week5

October 29, 2017

1 Data Visualization

The effort to understand data by placing it in a visual context

2 Dr. Edward Tufte

- Though leader and practicioner of data visualization
- Written two excellent books on the subject:
  - The Visual Display of Quantitative Information
  - Envisioning Information
- Put down some principles for data visualization

3 Excellence in Visualization

- Clear, precise, and efficient communication of complex ideas
- Greatest number of ideas in the smallest amount of time and space
- Multivariate
- Conveys the truth

4 Visualization Goals

- Content focus
- Comparison rather than description
- Integrity
- High resolution
- Utilize designs proven with time

5 The Message

- Can use tables, charts, animations, inforgraphics ..etc
- Powerful if the right data and graphic are combined
- We will focus mostly on charts and tables, but know that **the possibilities are bigger**.
- To improve your visualization, read the work of **Stephen Few**:
  - Show Me the Numbers: Designing Tables and Graphs to Enlighten

  - Information Dashboard Design: Displaying Data for At-a-Glance Monitoring

6 The Visualization Tools - In Python

- Matplotlib
- Bokeh
- ggplot
- Seaborn
- Plotly
- Altair (We will use this)
- .. others

They vary in their simplicity and capabilities: static, interactive, animated ..etc.

7 Other Visualization Platforms

- R: ggplot2, ggvis, .. libraries much like python
- Tableau: The current defacto standard in data visualization for non-programmers
- SAS, SPSS, Excel, Matlab, Stata … etc.

8 The Message: Charts Vs. Tables

- Tables used to accuratly show the values of specific data points
  - Dataframes, frequency tables, balance sheets …etc
- Charts used to display patterns and comparisons
  - Histograms, box plots, scatter plots, bar plots ..etc

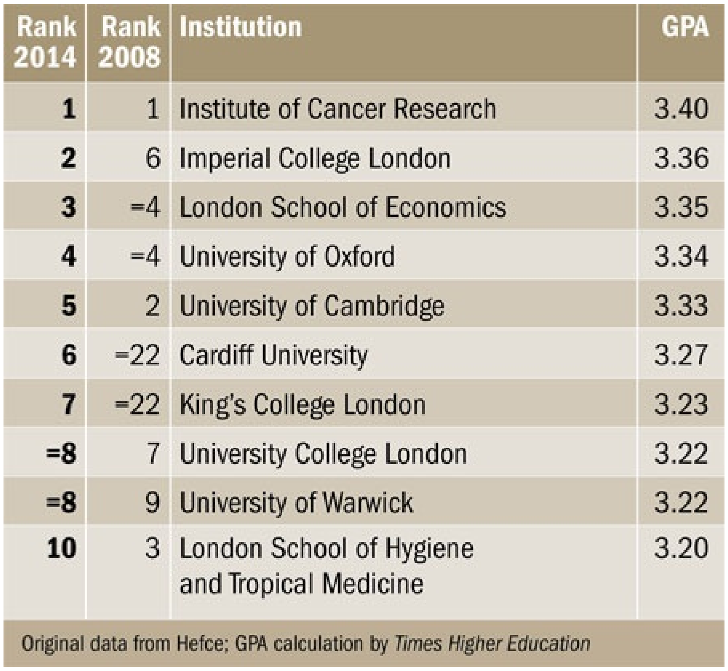
Source: Timer Higher Education

9 Message Types

- Time series: How values change with time
- Rankings: Categorical subdivisions ordered in ascending or descending order for comparison
- Part-to-whole: Categorical subdivisions to show ratio to the whole
- Deviation: Categorical subdivisions compared to reference (like mean or predicted values)

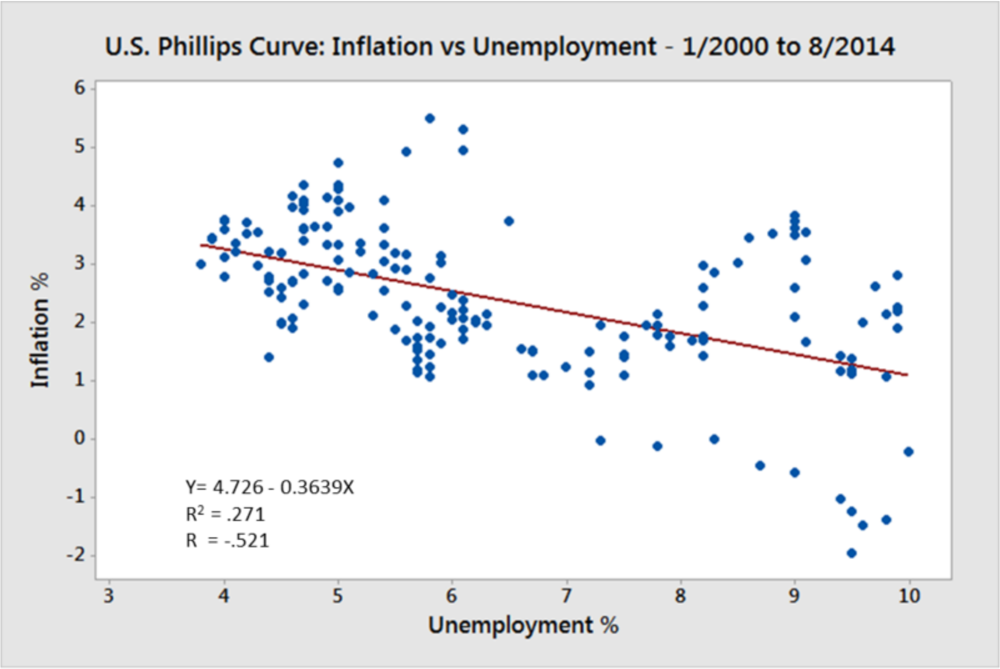
10 Message Types Cont.

- Frequency distributions
- Correlations: Comparison between two variables
- Nominal comparisons: Comparison of categorecal subdivisions without a particular order
- Geospatial: Comparison of data across map or layout



Rank 2014	Rank 2008	Institution	GPA
1	1	Institute of Cancer Research	3.40
2	6	Imperial College London	3.36
3	=4	London School of Economics	3.35
4	=4	University of Oxford	3.34
5	2	University of Cambridge	3.33
6	=22	Cardiff University	3.27
7	=22	King's College London	3.23
=8	7	University College London	3.22
=8	9	University of Warwick	3.22
10	3	London School of Hygiene and Tropical Medicine	3.20

Original data from Hefce; GPA calculation by *Times Higher Education*



Source Data: FRED Database
Inflation: CPI for All Urban Consumers

chart

11 The Right Chart for The Message

- See the chart selection matrix by Stephen Few
  - View also his presentation on improving charts
- See also selecting the right chart type by Andrew Abela

12 References and Resources

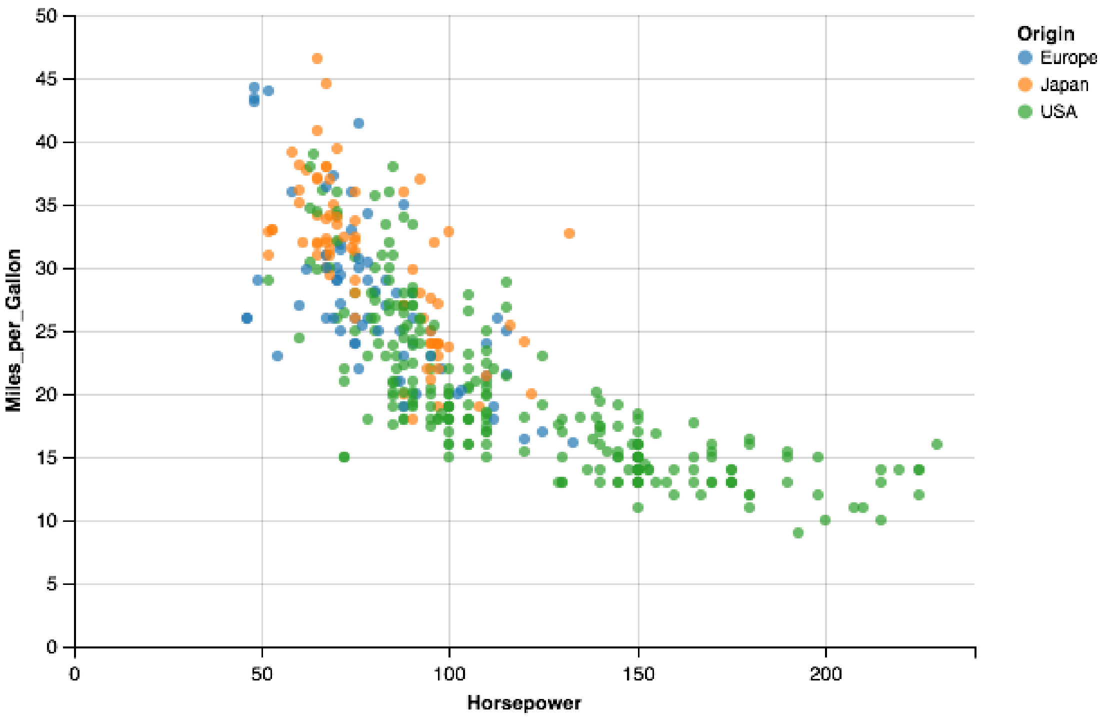
- Tufte, E. R. (2001). The visual display of quantitative information.
  - Chapter 1
- The Encyclopedia of Human-Computer Interaction
- Resources for 424 Info Vis. Course at University of Washington By. Prof. Maureen Stone and Prof. Polle Zellweger.
- Tableau public, try it for free

13 Visualization in Python

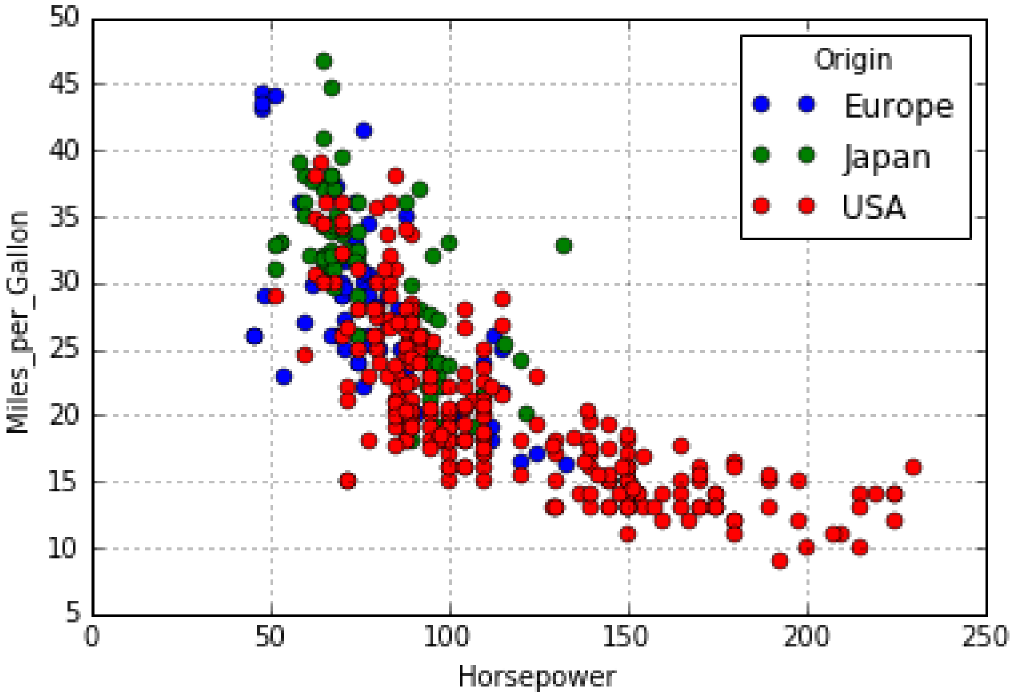
Install Altair
in cmd or terminal, type the following:

```
conda install altair --channel conda-forge
```

```
In [50]: # using altair
         import pandas as pd
         import altair as alt

         # you need a dataset
         cars_df = pd.read_json("https://github.com/vega/vega-datasets/raw/gh-pages

         # you can also load the sample data provided with altair using
         # cars_df = alt.load_dataset('cars')
         # for list of data sets, run the following command in jupyter:
         # alt.datasets.list_datasets()

         # Build the chart and configure it
         chart = alt.Chart(cars_df).mark_circle().encode(
             x='Horsepower',
             y='Miles_per_Gallon',
             color='Origin',
         )

         # display it
         chart
```



```
In [5]: # Same chart on matplotlib
        %matplotlib inline
        import matplotlib.pyplot as plt

        # use loop to plot each circle in a different color
        for (origin), group in cars_df.groupby('Origin'):
            plt.plot(group['Horsepower'], group['Miles_per_Gallon'],
                     'o', label=origin)

        # set the legend and labels
        plt.legend(title='Origin')
        plt.xlabel('Horsepower')
        plt.ylabel('Miles_per_Gallon');

        # enable grid
        plt.grid(True)
```



14 Altair uses a declarative syntax

- You express the logic of constructing the plot
- Matplotlib uses imperitave syntax where you give specific instructions to construct the plot
- Assumes that the data is in tidy form
  - Required reading: Tidy Data, by Hadley Wickham

15 The Syntax

```
Chart( data ).mark_type( options ).encode( channels )
   1     2        3         4        5        6

# alternatively you can reverse mark and encode
Chart( data ).encode( channels ).mark_type( options )

Chart( data ).mark_type( options ).encode( channels )
   1     2        3         4        5        6
```

15.0.1 1- Chart:

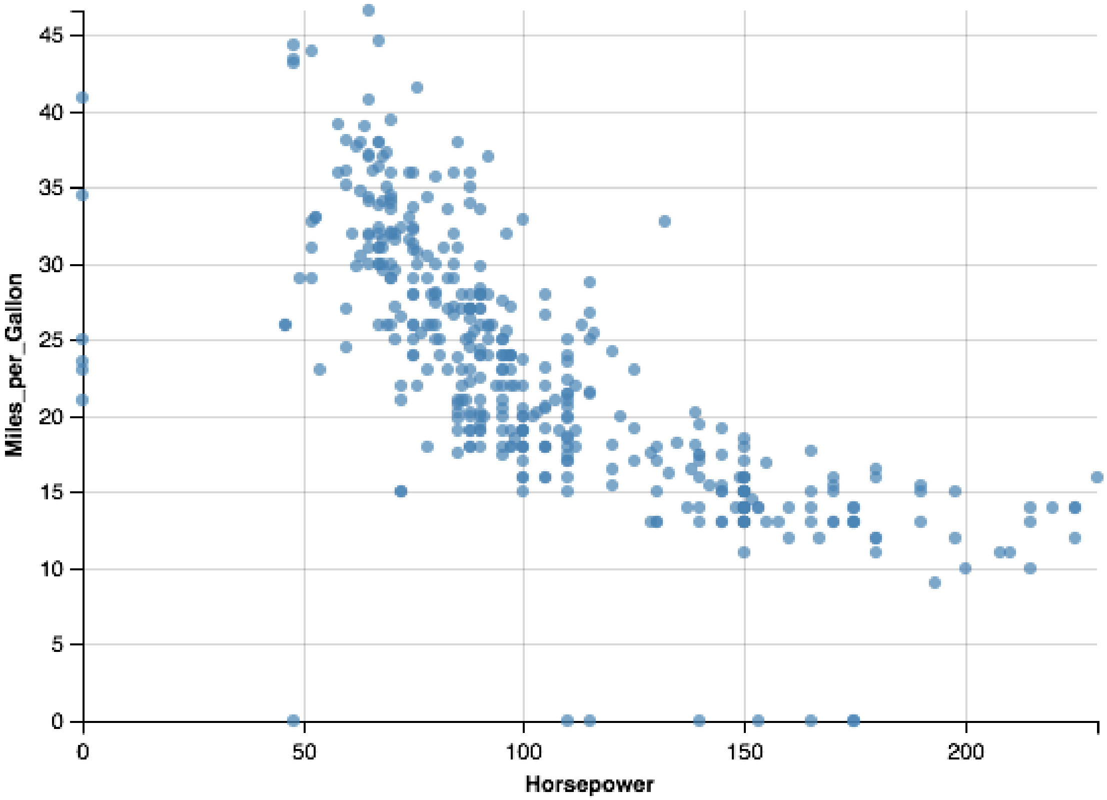
Construct a chart object (OOP), can be: - Chart: Used to display a single chart, our likely use case - LayeredChart: To place multiple charts on top of one another (When you want to be fancy)

```
Chart( data ).mark_type( options ).encode( channels )
   1      2          3          4          5          6
```

15.0.2 2- Data:

Tells Altair what data set to use for the plot, can be: - Pandas dataframe - Altair Data object - URL/filename of json or csv data - **Remember:** json must be list of dictionaries (called objects in javascript) - Use this to keep the size of the notebook small

```
In [44]: # url also works
         url = 'https://vega.github.io/vega-datasets/data/cars.json'

         alt.Chart(url).mark_circle().encode(
             x='Horsepower',
             y='Miles_per_Gallon',
             #color="Origin", # bug, does not work with url
         )
```

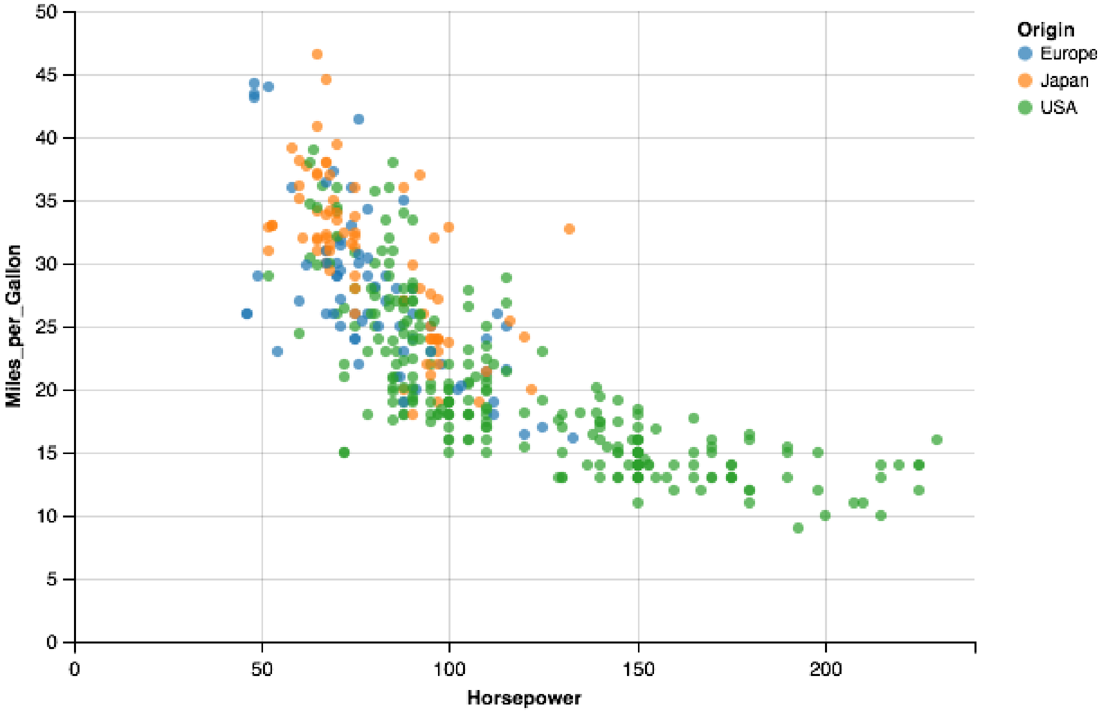


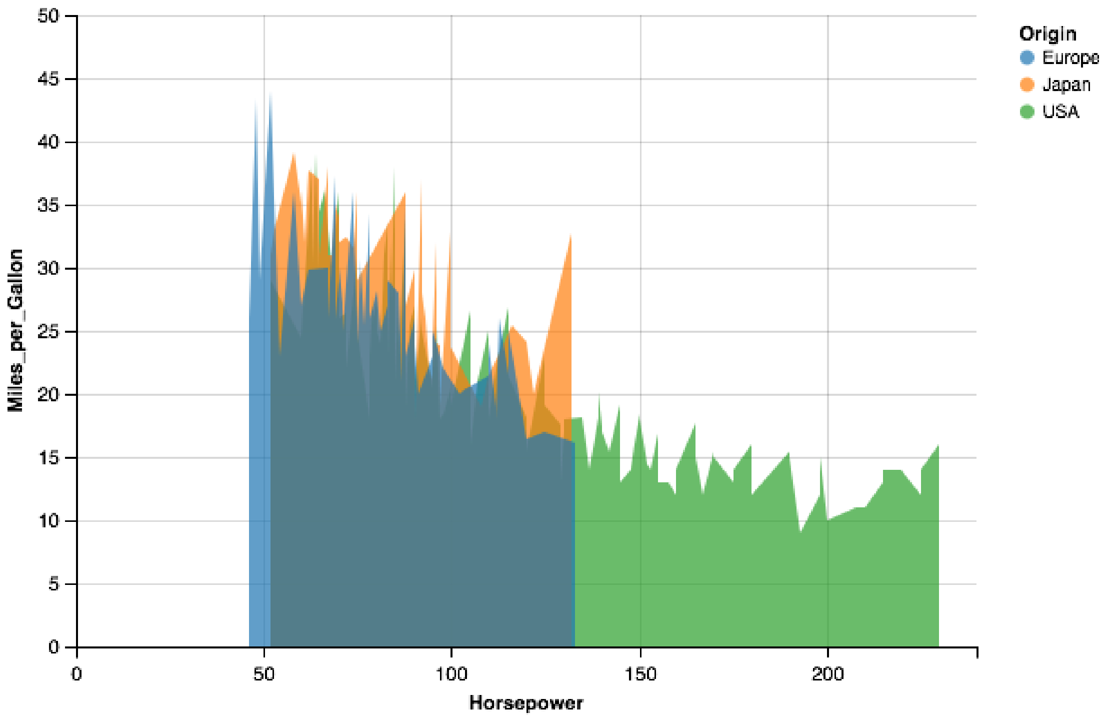
```
Chart( data ).mark_type( options ).encode( channels )
   1      2          3          4          5          6
```

15.0.3 3- Marks:

Tells Altair how to represent values on the chart, includes: - mark_line(), mark_area(), mark_round(), mark_bar() - Can be configured with mark_options - Unlike pandas, these will mutate the original chart - Complete list available here

```
In [51]: # we can use this command to display multiple charts from a single cell
         chart.display()

         # let's modify our chart
         chart.mark_area() # this mutated chart

         # try other mark_* types
         chart.display() # this will show the mutated plot
```





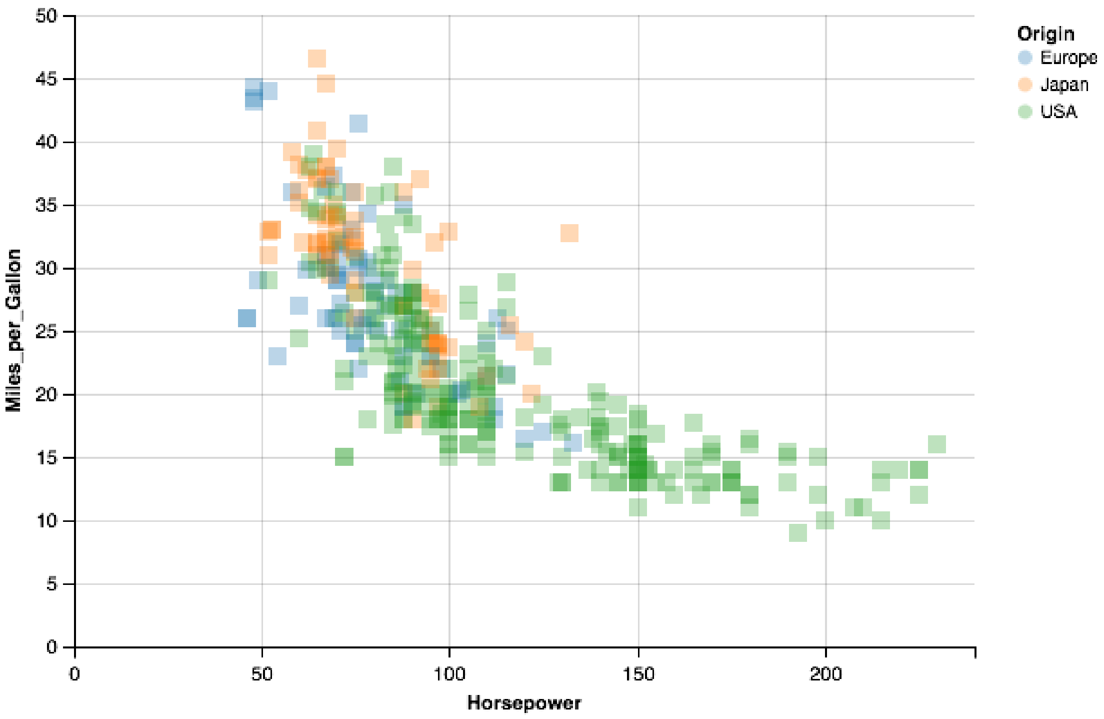
```
Chart( data ).mark_type( options ).encode( channels )
   1      2          3          4          5          6
```

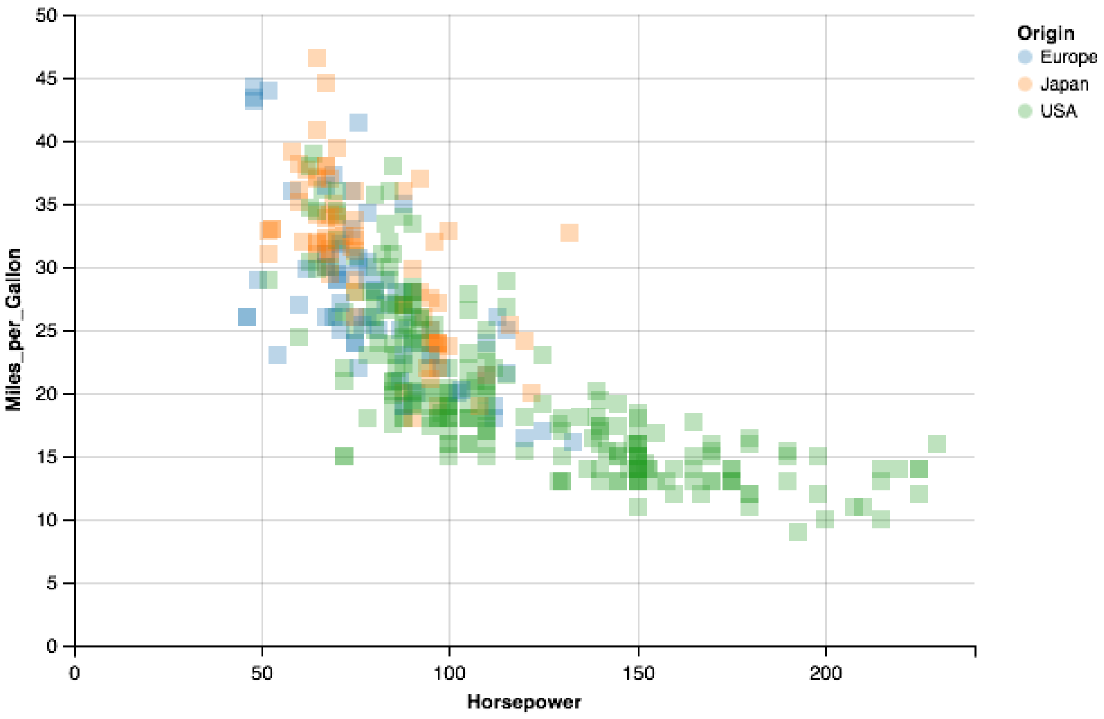
15.0.4 4- Mark options:

- Options to change the properties of **all** marks
- Options passed as arguments and can be found here, e.g.:

```
alt.Chart(url).mark_circle(
color='red',
opacity=0.3
)
```

```
In [46]: # These are options that affect all the points
         chart.mark_square(opacity=0.3, size=100)
```


Miles_per_Gallon
50
45
40
35
30
25
20
15
10
5
0
0
50
100
150
200
Horsepower
Origin
● Europe
● Japan
● USA


Miles_per_Gallon
50
45
40
35
30
25
20
15
10
5
0
0
50
100
150
200
Horsepower
Origin
● Europe
● Japan
● USA

```
Chart( data ).mark_type( options ).encode( channels )
   1     2        3         4        5        6
```

15.0.5 5- Encode:

- Must be there, tells altair how to plot the values

```
Chart( data ).mark_type( options ).encode( channels )
   1     2        3         4        5        6
```

15.0.6 6- Encoding Channels

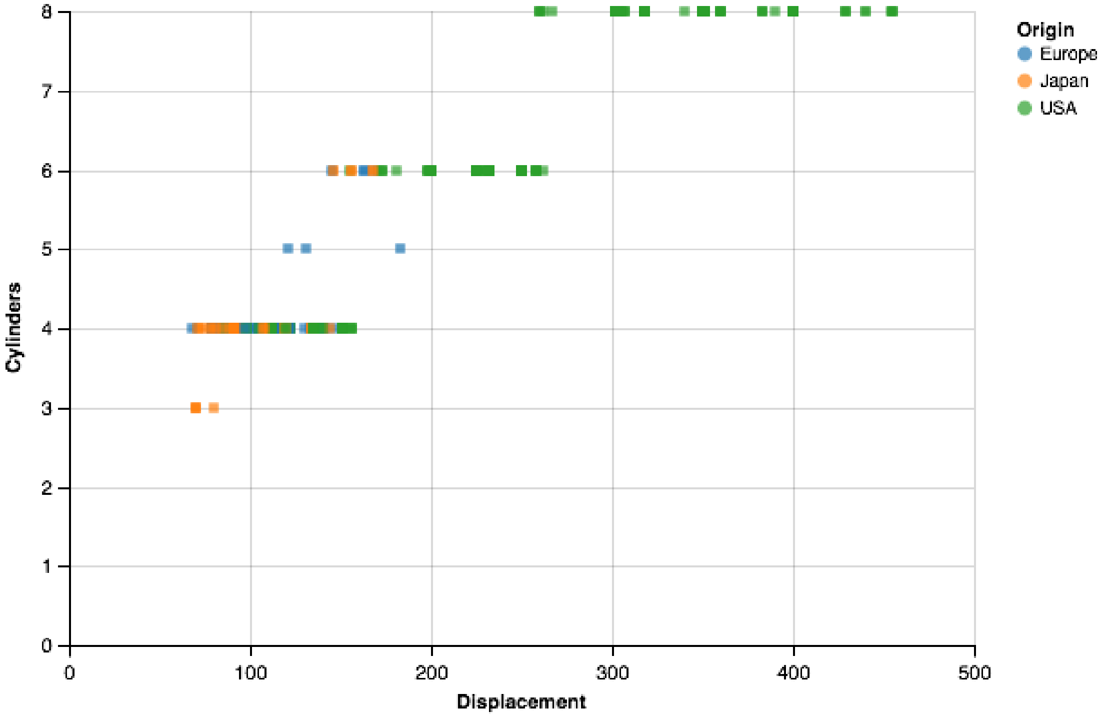
These are the options to tell altair how to: - Link data to axis - Plot the data - Group/transform the data

These options are referred to as **Channels**

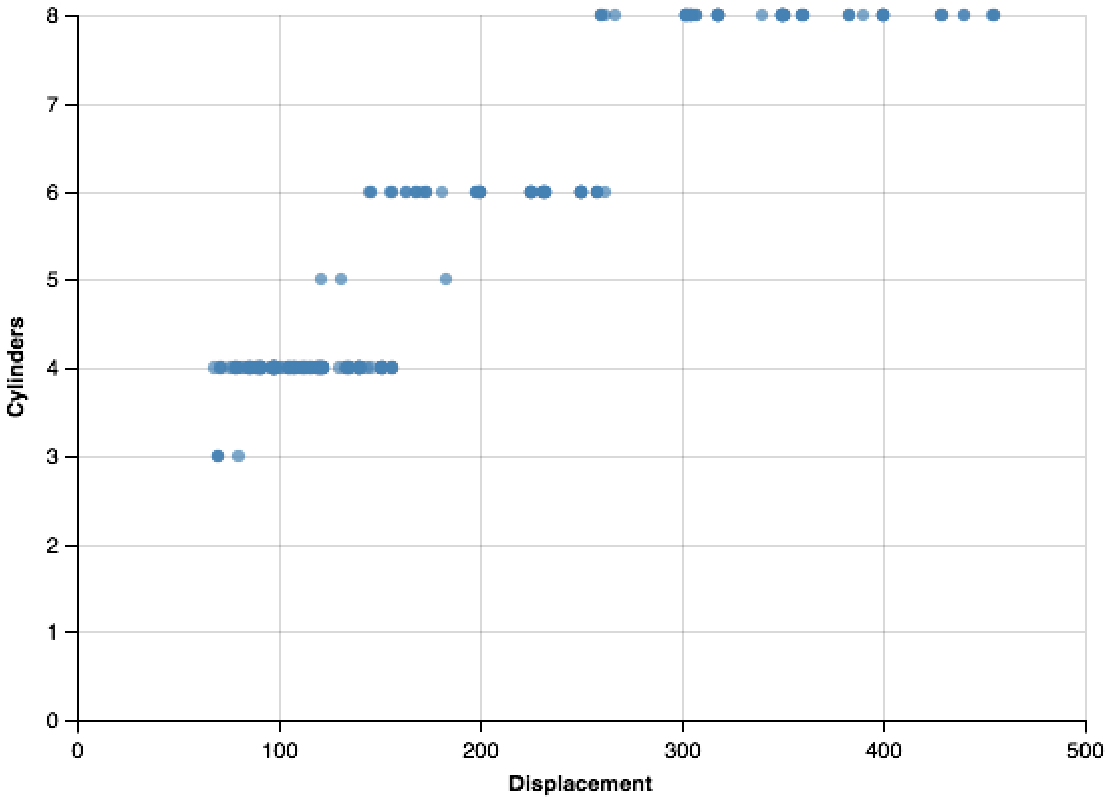
16 Most important channel configurations:

- x: Name of column to map to x axis (as a string)
- y: Name of column to map to x axis (as a string)

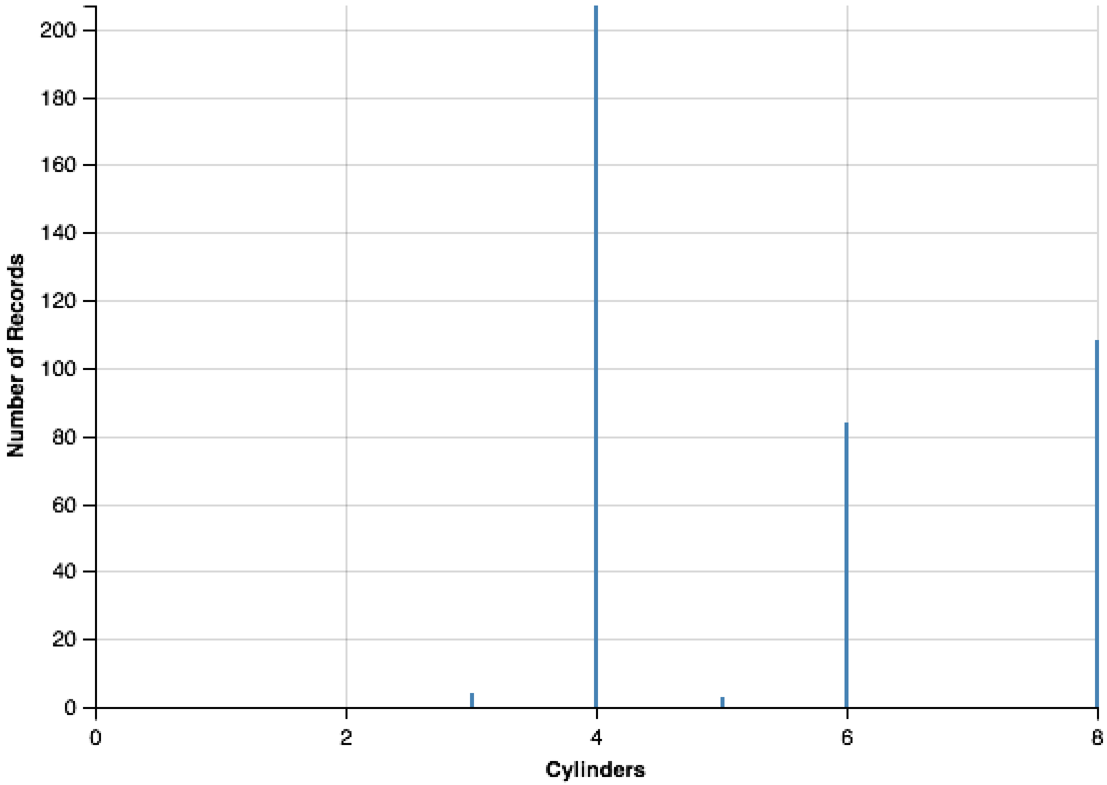
```
In [56]: # plot Displacement vs Cylinders
         chart.encode(x="Displacement", y="Cylinders")

         # notice how previous options remain if not changed (like color)
```



```
In [58]: # it's better to create a new chart object for new charts
         # so that it is not affected by previous changes

         alt.Chart(cars_df).mark_circle().encode(x="Displacement", y="Cylinders")

         # Notice how values are no longer colored
```



```
In [82]: alt.Chart(cars_df).mark_bar().encode(
             x="Cylinders",
             y="count(*)",)
```



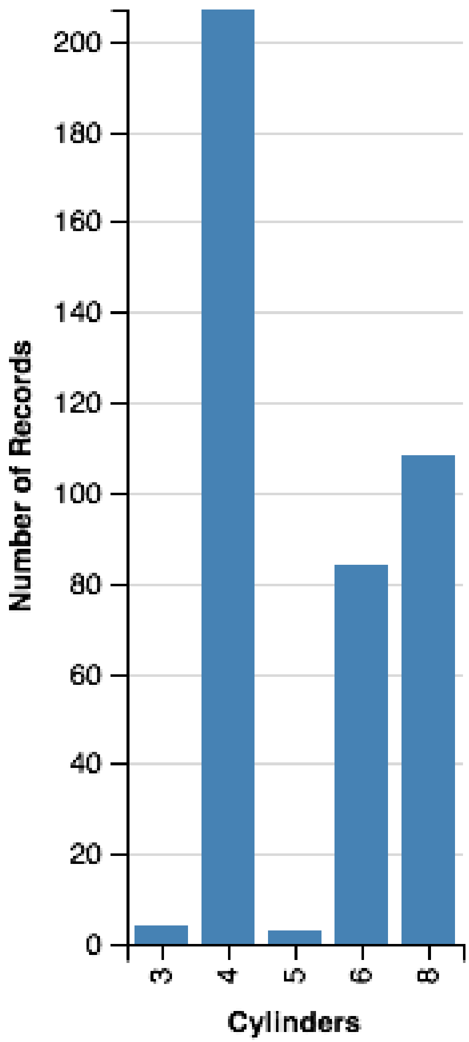
17 Aggregation Function in Altair

You can use the following functions to describe the aggregation for the axes values in the following format: `'aggregation(variable)'`

Use * in place of variable to mean **for any row/observation**

The functions include: sum, mean, media, variance, stdev, distinct .. and more

```
In [83]: #
         alt.Chart(cars_df).mark_bar().encode(
             x="Cylinders:N",
             y="count(*)",)
```

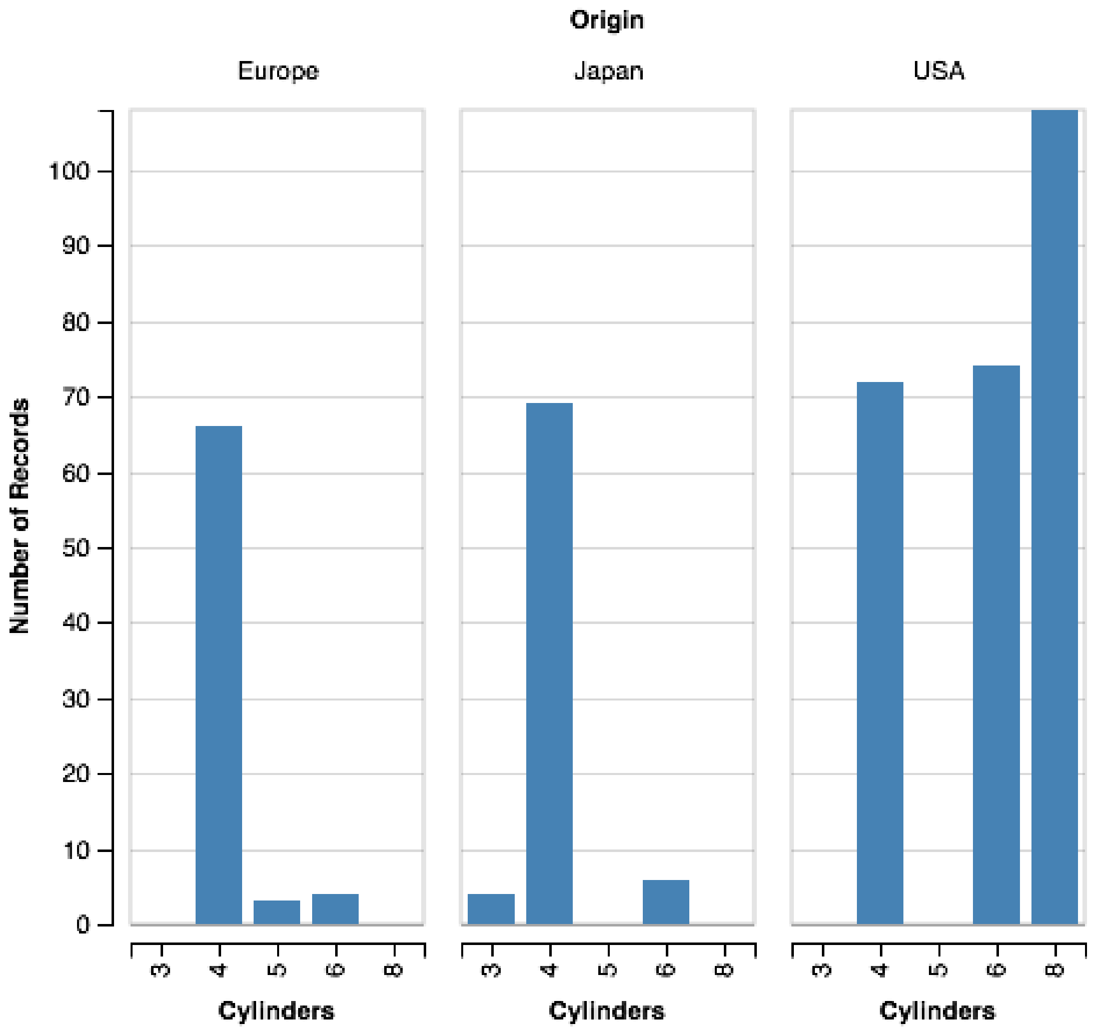


18 Column names can describe the datatype

- using : and a letter after the name to describe the type.
- For example: `'sales:Q'` tells Altair that the sales column is a quantitative value.
- Letter can be:

Data Type	Letter	Description
quantitative	Q	a continuous real-valued quantity
ordinal	O	a discrete ordered quantity
nominal	N	a discrete unordered category
temporal	T	a time or date value

```
In [84]: # you can use column or row to split the graphs based on group
         # this is called a trellis plot

         alt.Chart(cars_df).mark_bar().encode(
             column="Origin",
             x="Cylinders:N",
             y="count(*)",)
```

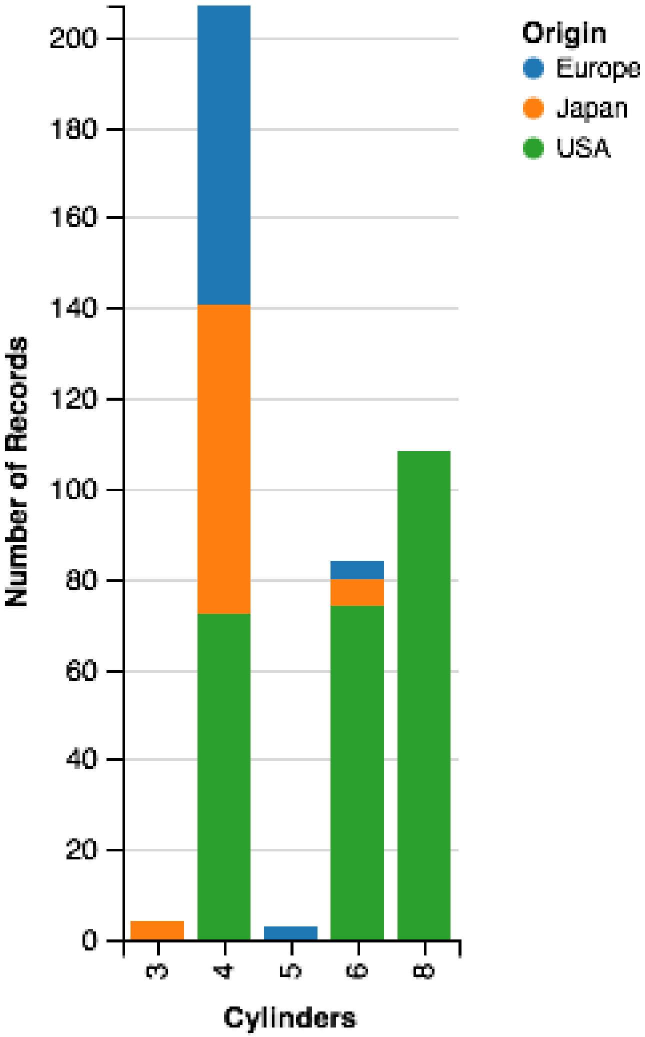


19 Channels With Legends

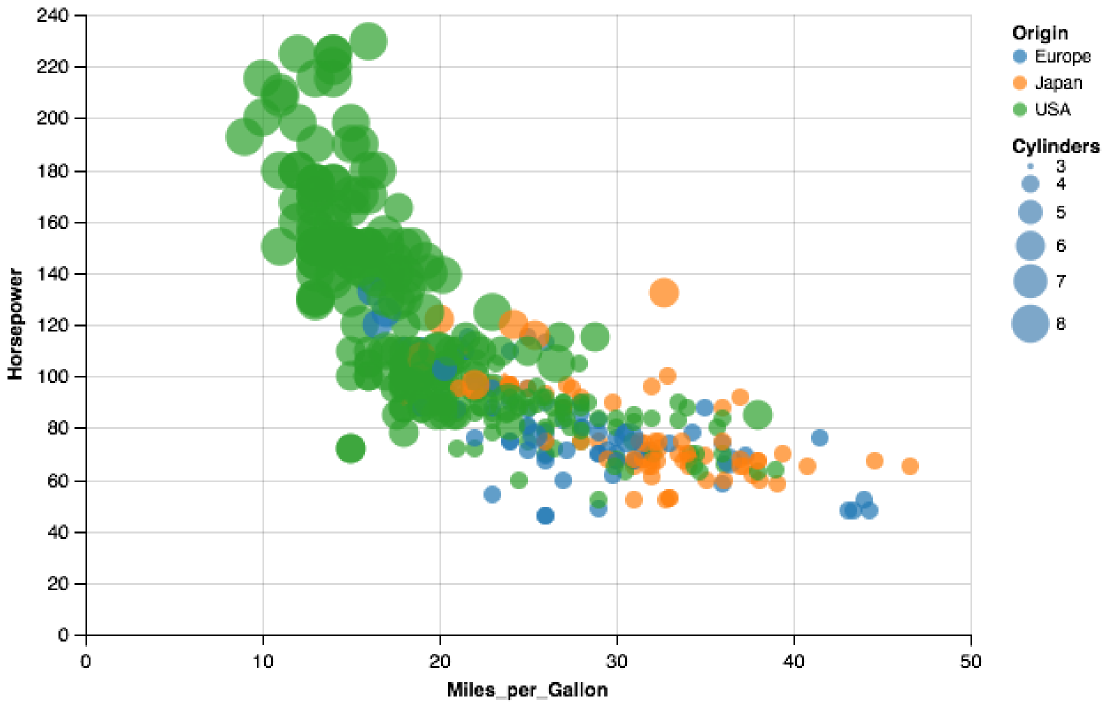
- These are the channels that produce a legend on the graph.
- Used typically with a categorical grouping variable
- These channel configurations affect individual points on the plot based on its value
  - Remember, configuring a mark will affect all points on the plot

- The channels include: color, opacity, size, and shape

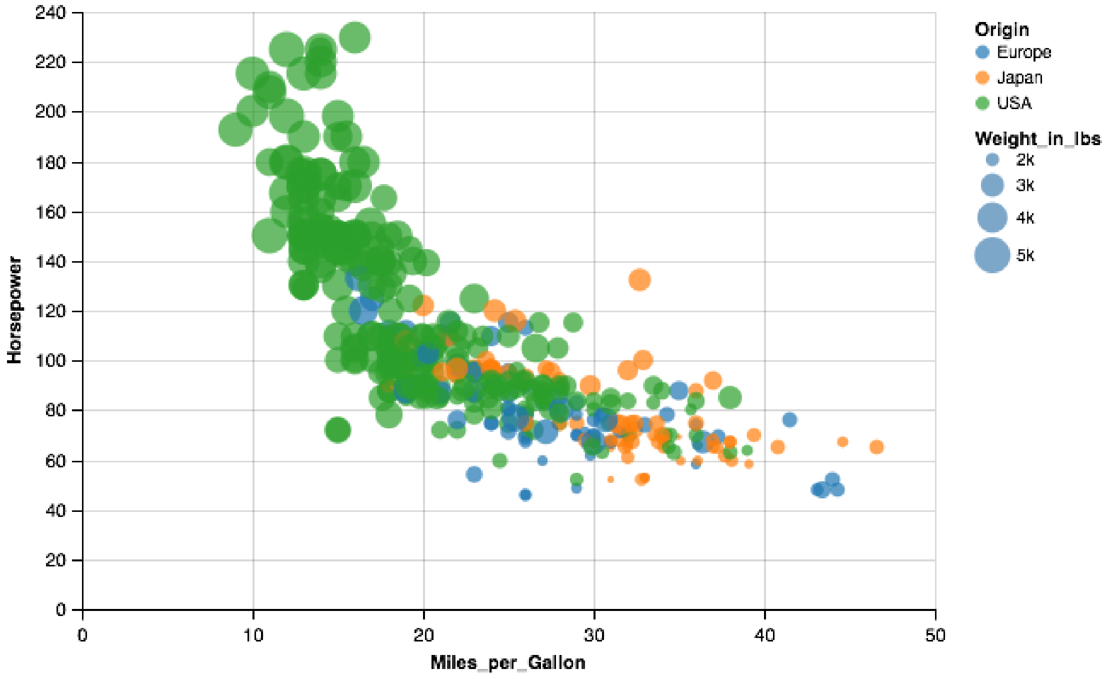
```
In [19]: alt.Chart(cars_df).mark_bar().encode(
             color="Origin",
             x="Cylinders:N",
             y="count(*)",)
```



```
In [28]: alt.Chart(cars_df).mark_circle().encode(
             color="Origin",
             size="Cylinders",
             x="Miles_per_Gallon",
             y="Horsepower",)
```



```
In [29]: alt.Chart(cars_df).mark_circle().encode(
             color="Origin",
             size="Weight_in_lbs",
             x="Miles_per_Gallon",
             y="Horsepower",)
```



20 Notes on Altair

- Data is included with plot, the more plots in the notebook, the greater its size in MB
- Maximum data points are 5000 to miaintain performance, can be increased to 10000 using `cart.max_rows = 10000`
- Use chart_display() to display multiple charts from a single cell
- Unlike jupyter, performing methods on chart object will mutate it