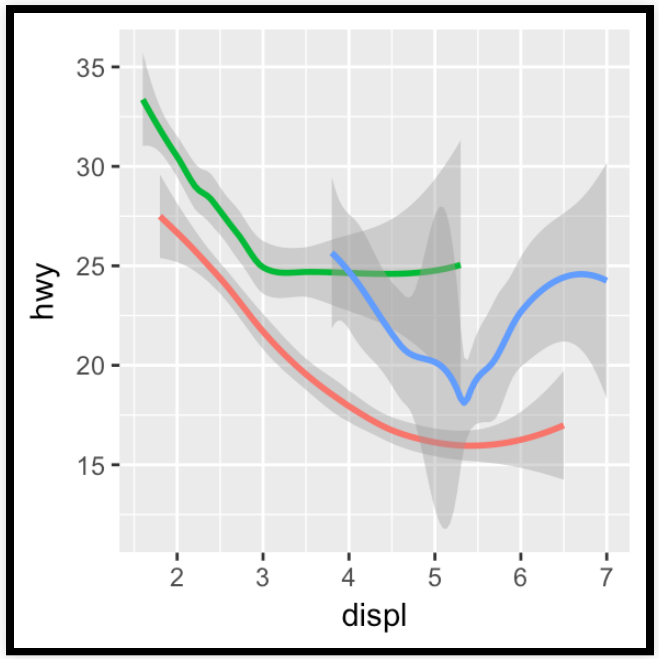
```
ggplot(data = mpg) +
  geom_smooth(mapping = aes(x = displ, y = hwy))
```




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



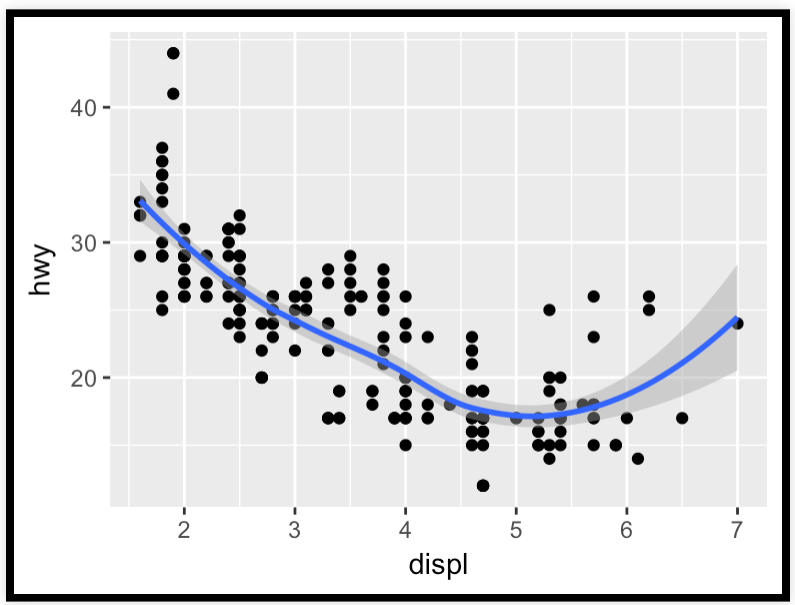

```
ggplot(data = mpg) +
  geom_smooth(
    mapping = aes(x = displ, y = hwy, color = drv),
    show.legend = FALSE
  )
```


35
30
25
20
15
hwy
2
3
4
5
6
7
displ

Geometric objects

To display multiple geoms in the same plot, add multiple geom functions to `ggplot()`:

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



Geometric objects

This, however, introduces some duplication in our code. Imagine if you wanted to change the y-axis to display `cty` instead of `hwy`. You'd need to change the variable in two places, and you might forget to update one. You can avoid this type of repetition by passing a set of mappings to `ggplot()`. ggplot2 will treat these mappings as global mappings that apply to each geom in the graph. In other words, this code will produce the same plot as the previous code:

Geometric objects

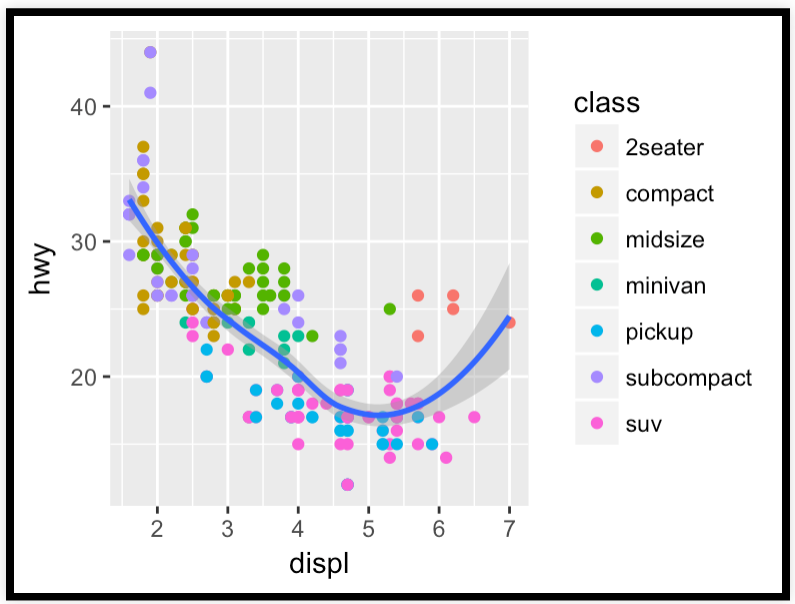
```
ggplot(data = mpg, mapping = aes(x = displ, y = hwy)) +
  geom_point() +
  geom_smooth()
```

Geometric objects

If you place mappings in a geom function, ggplot2 will treat them as local mappings for the layer. It will use these mappings to extend or overwrite the global mappings *for that layer only*. This makes it possible to display different aesthetics in different layers.

Geometric objects

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

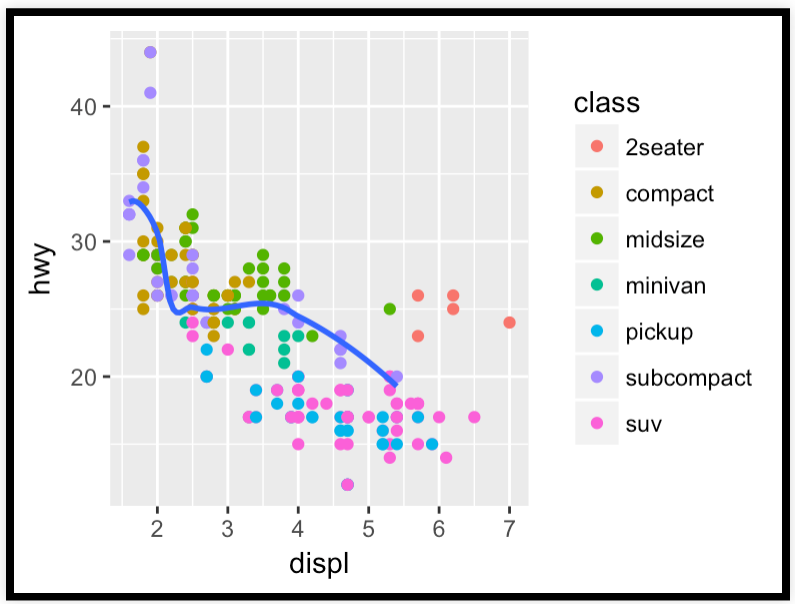


Geometric objects

You can use the same idea to specify different `data` for each layer. Here, our smooth line displays just a subset of the `mpg` dataset, the subcompact cars. The local data argument in `geom_smooth()` overrides the global data argument in `ggplot()` for that layer only.

Geometric objects

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



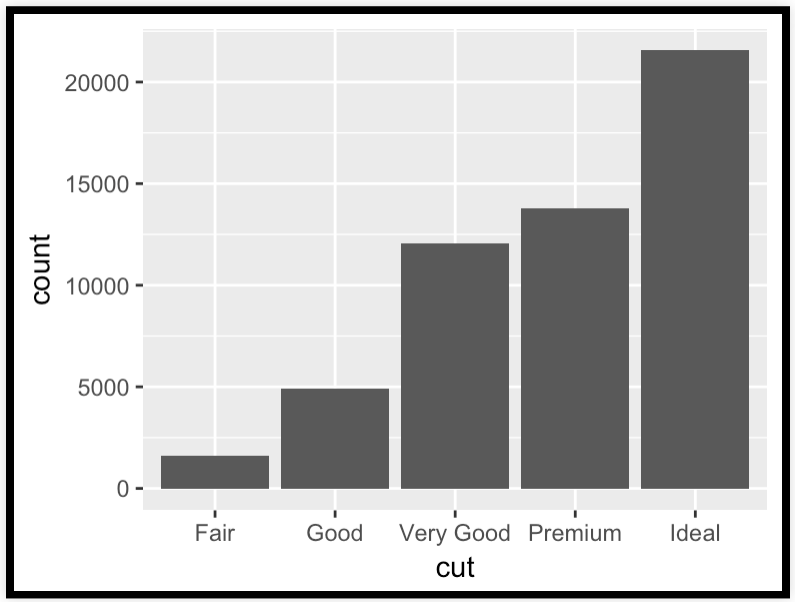
Exercises

1. Will these two graphs look different? Why/why not?

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

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

Statistical transformations

```
ggplot(data = diamonds) +
  geom_bar(mapping = aes(x = cut))
```



Statistical transformations

On the x-axis, the chart displays `cut`, a variable from `diamonds`. On the y-axis, it displays count, but count is not a variable in `diamonds`! Where does count come from? Many graphs, like scatterplots, plot the raw values of your dataset. Other graphs, like bar charts, calculate new values to plot:

Statistical transformations

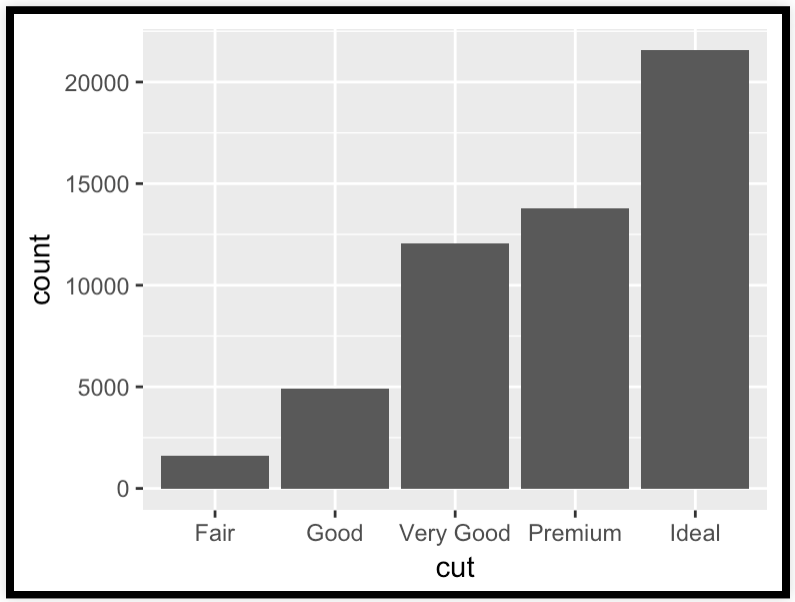
- bar charts, histograms, and frequency polygons bin your data and then plot bin counts, the number of points that fall in each bin.
- smoothers fit a model to your data and then plot predictions from the model.
- boxplots compute a robust summary of the distribution and then display a specially formatted box.

Statistical transformations

You can generally use geoms and stats interchangeably. For example, you can recreate the previous plot using `stat_count()` instead of `geom_bar()`:

Statistical transformations

```
ggplot(data = diamonds) +
  stat_count(mapping = aes(x = cut))
```



Statistical transformations

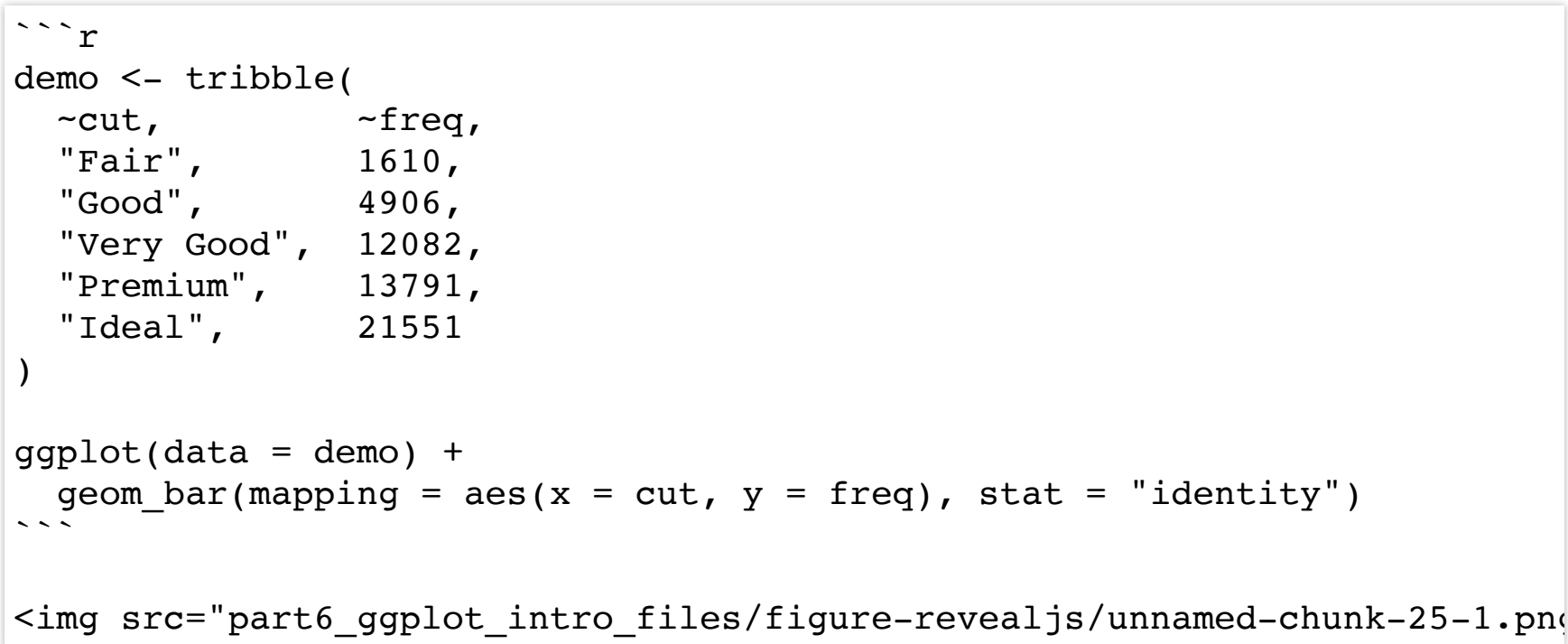
This works because every geom has a default stat; and every stat has a default geom. This means that you can typically use geoms without worrying about the underlying statistical transformation. There are three reasons you might need to use a stat explicitly:

Statistical transformations

1. You might want to override the default stat. In the code below, I change the stat of `geom_bar()` from count (the default) to identity. This lets me map the height of the bars to the raw values of a y variable. Unfortunately when people talk about bar charts casually, they might be referring to this type of bar chart, where the height of the bar is already present in the data, or the previous bar chart where the height of the bar is generated by counting rows.

Statistical transformations

```r
demo <- tribble(
  ~cut,         ~freq,
  "Fair",       1610,
  "Good",       4906,
  "Very Good",  12082,
  "Premium",    13791,
  "Ideal",      21551
)

ggplot(data = demo) +
  geom_bar(mapping = aes(x = cut, y = freq), stat = "identity")
```



Statistical transformations

1. You might want to override the default mapping from transformed variables to aesthetics. For example, you might want to display a bar chart of proportion, rather than count:

Statistical transformations

```r
ggplot(data = diamonds) +
  geom_bar(mapping = aes(x = cut, y = ..prop.., group = 1))
```

Statistical transformations

1. You might want to draw greater attention to the statistical transformation in your code. For example, you might use `stat_summary()`, which summarises the y values for each unique x value, to draw attention to the summary that you're computing:

Statistical transformations

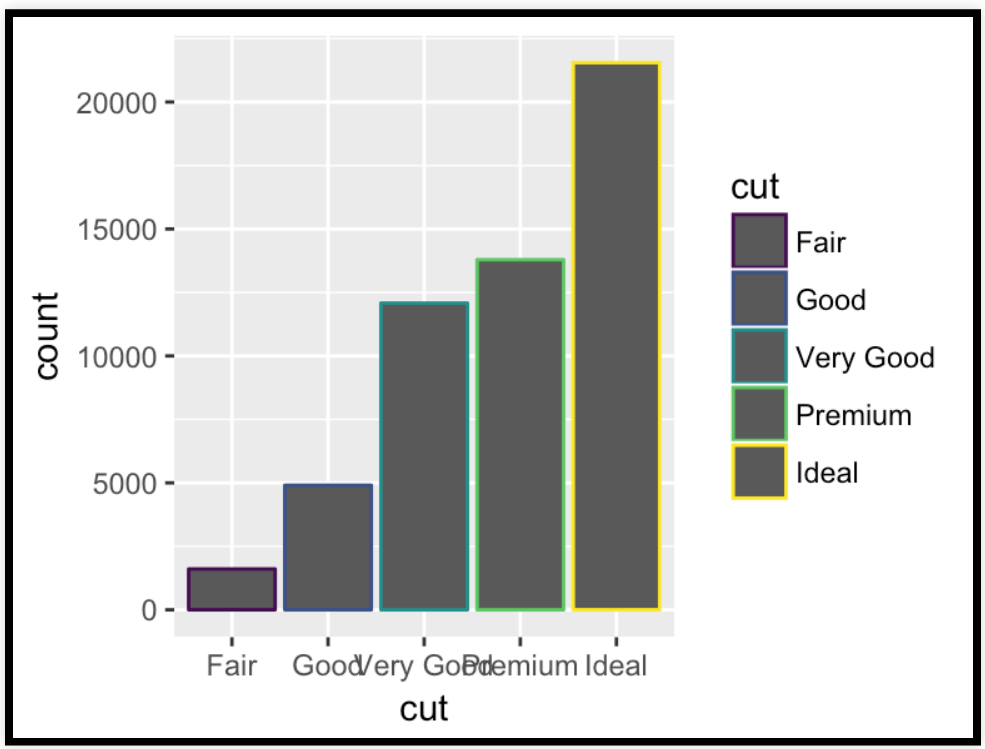
```r
ggplot(data = diamonds) +
  stat_summary(
    mapping = aes(x = cut, y = depth),
    fun.ymin = min,
    fun.ymax = max,
    fun.y = median
  )
```

Position adjustments

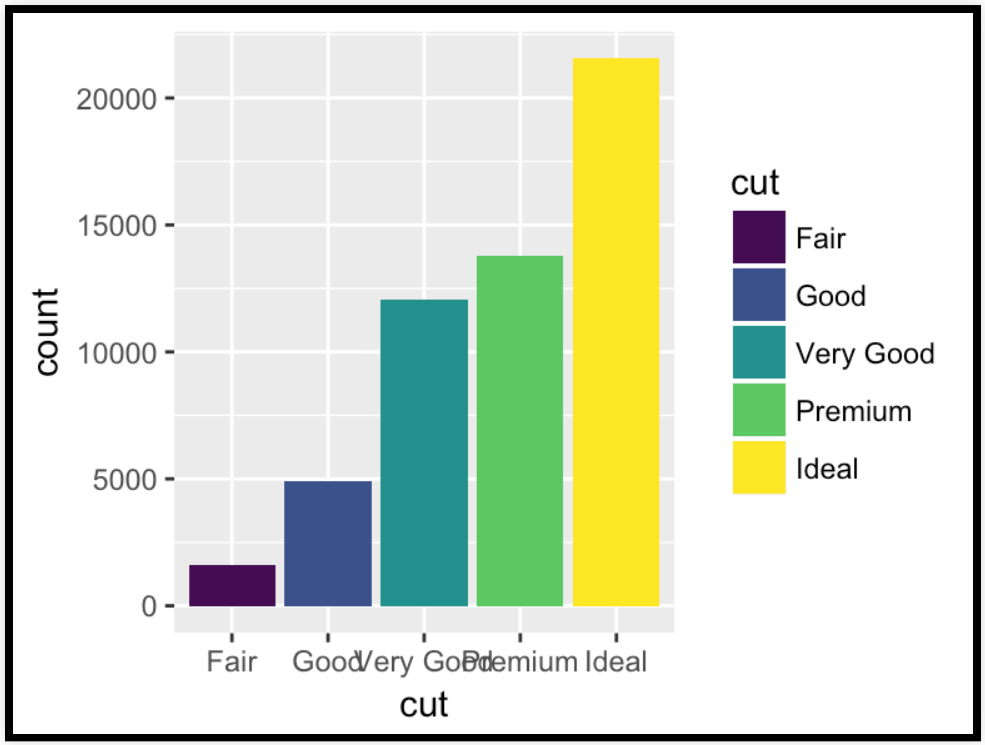
There's one more piece of magic associated with bar charts. You can colour a bar chart using either the `colour` aesthetic, or, more usefully, `fill`:

Position adjustments

```
ggplot(data = diamonds) +
  geom_bar(mapping = aes(x = cut, colour = cut))
```




```
ggplot(data = diamonds) +
  geom_bar(mapping = aes(x = cut, fill = cut))
```

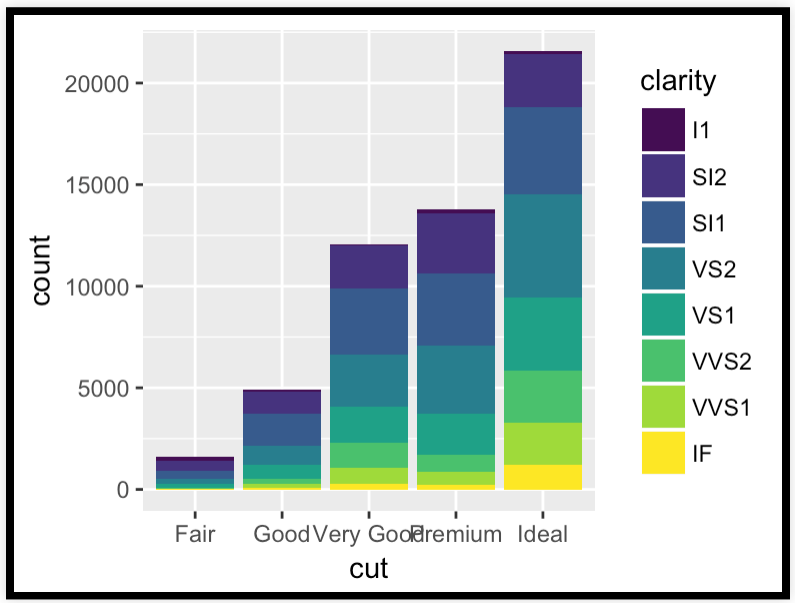

20000
15000
10000
5000
0
count
Fair
Good
Very Good
Premium
Ideal
cut
cut
Fair
Good
Very Good
Premium
Ideal

Position adjustments

Note what happens if you map the fill aesthetic to another variable, like `clarity`: the bars are automatically stacked. Each colored rectangle represents a combination of `cut` and `clarity`.

Position adjustments

```
ggplot(data = diamonds) +
  geom_bar(mapping = aes(x = cut, fill = clarity))
```



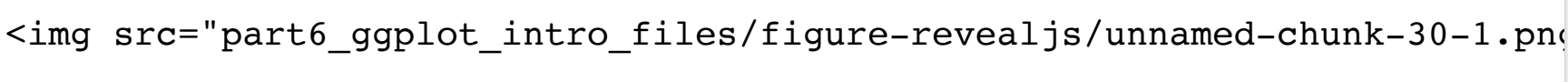
Position adjustments

The stacking is performed automatically by the **position adjustment** specified by the `position` argument. If you don't want a stacked bar chart, you can use one of three other options: `"identity"`, `"dodge"` or `"fill"`. ## Position adjustments

- `position = "identity"` will place each object exactly where it falls in the context of the graph. This is not very useful for bars, because it overlaps them. To see that overlapping we either need to make the bars slightly transparent by setting `alpha` to a small value, or completely transparent by setting `fill = NA`.

Position adjustments

```r
ggplot(data = diamonds, mapping = aes(x = cut, fill = clarity)) +
  geom_bar(alpha = 1/5, position = "identity")
```




```r
ggplot(data = diamonds, mapping = aes(x = cut, colour = clarity)) +
  geom_bar(fill = NA, position = "identity")
```

Position adjustments

- `position = "fill"` works like stacking, but makes each set of stacked bars the same height. This makes it easier to compare proportions across groups.

Position adjustments

```r
ggplot(data = diamonds) +
  geom_bar(mapping = aes(x = cut, fill = clarity), position = "fill")
```

Position adjustments

- `position = "dodge"` places overlapping objects directly *beside* one another. This makes it easier to compare individual values.

Position adjustments

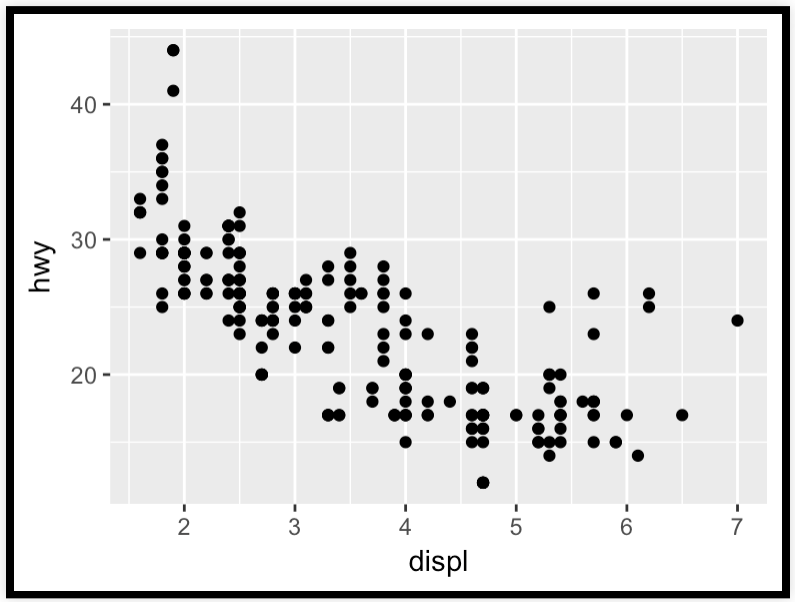
```r
ggplot(data = diamonds) +
  geom_bar(mapping = aes(x = cut, fill = clarity), position = "dodge")
```

<img src="part6_ggplot_intro_files/figure-revealjs/unnamed-chunk-32-1.pn

Position adjustments

There's one other type of adjustment that's not useful for bar charts, but it can be very useful for scatterplots. Recall our first scatterplot. Did you notice that the plot displays only 126 points, even though there are 234 observations in the dataset?

Position adjustments

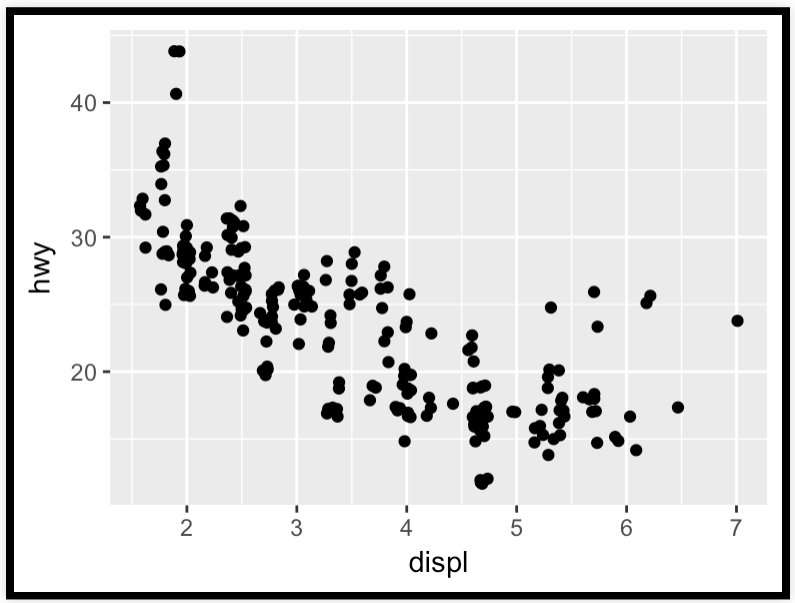


Position adjustments

You can avoid this gridding by setting the position adjustment to “jitter”. `position = "jitter"` adds a small amount of random noise to each point. This spreads the points out because no two points are likely to receive the same amount of random noise.

Position adjustments

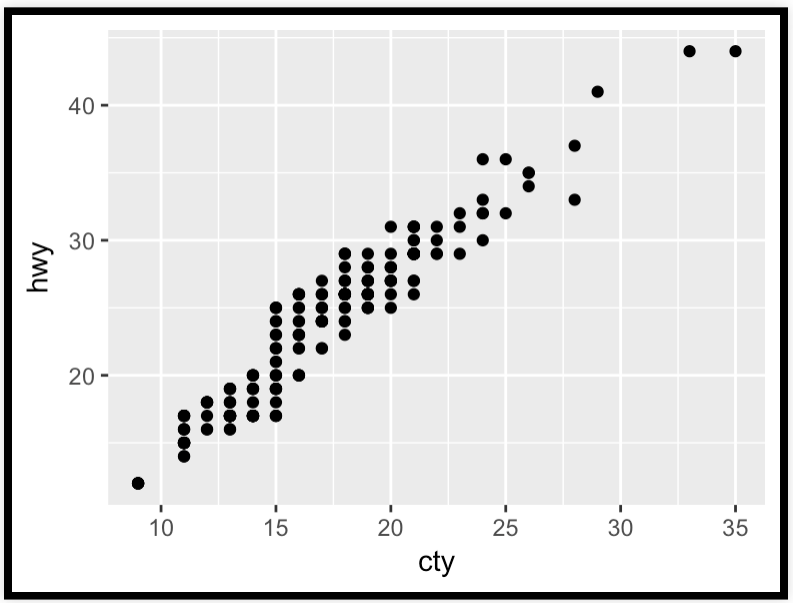
```
ggplot(data = mpg) +
  geom_point(mapping = aes(x = displ, y = hwy), position = "jitter")
```



Exercises

1. What is the problem with this plot? How could you improve it?

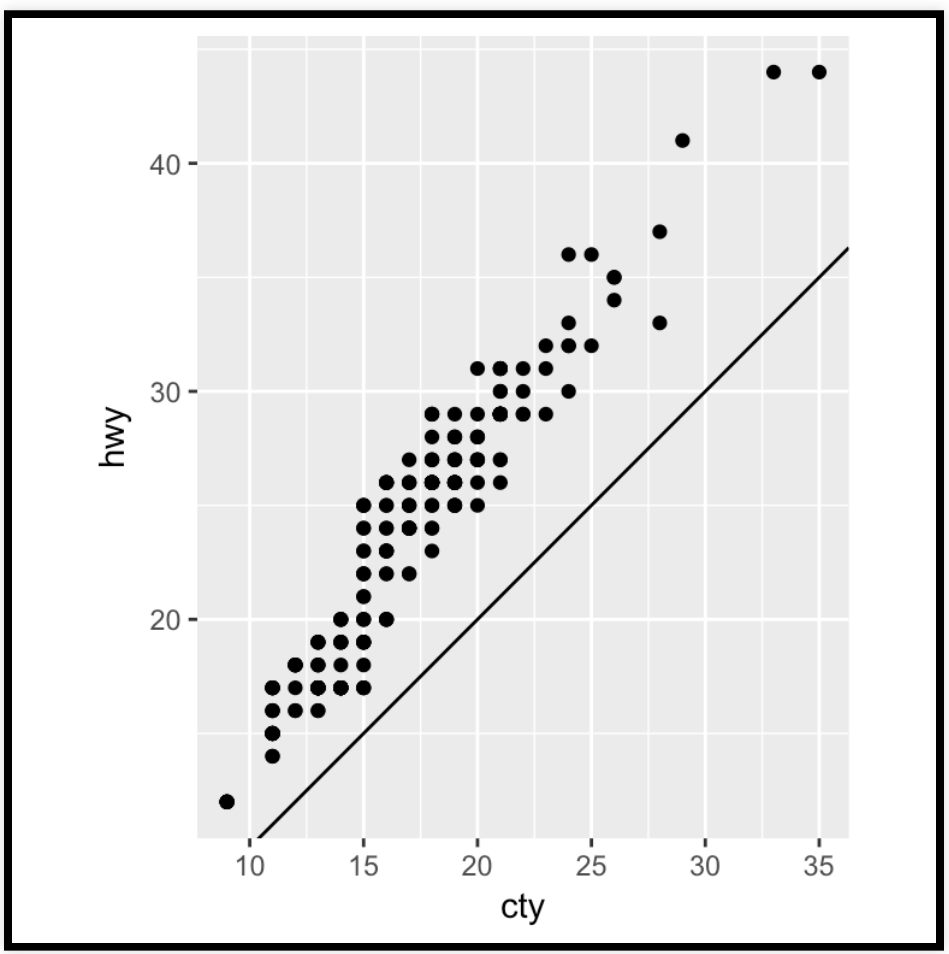
```
ggplot(data = mpg, mapping = aes(x = cty, y = hwy)) +
  geom_point()
```



2. What does the plot below tell you about the relationship

between city and highway mpg? Why is `coord_fixed()` important? What does `geom_abline()` do?

```
ggplot(data = mpg, mapping = aes(x = cty, y = hwy)) +
  geom_point() +
  geom_abline() +
  coord_fixed()
```



The layered grammar of graphics

In the previous sections, you learned much more than how to make scatterplots, bar charts, and boxplots. You learned a foundation that you can use to make *any* type of plot with ggplot2. To see this, let's add position adjustments, stats, coordinate systems, and faceting to our code template:

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

Final thoughts

tidyverse really is the cutting edge of R

- These are the R tools professional data scientists are using
- Their power and ease of use is continually growing
- tidyverse does much more than you can keep in your working memory. Before you spend a long time bashing your head into an arduous cleaning or wrangling task, look for tidyverse solutions

Follow #tidytuesday on twitter

- Each week, a new messy dataset and tidying task
- Check out others' work

Stay active with the R User Group

- Email me to join the list: cskovron@northwestern.edu