2.1 Data Visualisation

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Reading List

- The Art of Data Science, Chapter 4.1, 4.2.
- R for Data Science Online Book, Chapters 2, 3





Learning Objectives of Exploratory Data Analysis

- Understand how to do exploratory data analysis with the tidyverse package in R
- Explore features of data using data visualisation.
- Explain common features of data, such as categorical variables, missing values, unreliable/non-validated data, outliers and high cardinality features, that may lead to problems.
- Apply appropriate methods to deal with common data problems.
- Apply a range of techniques to assess data quality.
- Use R to manipulate (eg filter, merge, sort, group by, summarise, etc.)
- Use R to import, export and tidy data.
- Apply the process to do exploratory data analysis with practical datasets
- Apply R Markdown for communication and reproducible analysis





Exploratory Data Analsis: an Introduction





Exploratory Data Analysis (EDA)

- A set of procedures to produce descriptive and graphical summaries of the data
- Explore the data as they are without making assumptions
- To examine your data and understand relationship among variables
- To determine if there are any problems with your dataset
- To determine whether the question you are asking can be answered by the data that you have
- To develop a sketch of the answer to your question





The process of exploratory data analysis

The EDA is an iterative cycle. You:

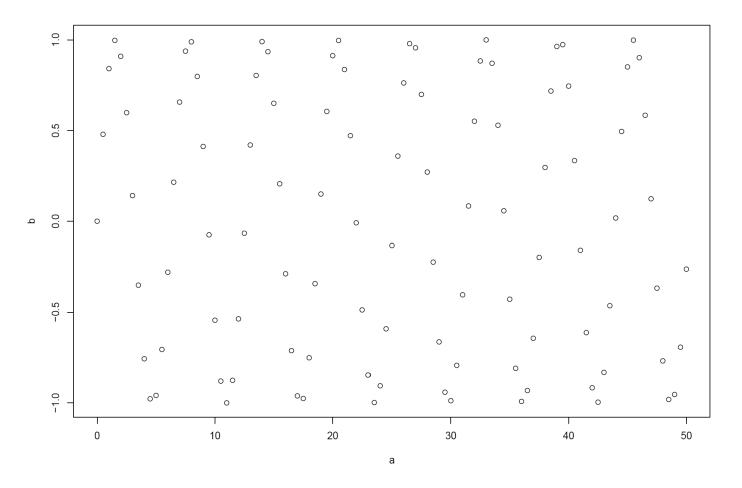
- 1. Formulate your question
- 2. Search for answers by
 - 1. Collect and Import data
 - 2. Check data quality and Cleansing data
 - 3. Manipulate and Transform data
 - 4. Visualise data
- 3. Use what you learn to refine your questions and/or generate new questions
- Data Visualization is arguably the most important tool for EDA.





Example

• What pattern can you see from this plot?





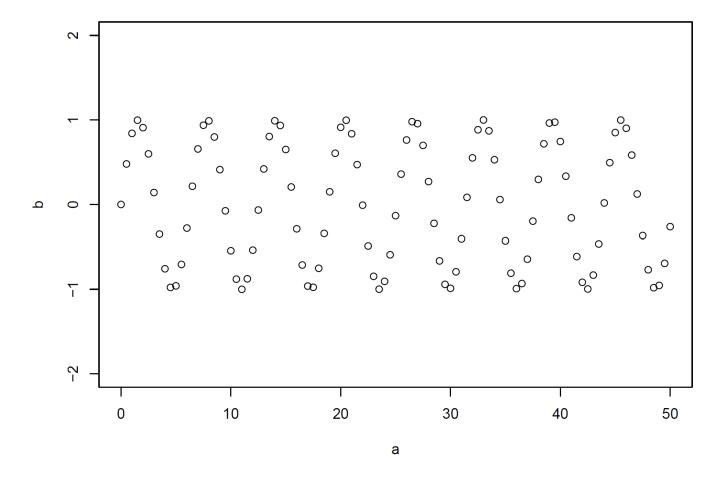






Example

• What pattern can you see from this plot?







Data Visualization

'Visually attractive graphics also gather their power from content and interpretations beyond the immediate display of some numbers. The best graphics are about the useful and important, about life and death, about the universe. Beautiful graphics do not traffic with the trivial.' — Edward Tufte





Data Visulization using ggplot2





Explore features of data using data visualisation

- A statistical graphic maps variables of
 - 1. a dataset to
 - 2. aesthetic properties of
 - 3. geometric objects.
- ggplot2 is part of tidyverse
- Using ggplot2 to visualise your data
- A ggplot2 grammar guide





ggplot2

```
1 #install.packages("tidyverse")
2 library(tidyverse)
```

- reload the package everytime you start a new session.
- package::function()
 - ggplot2::ggplot()





First steps

- Question: Do cars with big engines use more fuel than cars with small engines?
- Data: The mpg data frame in ggplot2 (ggplot2::mpg)
 - mpg contains observations collected by the US Environmental Protection Agency on 38 models of car, 1999-2008.
 - A data frame with 234 rows and 11 variables:
- Variables:
 - manufacturer: manufacturer name
 - model: model name
 - displ: engine displacement, in litres
 - year: year of manufacture
 - cyl: number of cylinders
 - trans: type of transmission
 - drv: the type of drive train, where f = front-wheel drive, r = rear wheel drive, 4 = 4wd





The mpg data

1 mpg

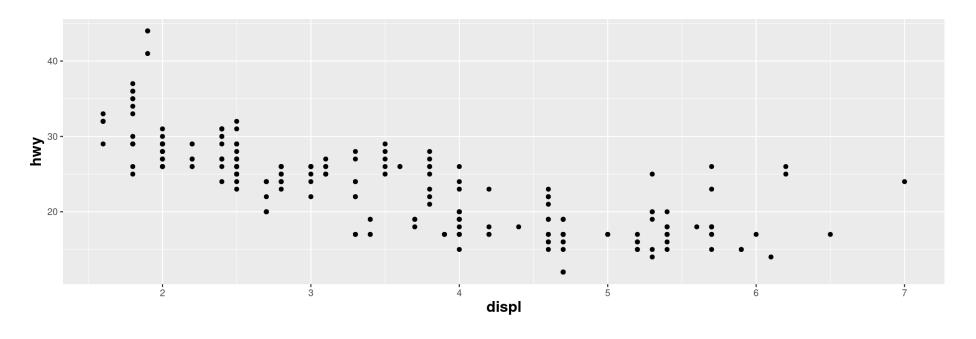
manufacturer <chr></chr>	model <chr></chr>		displ <dbl></dbl>	year <int></int>	cyl <int></int>
audi	a4		1.8	1999	4
audi	a4		1.8	1999	4
audi	a4		2.0	2008	4
audi	a4		2.0	2008	4
audi	a4	'	2.8	1999	6
audi	a4		2.8	1999	6
audi	a4	'	3.1	2008	6
audi	a4 quattro		1.8	1999	4
audi	a4 quattro		1.8	1999	4
audi	a4 quattro		2.0	2008	4





Creating a plot

```
1 ggplot(data = mpg) + # the dataset
2  aes(x = displ) + # the x position
3  aes(y = hwy) +
4  # the y position
5  geom_point() + # the point geometric shape
6  # Adjust axis titles' front size
7  theme(axis.title=element_text(size=14, face="bold"))
```







Declaring Data





Declaring data: method 1

```
1 ggplot(data = mpg)
```





Declaring data: method 2

• Pipe data into ggplot() using the pipe operator: %>%

```
1 mpg %>% # data piped into
    ggplot() # initiating plot
```





Exercises

- 1. Run ggplot(data = mpg). What do you see?
- 2. How many rows are in mpg? How many columns?
- 3. What does the drv variable describe? Read the help for ?mpg to find out.
- 4. Make a scatterplot of hwy vs cyl.
- 5. What happens if you make a scatterplot of class vs drv? Why is the plot not useful?





Aesthetic Mapping





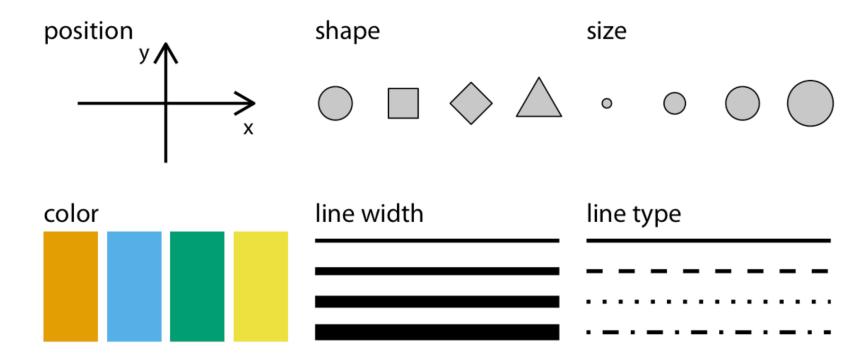
Aesthetic mappings

- An aesthetic is a visual property of the objects in your plot.
- Aesthetics include things like the *position*, *size*, the *shape*, or the *color* of your points.
- Mapping: variables are 'mapped' to (represented by) aesthetics.





A main pool of Aesthetics



A main pool of aesthetics

Note: This figure is from Wilke's Fundamentals of data Visualization.





aes() means 'Ask'

- aes(): What variables are we asking the aesthetic (color, position, shape, etc.) to represent?
- aes(color=gender): 'Please represent the variable gender for me using different colors.'





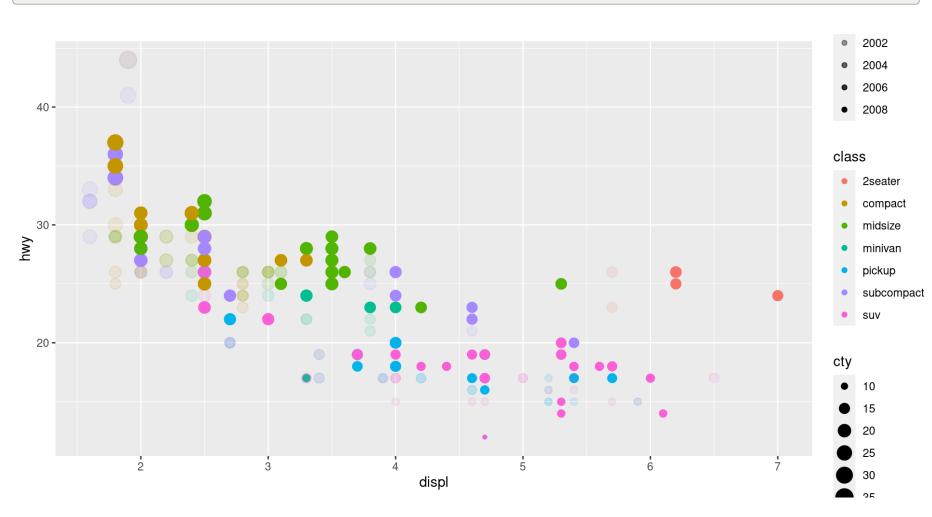
More aes mappings

```
1 mpg_plot= ggplot(data = mpg) + # the dataset
     aes(x = displ) + # the x position
     aes(y = hwy) + # the y position
     geom_point() +
     #the point geometric shape, the above aes are requied and
5
     #the below are optional
7
     #theme(axis.title=element_text(size=14, face="bold"))+
     aes(color = class) + # Color for type of car
8
9
     #aes(shape = class) +
     #ggplot2 will only use six shapes at a time. By default,
10
11
     #additional groups will go unplotted when using 'shape'.
     aes(size = cty) + # Size for city miles per gallon
12
     aes(alpha = year) # transparency for year of manufacture
13
```



Plot

1 print(mpg_plot)



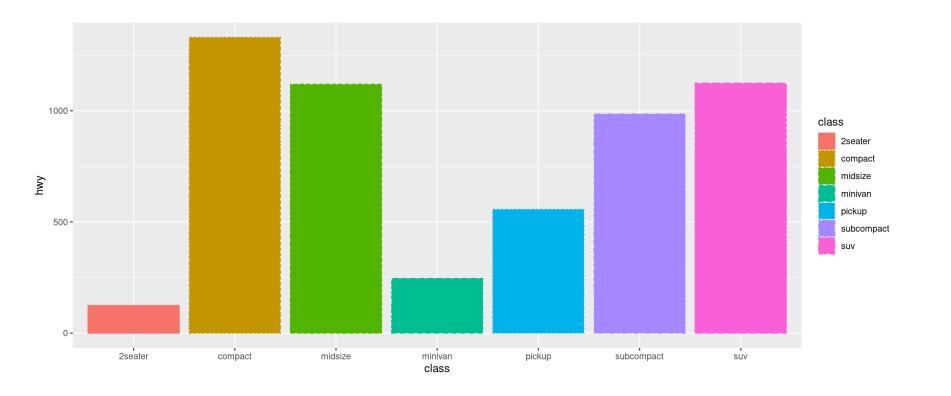






Other aes for other geometric objects

```
1 mpg %>% # data piped into
2    ggplot() + # initiating plot
3    aes(x = class) + #categorical variable
4    aes(y = hwy) +
5    geom_col() + #Use `geom_col` to creat a column geometry
6    aes(color = class) +
7    aes(fill = class) + # new aes 'fill'
8    aes(linetype = class) #new aes 'linetype'
```







Unmapped aesthetics

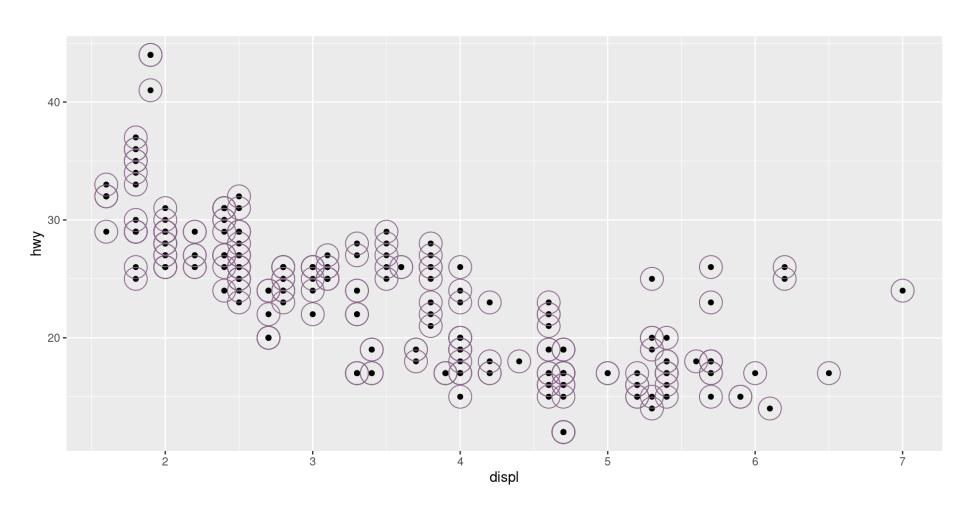
```
mpg_plot= ggplot(data = mpg) + # the dataset
    aes(x = displ) + # the x position
    aes(y = hwy) + # the y position
    geom_point() + # the point geometric shape
    #Another geom layer with aesthetics
    #that don't do representation
    geom_point(
        color="plum4",
        size=8,
        shape=21
    )
```





Plot

1 print(mpg_plot)







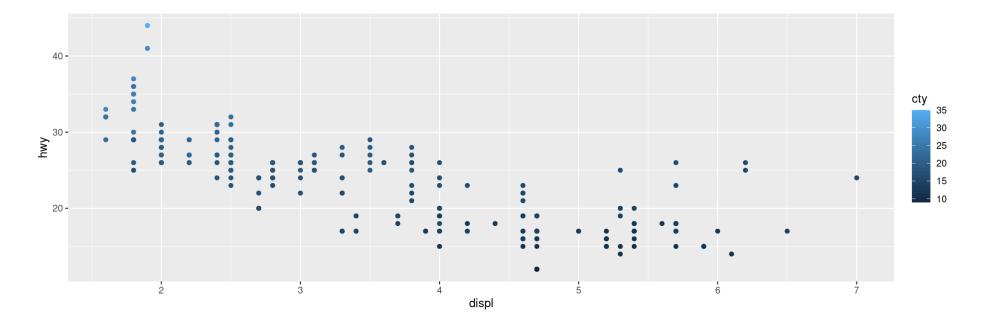
Exercises:

- 1. Look at the help for geom_text (?geom_text). What are the required aesthetics?
- 2. Which variables in mpgare 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?
- 3. Map a continuous variable to color, size, and shape. How do these aesthetics behave differently for categorical vs. continuous variables?





```
1 ggplot(data = mpg) + # the dataset
2 aes(x = displ) + # the x position
3 aes(y = hwy) +
4 aes(color = cty)+ #color, size and shape
5 # the y position
6 geom_point() # the point geometric shape
```











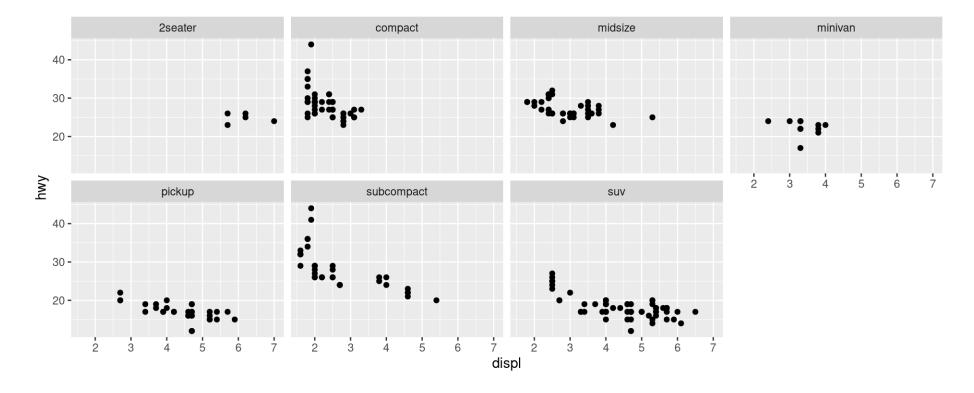




Facets: facet_wrap

• facet your plot by a single variable

```
1 ggplot(data = mpg) +
2   geom_point(mapping = aes(x = displ, y = hwy)) +
3   # ~ followed by a discrete variable
4   facet_wrap(~ class, nrow = 2)
```





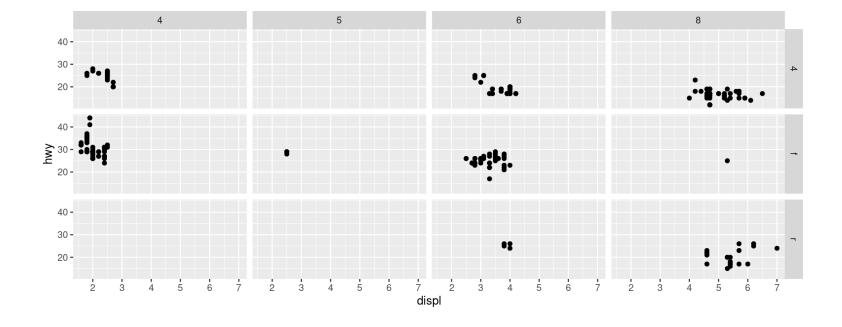


Facets: facet_grid

• facet your plot on the combination of two variables

```
ggplot(data = mpg) +
geom_point(mapping = aes(x = displ, y = hwy)) +
two variable names separated by a ~
facet_grid(drv ~ cyl)

#facet_grid(. ~ cyl) #not facet in the rows
#facet_grid(drv~.) #not facet in the rows
```







Geometric Object





A complete sentence of ggplot

- data + aes + geom
- plots
- Nouns: geometric objects
 - geom_point()
 - geom_col()
 - geom_line()
 - geom_text()
 - geom_segment()
 - geom_smooth()
 - geom_bar()
 - etc.
- The conditional mood: geom specific data and aesthetic mapping

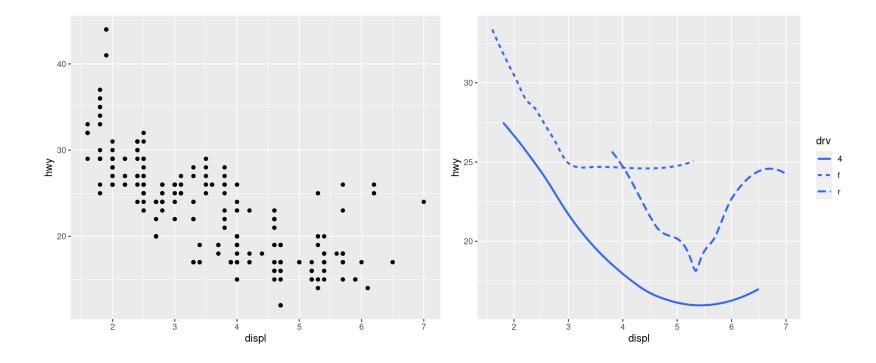




Different Geoms

Compare with

```
1 library(grid)
2 library(gridExtra)
3 p1=ggplot(data = mpg) +
    geom_point(mapping = aes(x = displ, y = hwy)) # geom_point
5 p2=ggplot(data = mpg) +
    geom\_smooth(mapping = aes(x = displ, y = hwy, linetype=drv), se=FALSE) # geom\_smooth
7 grid.arrange(p1, p2, ncol = 2)
```





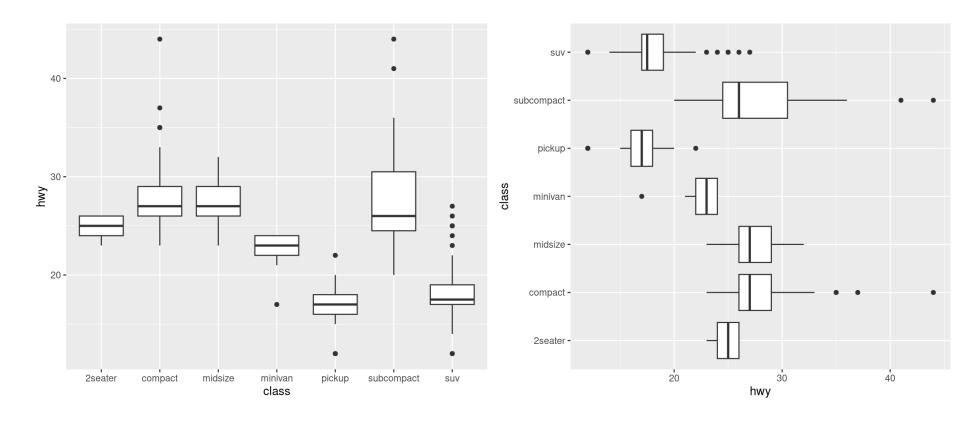




Another Example: boxplot

```
p1=ggplot(data = mpg, mapping = aes(x = class, y = hwy)) +
    geom_boxplot()

p2=ggplot(data = mpg, mapping = aes(x = class, y = hwy)) +
    geom_boxplot() +
    coord_flip() #switches the x and y axes
    grid.arrange(p1, p2, ncol = 2)
```





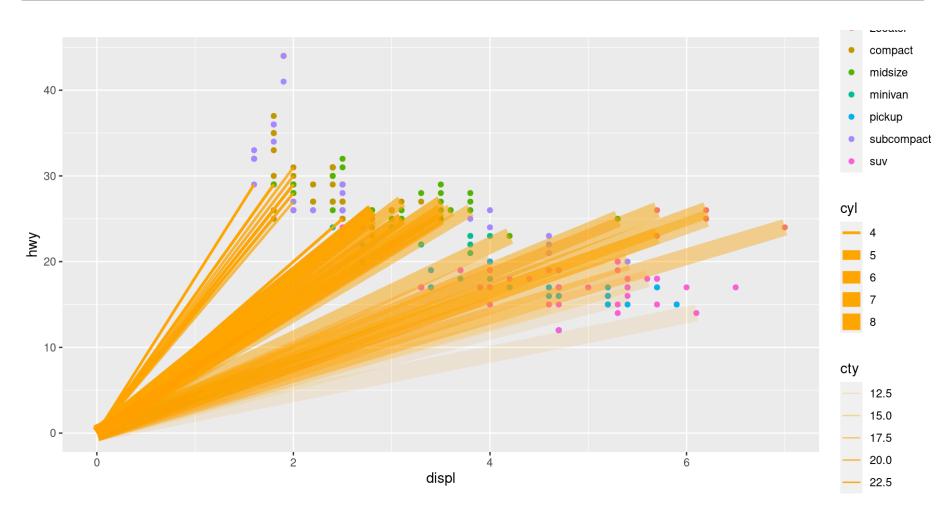


Going local with data and aesthetics

```
1 mpg_plot= ggplot(data = mpg) + # the dataset
     aes(x = displ, y = hwy) +
     geom_point() +
     aes(color = class) +
     #xend and yend are required for geom_segment
     #like creating a column with a single value
     aes(xend = 0) + aes(yend = 0) +
 7
     #geom_segment() draws a straight line
8
     #between points (x, y) and (xend, yend)
9
10
     geom_segment(
      #geom specific data, using 'sebset' to select data
11
      data = subset(mpg, fl=="p"),
12
      # geom specific (local) aesthetics
13
14
       aes(size = cyl, alpha = cty),
       color = "orange"
15
16
```







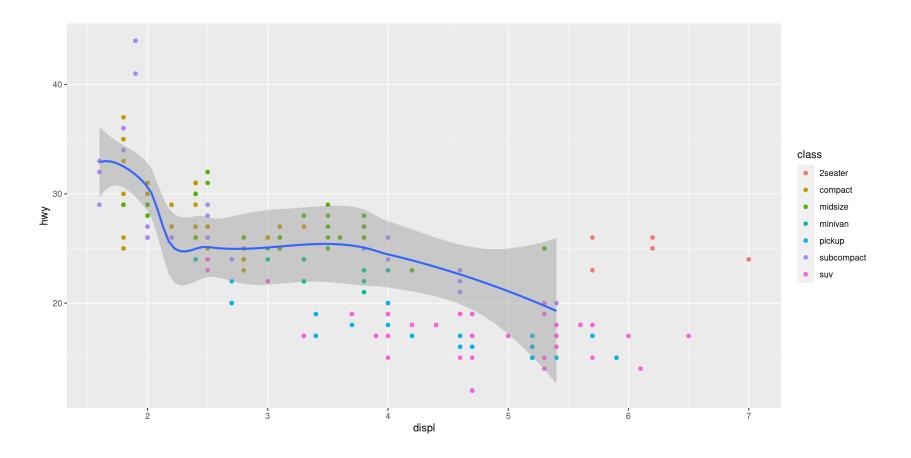






Another Example

```
ggplot(data = mpg, mapping = aes(x = displ, y = hwy)) + #global aes
geom_point(mapping = aes(color = class)) + #local aes
#local data and aes
geom_smooth(data = filter(mpg, class == "subcompact"),
se = TRUE) #se: standard error
```

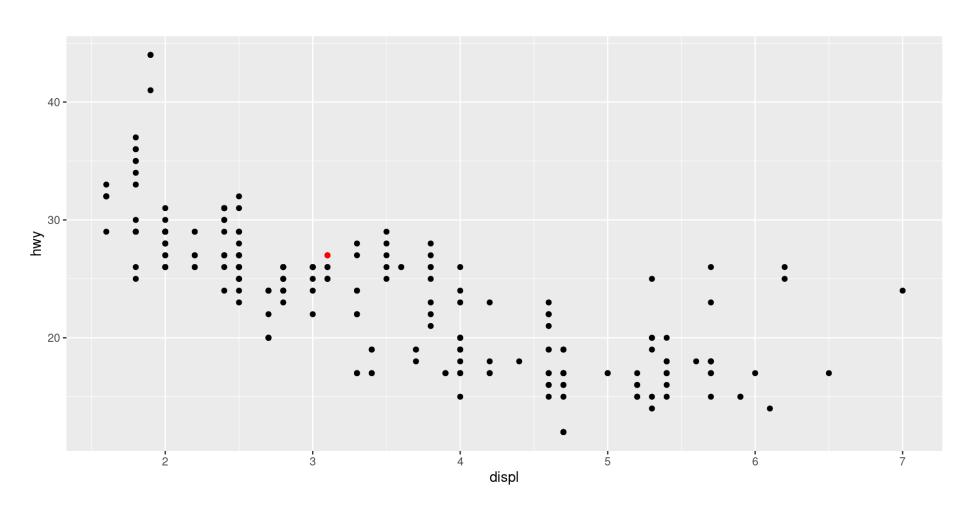














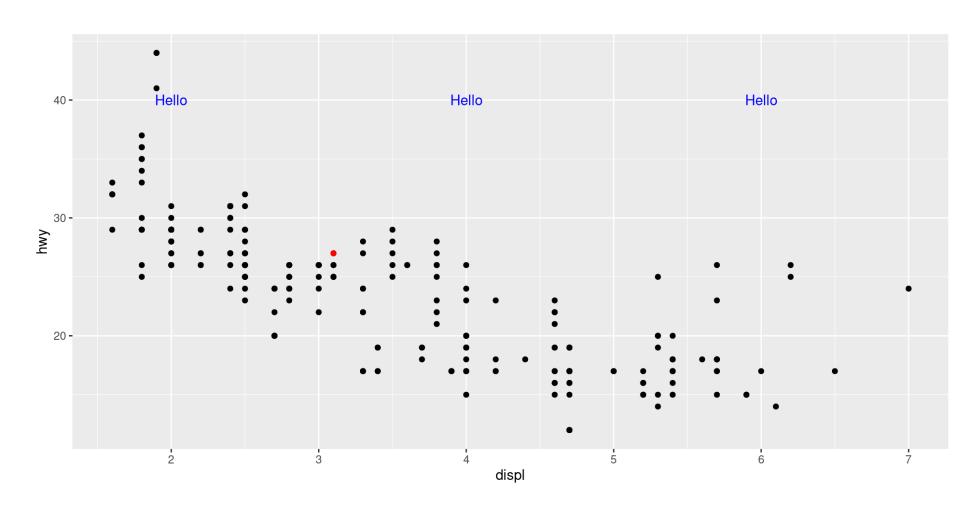




```
1 mpg_plot= ggplot(data = mpg) + # the dataset
     aes(x = displ) + # the x position
     aes(y = hwy) + # the y position
     geom_point() + # the point geometric shape
5
     annotate(geom="point",
6
              x=3.1,
 7
              y=27,
              color="red")+
8
9
     annotate(geom="text",
              x=c(2, 4, 6),
10
11
              y=40,
12
              label="Hello",
13
              color="blue")
```







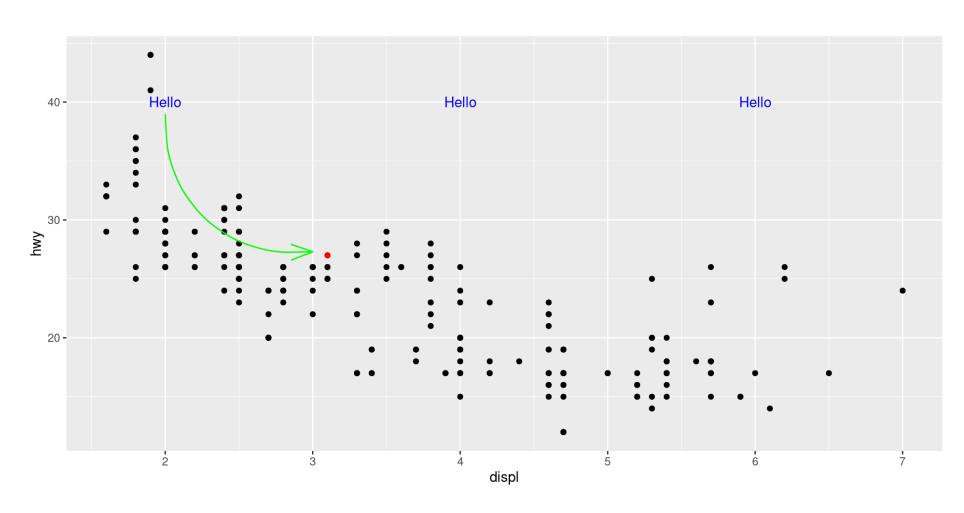




```
1 mpg_plot= ggplot(data = mpg) + # the dataset
     aes(x = displ) + # the x position
     aes(y = hwy) + # the y position
     geom_point() + # the point geometric shape
     annotate(geom="point",
5
6
              x=3.1,
 7
              y=27,
8
              color="red")+
9
     annotate(geom="text",
10
              x=c(2, 4, 6),
11
              y=40,
12
              label="Hello",
              color="blue")+
13
     annotate(geom="curve",
14
15
              x=2,
              y=39,
16
17
              xend=3,
18
              yend=27.3,
              color="green",
19
              arrow=arrow(angle=20))
20
```











• use geom_abline, geom_hline, and geom_vline

```
mpg_plot= ggplot(data = mpg) + # the dataset

aes(x = displ) + # the x position

aes(y = hwy) + # the y position

geom_point() + # the point geometric shape

geom_abline(slope=5, intercept=3) +

geom_hline(yintercept= 30,

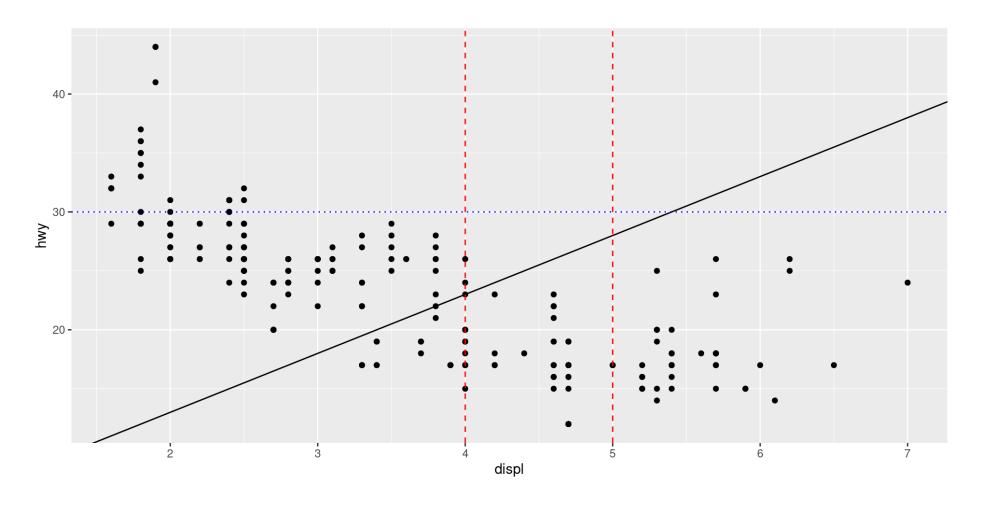
linetype="dotted", color="blue")+

geom_vline(xintercept=c(4,5),

linetype="dashed", color="red")
```











Exercises

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

2. What happens if you map an aesthetic to something other than a variable name, like aes(colour = displ < 5)? Note, you'll also need to specify x and y.





Interactive data visualisation (optional)

- R package: Shiny
- can host standalone apps on a webpage
 - Example: Life Expectancy using data from the
- can embed them in R Markdown documents or build dashboards.



