Effective data visualization using python

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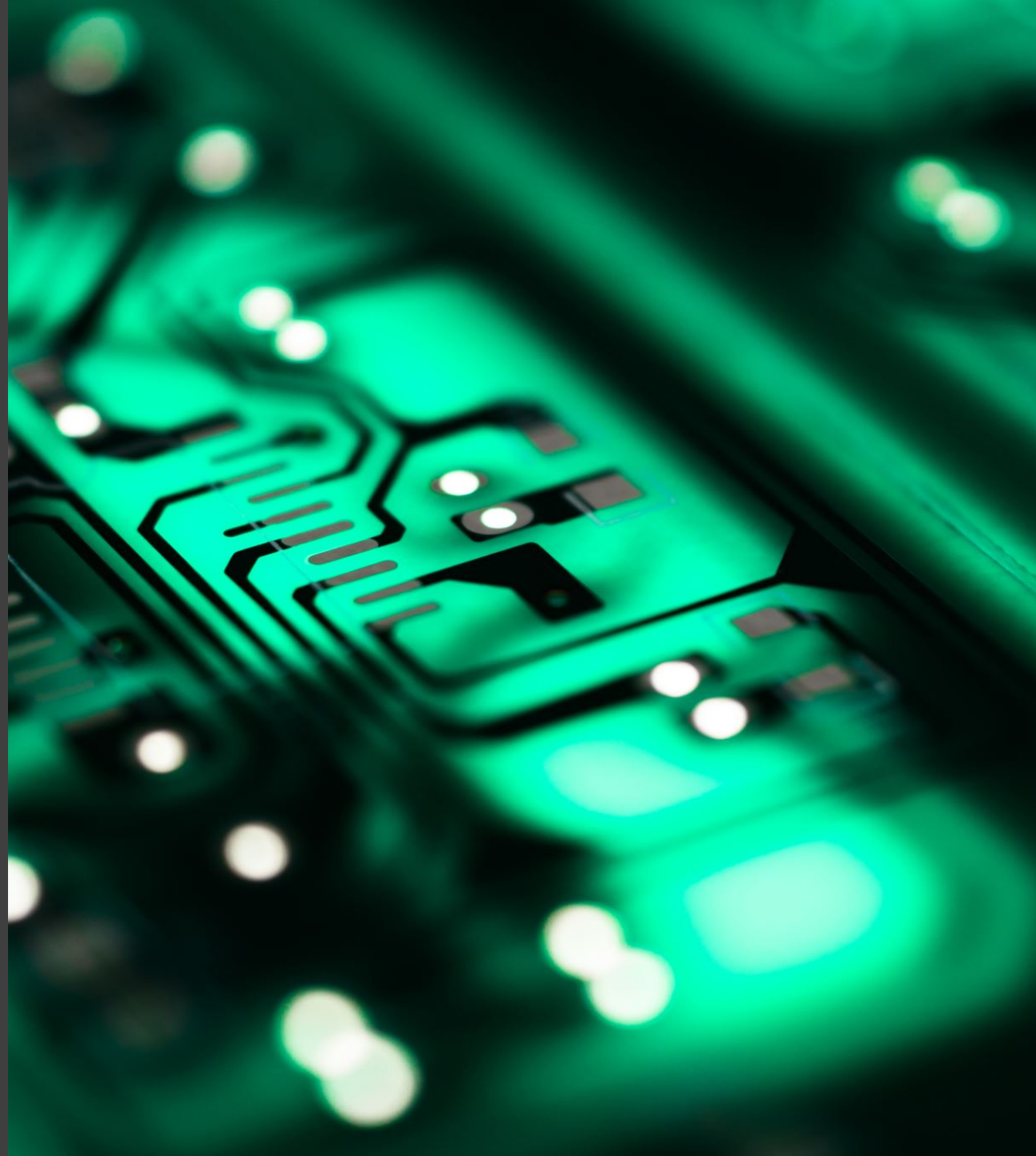


Learning objectives

- By the end of this module you should be able to:
  - Visually displayed data in real time
  - Understand the strengths and weaknesses of different visualizations techniques
  - Create various type of plots
  - Use seaborn and matplotlib to make elements of plots easier to read and understand

Why is data visualization a critical skill?

We are drowning in information, but starving for knowledge (John Naisbitt)

Creating data visualizations requires more than computational skills

Why are figures important?

Visualizations stand out

- First things you notice

A picture tells a thousand words

- Cliché but true

They are more spreadable

- An image can go viral, a passage likely won’t

They are multi-purpose

- Can be used in papers, posters, talks, etc.

What is the goal of data visualization?

Make your result clear

The main point of the visualization is, ideally, gathered at first glance

Retain focus

If a figure is too busy, the impact can be lost

Don’t fool your audience

Visualization should show what is in the data

Be transparent

Make sure labels and titles are descriptive and not ambiguous

More on the use of figures

- Object of this module is to learn how to make visuals
- If you would like to explore more about how to effectively use visuals
  - https://cs.stanford.edu/~marinka/slides/marinka-figures19.pdf
  - These slides by Marinka Zitnik have some very useful information

GUI-based visualization*

Pros

- Fast and easy to use
- Many powerful adjustments and calculations can be made without underlying knowledge

Cons

- Many powerful adjustments and calculations can be made without underlying knowledge
- Not reproducible, all adjustments are made by hand

*Excel, Prism, etc.

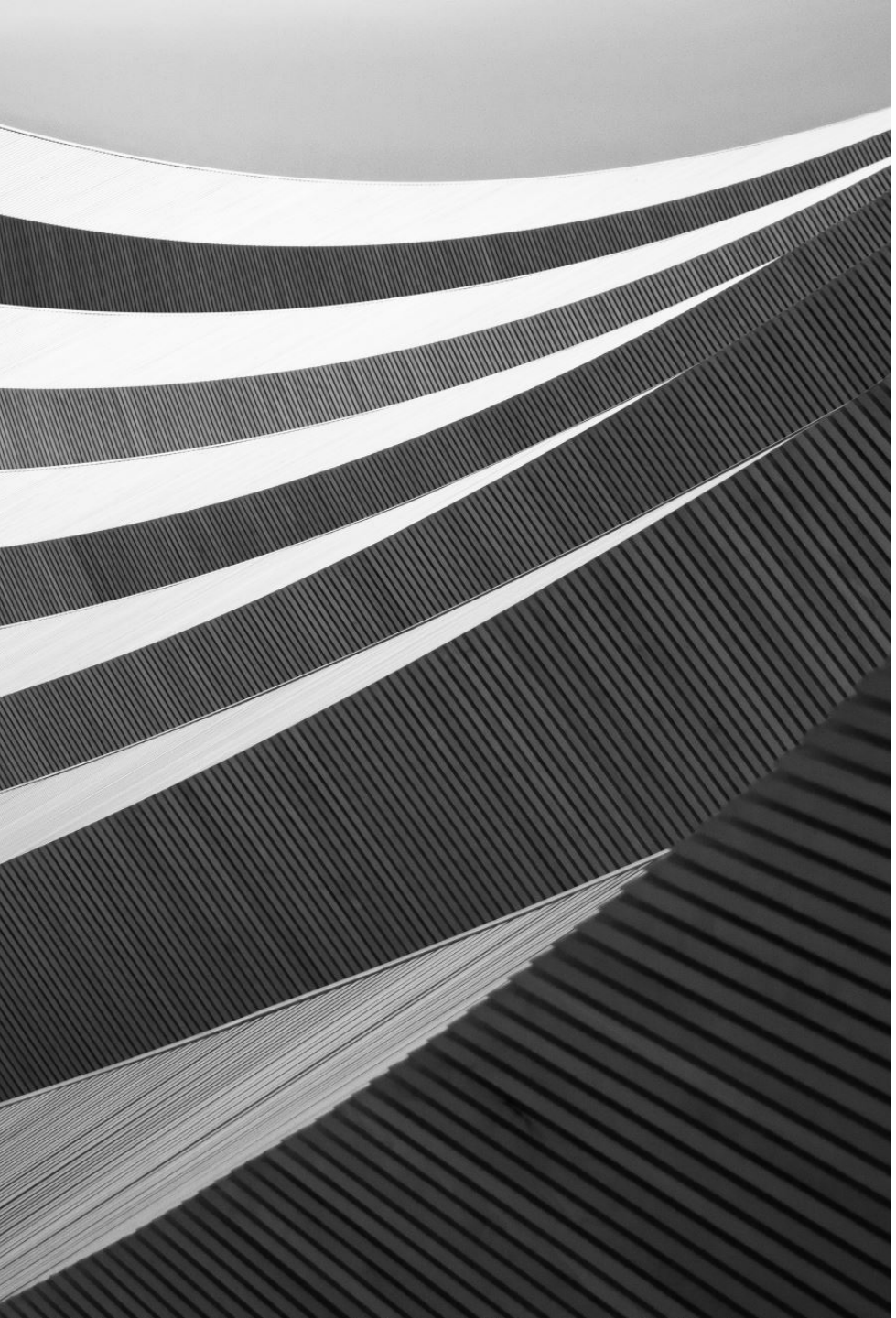
Code-based visualization

Pros

- Easy to share(more on this in later modules)
- Can be combined with data manipulation and cleaning
- Very transparent and reproducible
- Scalable

Cons

- Higher barrier of entry
- Less intuitive



Python Libraries for visualization

Matplotlib

Includes the basic functions and objects for creating plots

Many of the functions relate to the axis and figure objects

Has built-in visualization functions. These can be used, but seaborn tends to looks nicer (a subjective measure)

Seaborn

Builds on top of the matplotlib objects

Includes high level interfaces for creating visualizations

Seaborn example datasets

- Seaborn has example datasets available online
- These can be accessed with

```
seaborn.load_dataset(<dataset_name>)
```

Import seaborn

```
import seaborn as sns
```

Let’s practise

```
categorical_data = sns.load_dataset('tips')
```

We will use the “tips” dataset for the first examples in these slides

```
categorical_data = sns.load_dataset('tips')
categorical_data.head()
```

	total_bill	tip	sex	smoker	day	time	size
0	16.99	1.01	Female	No	Sun	Dinner	2
1	10.34	1.66	Male	No	Sun	Dinner	3
2	21.01	3.50	Male	No	Sun	Dinner	3
3	23.68	3.31	Male	No	Sun	Dinner	2
4	24.59	3.61	Female	No	Sun	Dinner	4

Seaborn Visualizations

Categorical Plots

- Bar plots
- Box plots
- Strip plots
- Violin plots
- Swarm plots
- Boxen plots
- Point plots
- Count plots

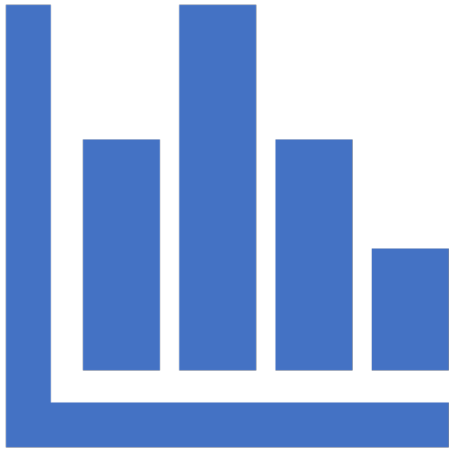
Relational plots

- Line plots
- Scatter plots

Matrix Plots

- Heatmaps
- Clustermaps

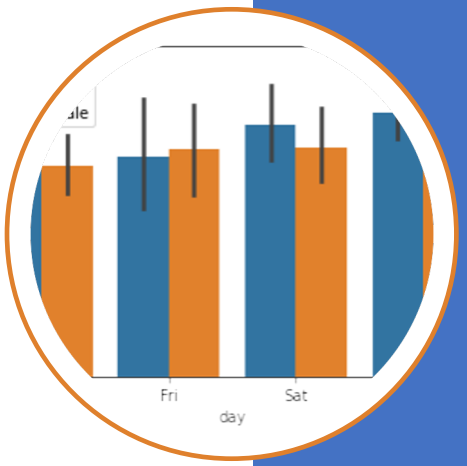
Categorical plots



- Plots where we have a categorical variable (e.g. color, time, tissue site) and a numerical variable or measurement
  - Typically aim to compare one measurement across many categories
- Many different ways to plot

Bar plots

- Useful for displaying percentages
  - Preferred over pie charts
- Can also be used to compare means or medians
- Does not convey distribution nor sample size



Draw bar plots grouped by a categorical variable

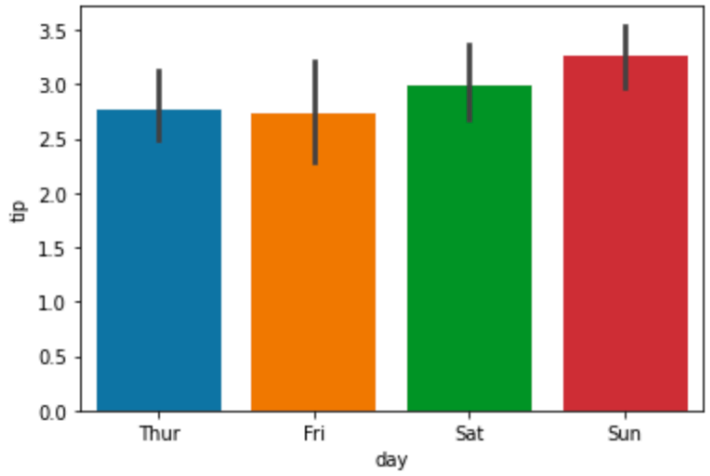
```
sns.barplot(data=categorical_data, x='day', y='tip')
```

Name of the data frame

Column names

```
sns.barplot(data=categorical_data, x='day', y='tip')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f5bca0a0048>
```



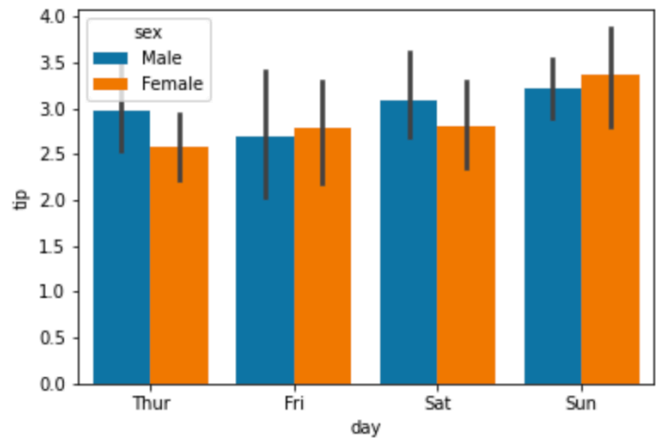
Bar plot with nested grouping by a two variable

```
sns.barplot(data=categorical_data, x='day', y='tip',hue='sex')
```

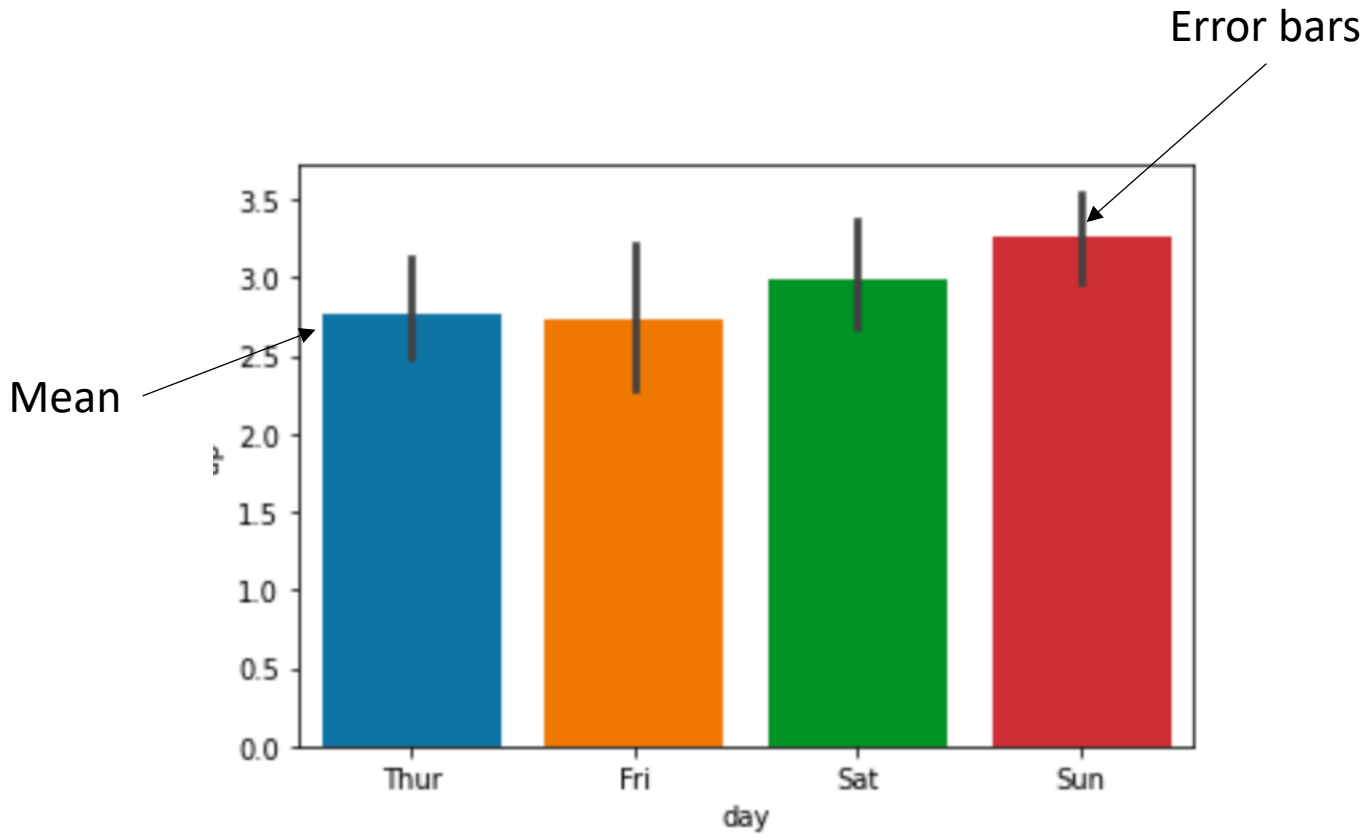
Split each bar into two based on this variable

```
sns.barplot(data=categorical_data, x='day', y='tip',hue='sex')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f5bc9b4de80>
```



Parameters of bar plot



Median instead of mean

```
sns.barplot(x='day', y='tip', data=categorical_data, estimator=np.median)
```

NumPy library

Median

NumPy

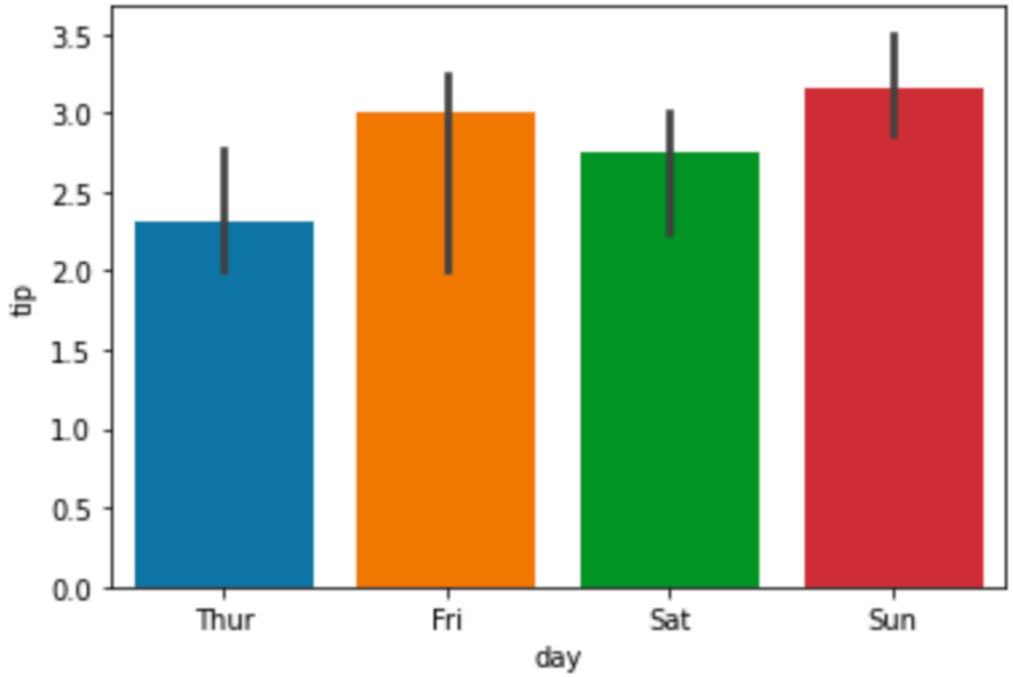
```
import numpy as np
```

library for the Python programming language, adding support for large, multi-dimensional arrays and matrices, along with a large collection of high-level mathematical functions to operate on these arrays.

Let’s practice

```
import numpy as np
sns.barplot(x='day', y='tip', data=categorical_data, estimator=np.median)
```

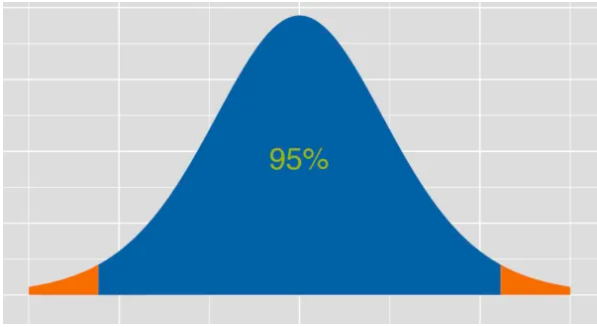
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06ca11dd68>
```



Error bars

- Default confidence interval for error bars is 95%
  - Can be changed with ci parameter
  - This is calculated using bootstrapping
  - Bootstrapping resamples from the sample with replacement 1000 times to generate the variance of the estimator

Change confidence interval



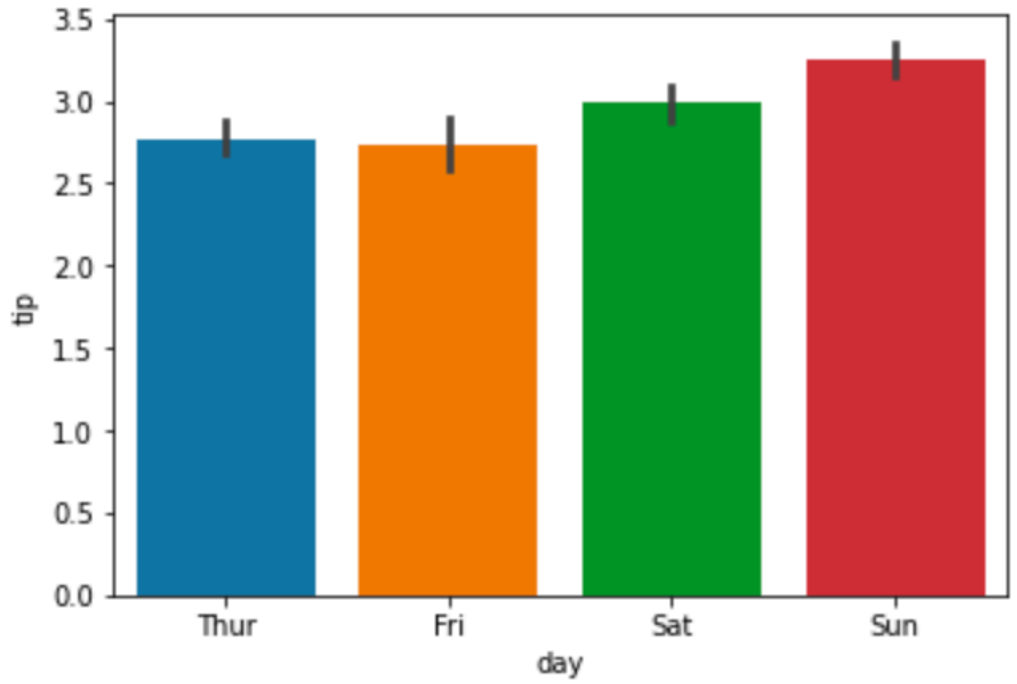

```
sns.barplot(data=categorical_data, x='day', y='tip',ci=50)
```

Default confidence interval for error bars is 95%

Let’s practice

```
sns.barplot(data=categorical_data, x='day', y='tip',ci=50)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c9f5f080>
```



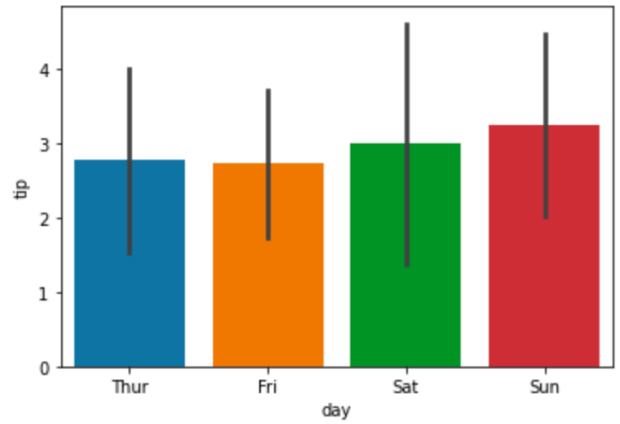
Change confidence interval

```
sns.barplot(data=categorical_data, x='day', y='tip', ci='sd')
```

changes this to just use standard deviation

```
sns.barplot(data=categorical_data, x='day', y='tip', ci='sd')
```

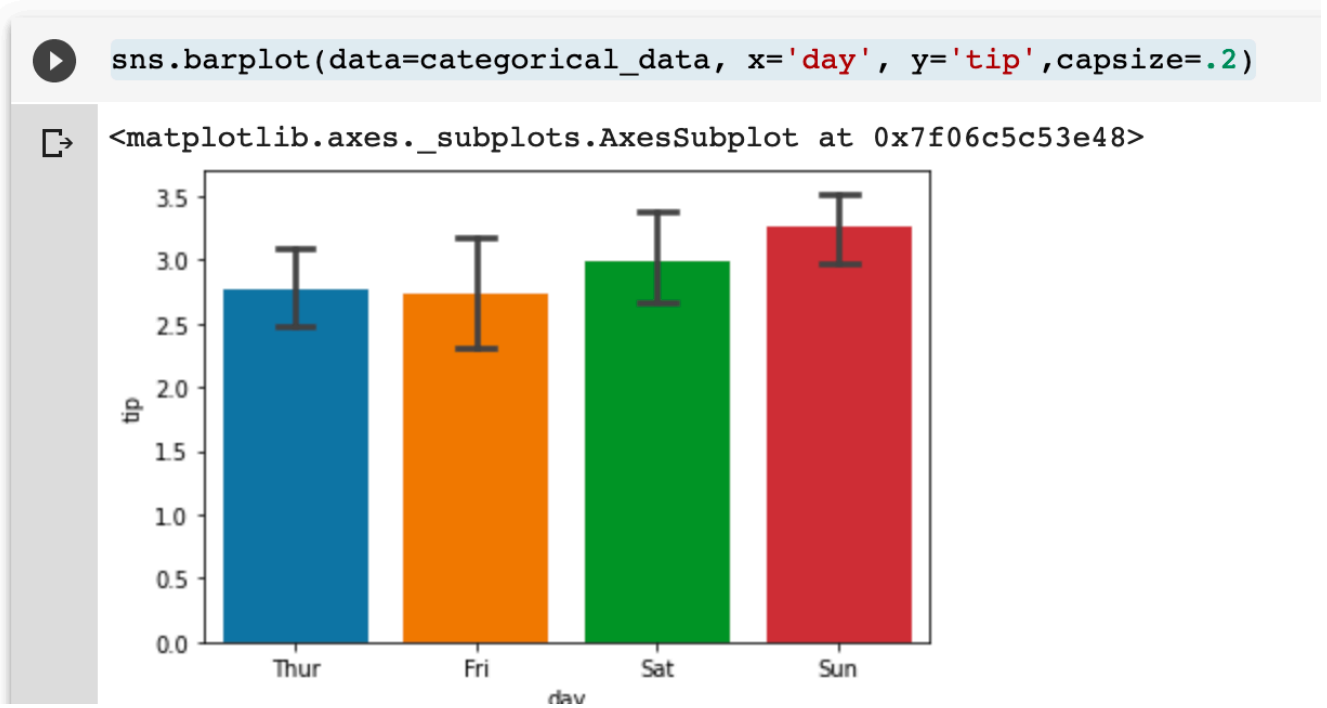
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c9e5eda0>
```



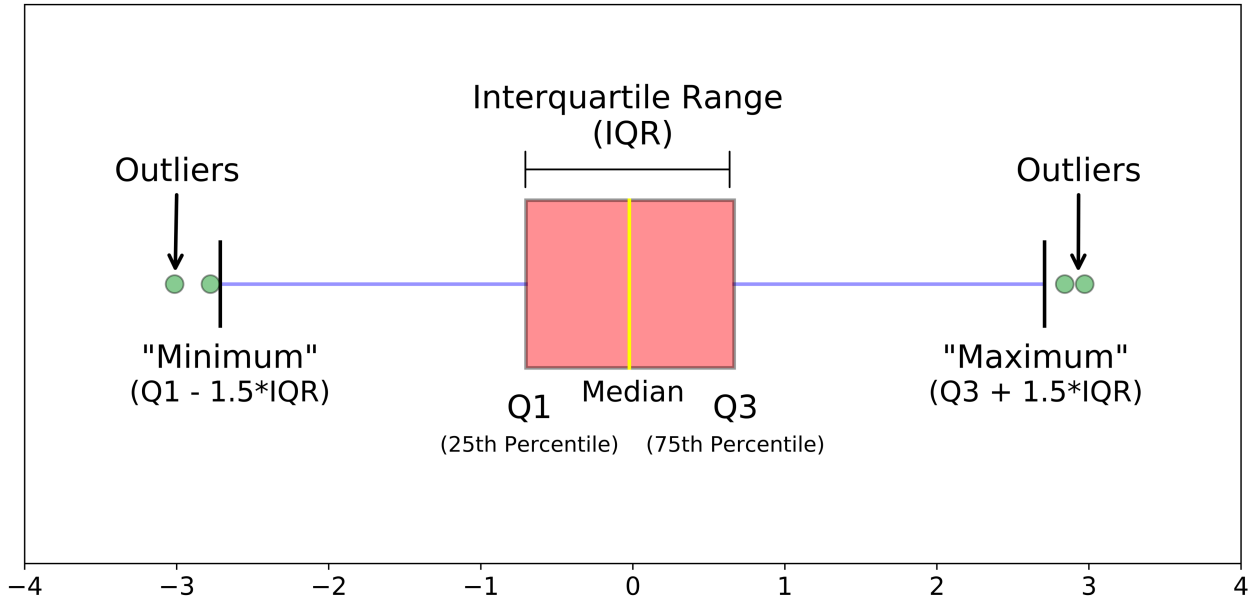
More options for bar plot

- We can add “caps” on error bars of certain size

```
sns.barplot(data=categorical_data, x='day', y='tip',capsize=.2)
```



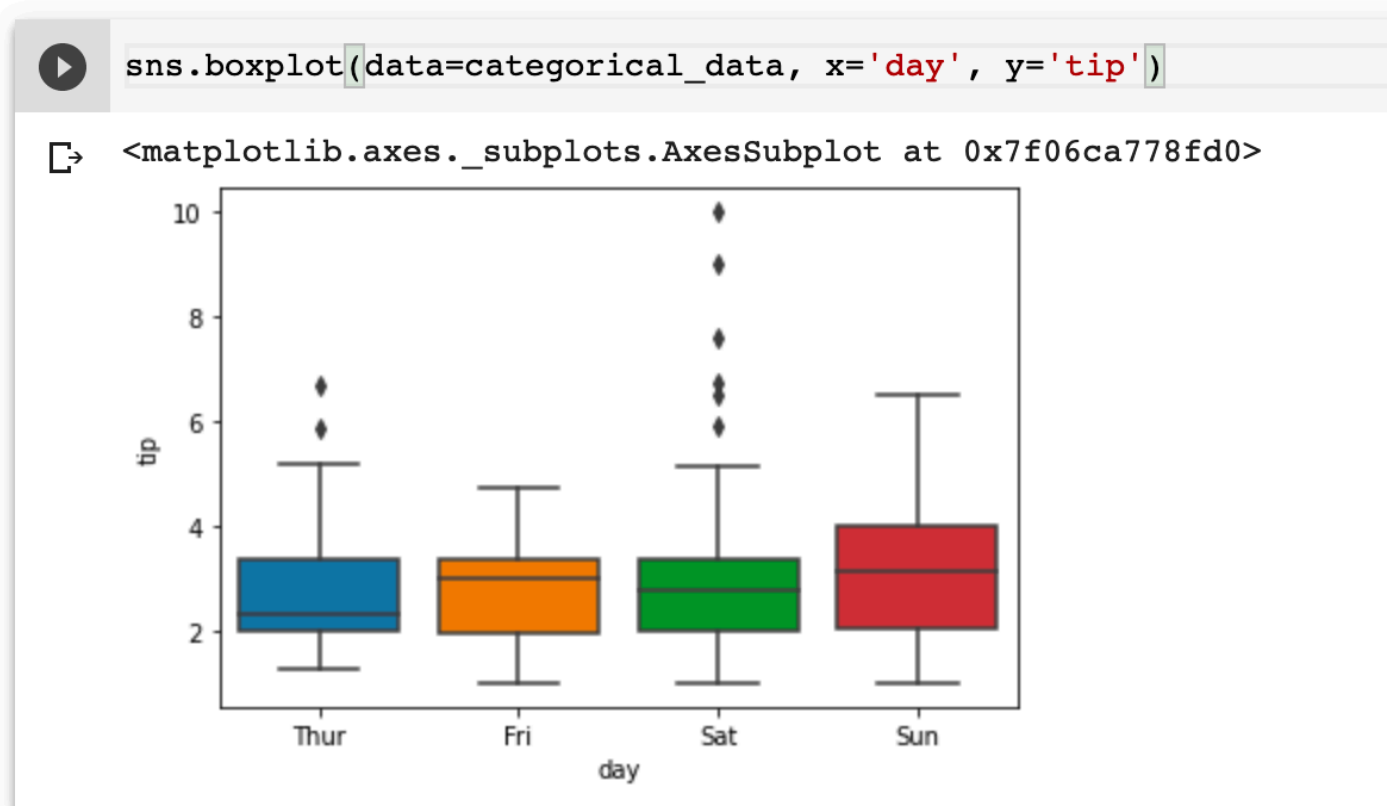
Box plots



- Sometimes referred as whisker plot
- Useful for displaying quantiles
- Conveys distribution information
- Able to displays outliers
- Does not convey sample size

Let’s practice

```
sns.boxplot(data=categorical_data, x='day', y='tip')
```



Outliers

Any point outside of the whisker range will be labelled as an outlier

The size of these points can be changed with the fliersize parameter

Setting it to 0 will effectively remove these points

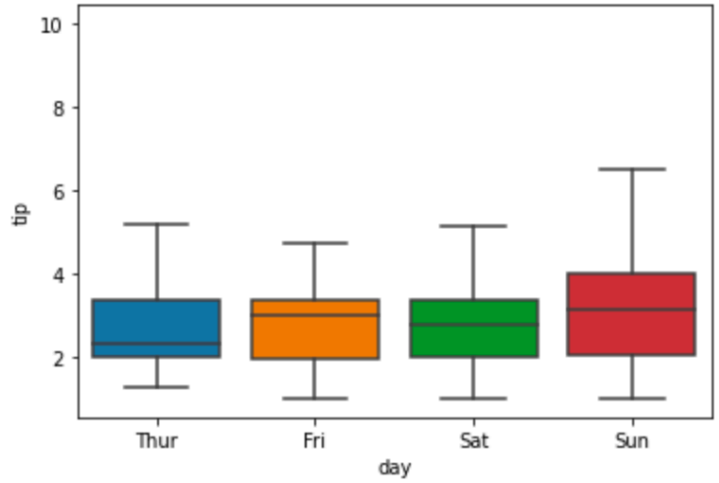
Let’s practice

```
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0)
```

Setting it to 0 will effectively remove these points

```
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c9dcdb00>
```



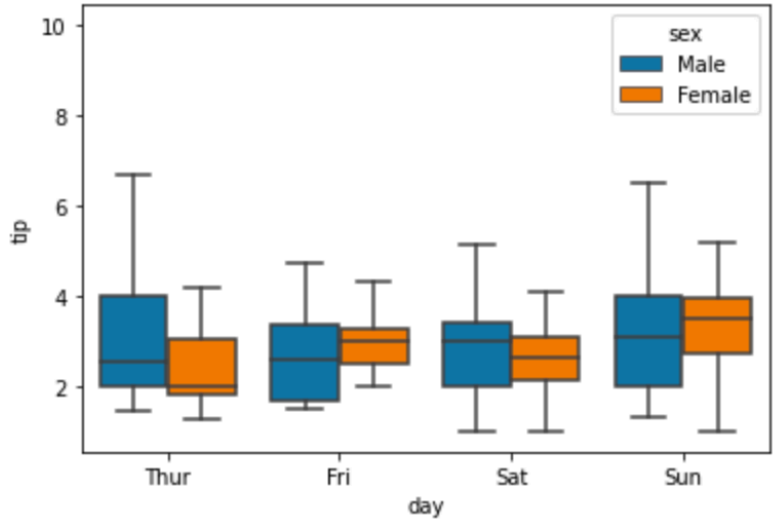
Box plot with nested grouping by a two variable

```
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0,hue='sex')
```

Split each box plot into two based on this variable

```
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0,hue='sex')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c9aa6630>
```

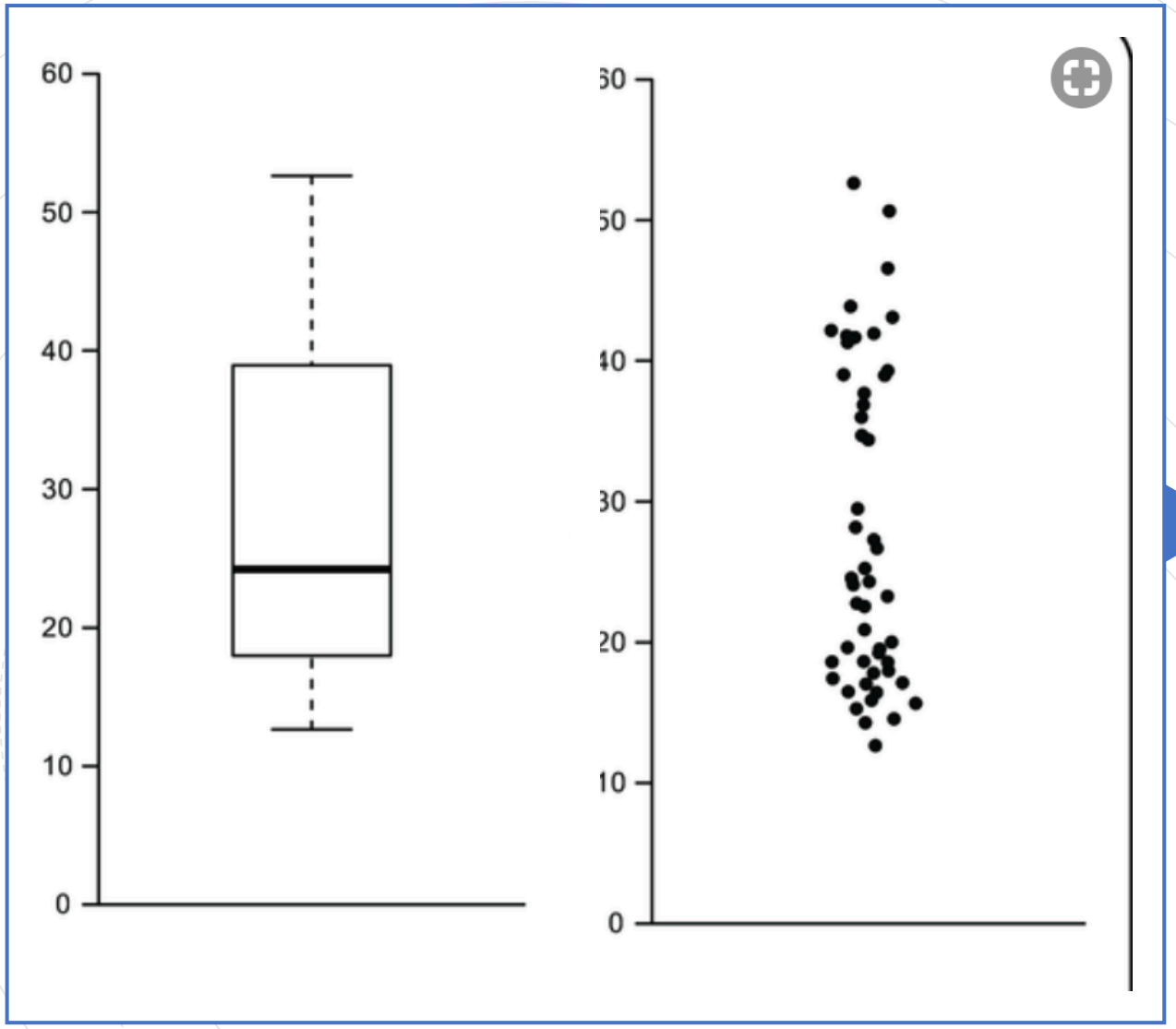


Clearly express distributions

Visualizations can be misleading

- Mean values can be inflated by outliers
- Differences may seem more significant because of small samples

Showing the data point may solve those problems



Multimodal distribution

Box plots cannot clearly describe multimodal distributions

Martinez, Edson Zangiacomi. "Description of continuous data using bar graphs: a misleading approach." *Revista da Sociedade Brasileira de Medicina Tropical* 48.4 (2015): 494-497.

Strip plots

Often overlaid onto another plot

Clearly displays sample size and distribution

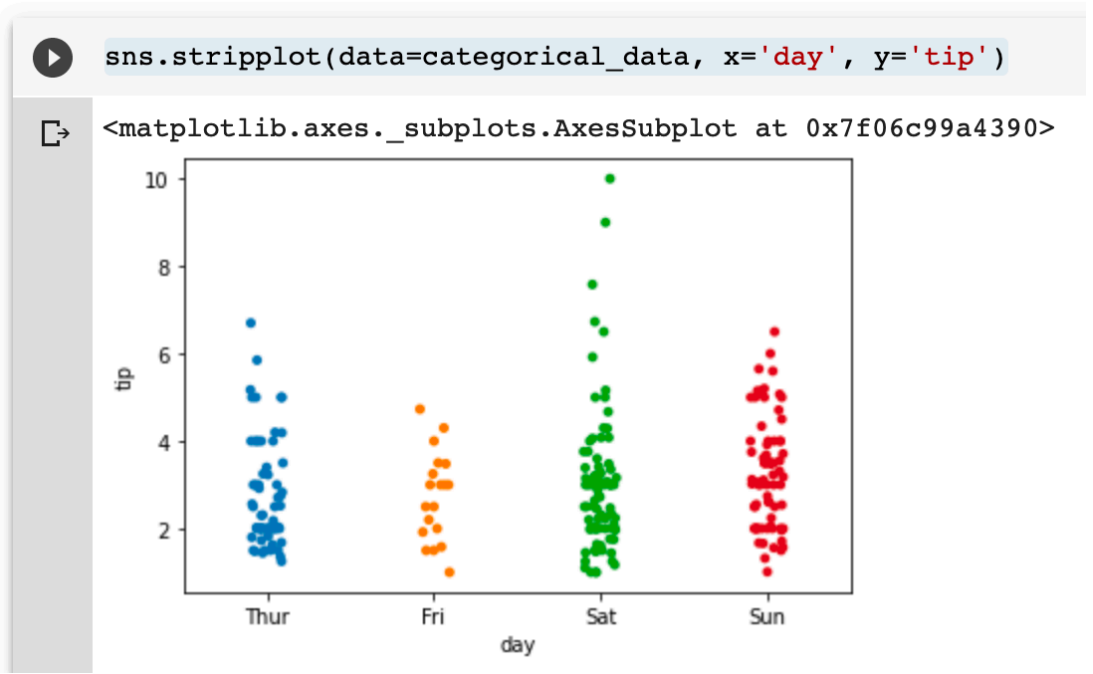
Does not convey estimators like mean or median

Strip plots

- Running the same function multiple times will produce slightly different plots
- The points have random horizontal spread

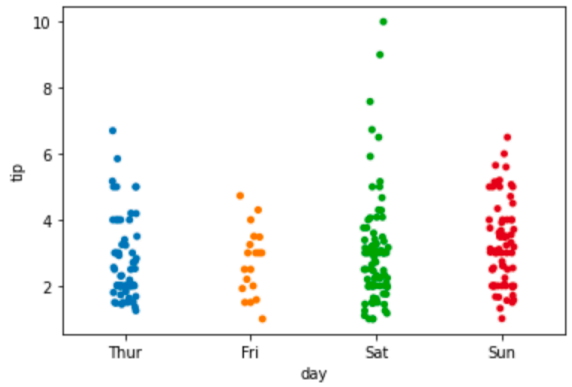
Let’s practice

```
sns.stripplot(data=categorical_data, x='day', y='tip')
```

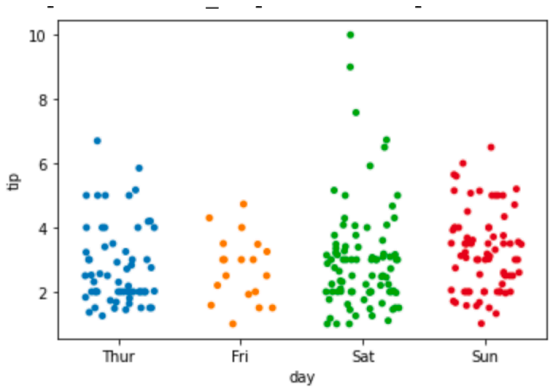


Jitter parameter

- If you have many similar points, there is a high chance that they will overlap
- The jitter parameter can change the horizontal spread of the points



default



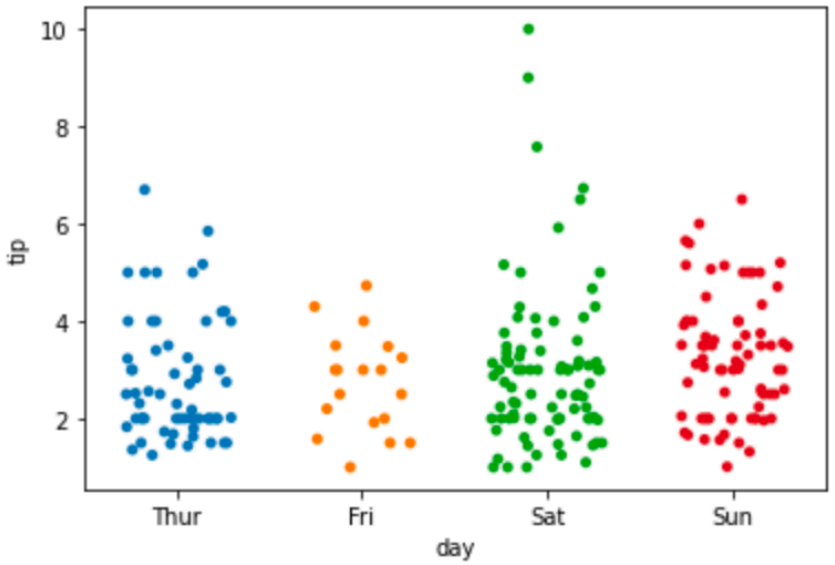
Jitter =0.3

Let’s practice

```
sns.stripplot(data=categorical_data, x='day', y='tip',jitter=.3)
```

```
sns.stripplot(data=categorical_data, x='day', y='tip',jitter=.3)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c994fc50>
```

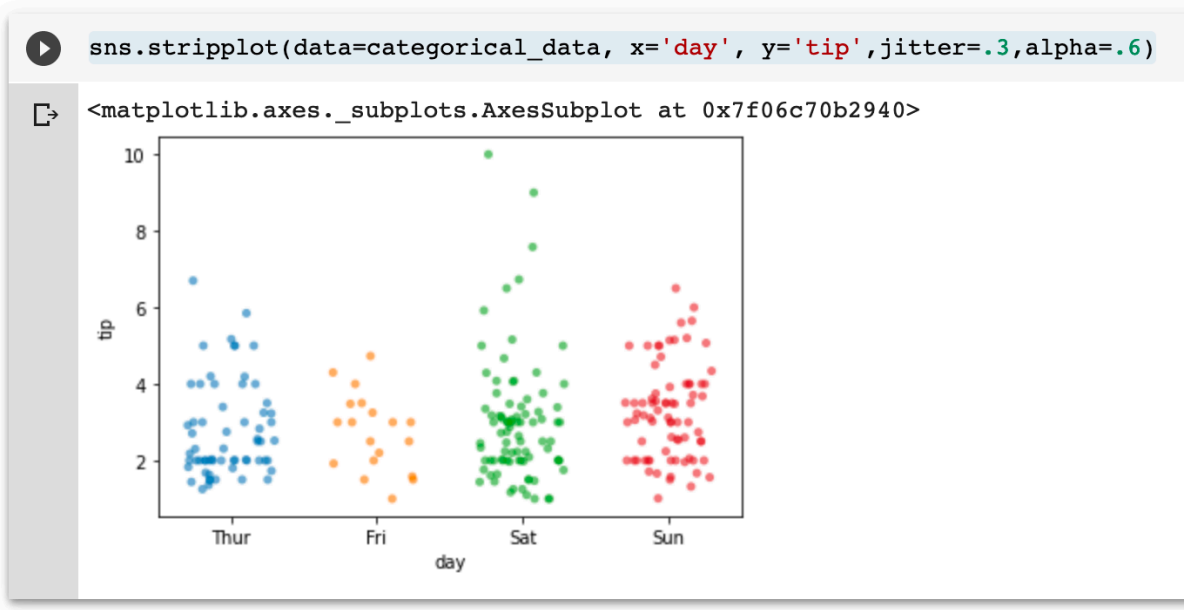


Overlapping points in strip plots

- The alpha parameter can also help to see the overlapped points better
- Alpha controls transparency, and can be used on other plots as well

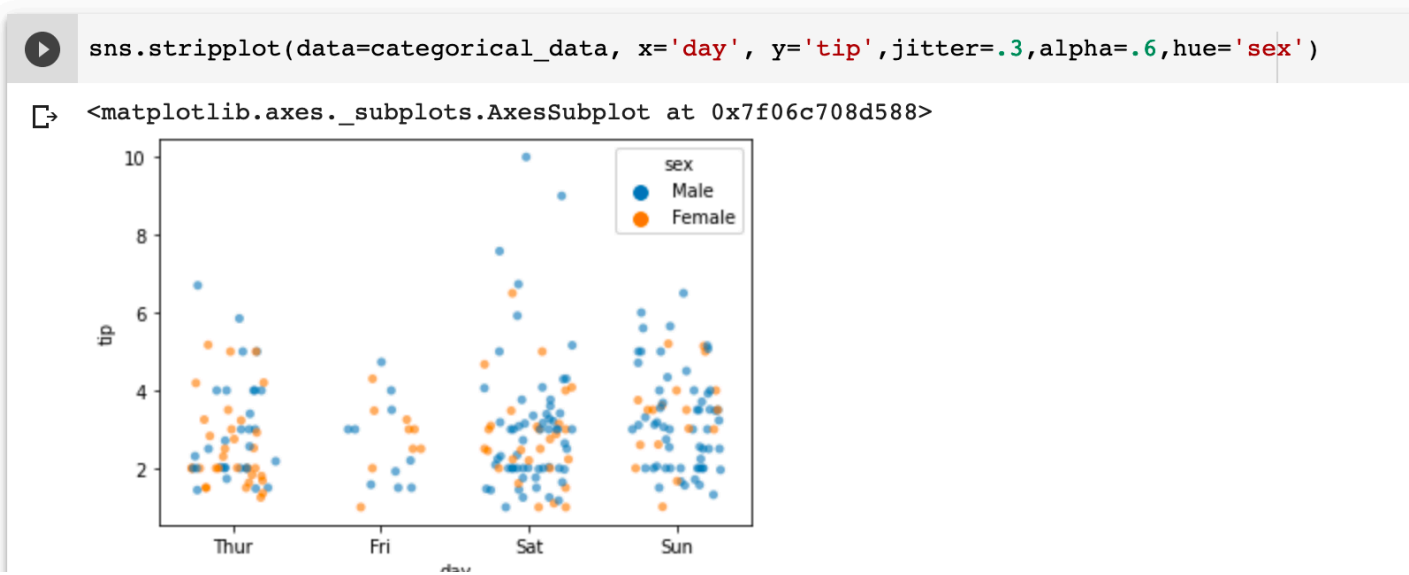
Let’s practice

```
sns.stripplot(data=categorical_data, x='day', y='tip',jitter=.3,alpha=.6)
```



Nested grouping by a two variable

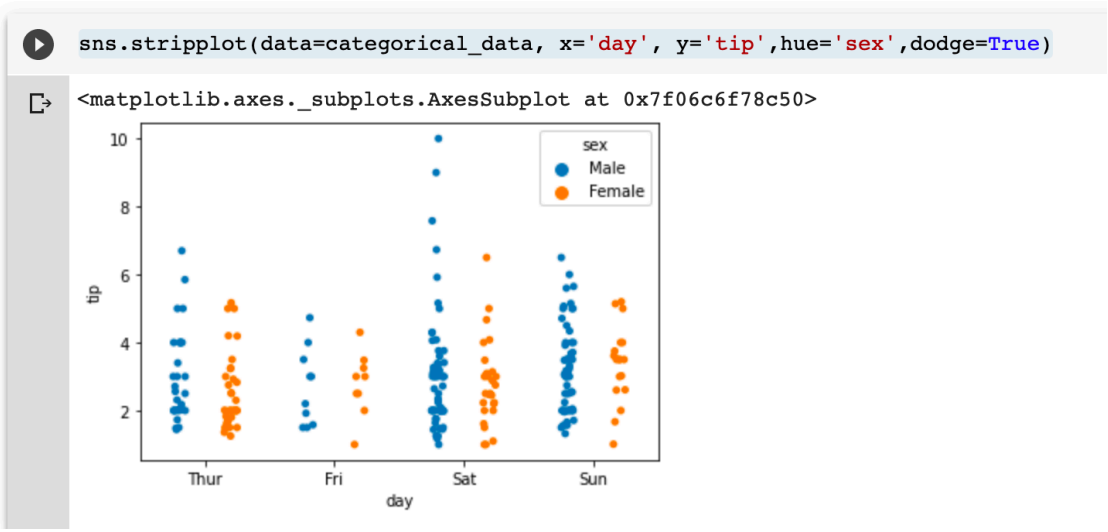
```
sns.stripplot(data=categorical_data, x='day', y='tip',jitter=.3,alpha=.6,hue='sex')
```



Dodge option

- By default, points separated by hue will overlap
- Using dodge parameter data point will be separated

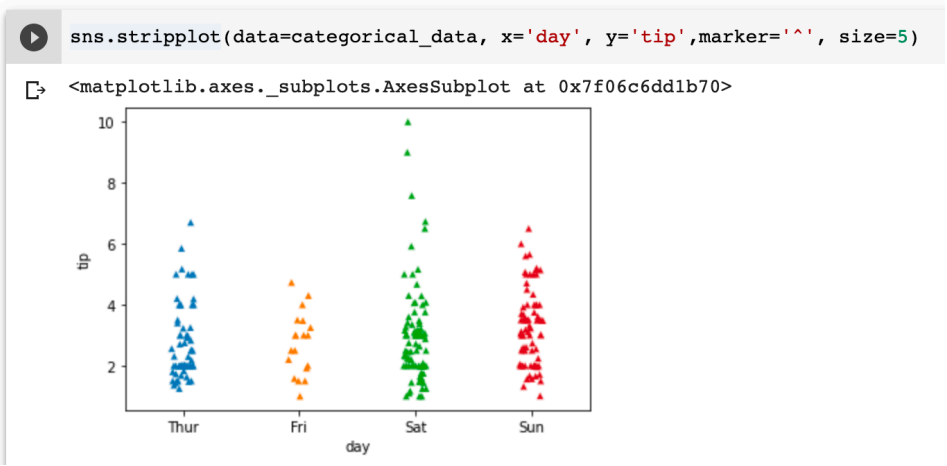
```
sns.stripplot(data=categorical_data, x='day', y='tip',hue='sex',dodge=True)
```



More options for strip plots

- The size and shape of every point is also editable
- There are plenty of built-in markers to use

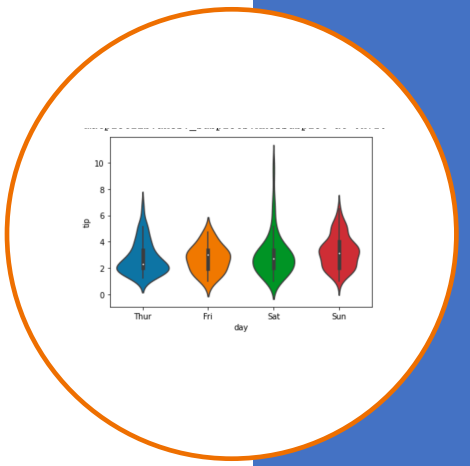
```
sns.stripplot(data=categorical_data, x='day', y='tip',marker='^', size=5)
```



Read more at https://seaborn.pydata.org/generated/seaborn.stripplot.html

Violin plots

- Uses kernel density estimation to display the underlying distribution
- Displays distribution and estimator
- Estimation is influenced by sample size



Kernel density estimation

- Useful if you want to visualize just the “shape” of some data, as a kind of continuous replacement for the discrete histogram

Read more here
https://mathisonian.github.io/kde/

Advantages of violin plots

- A violin plot is more informative than a plain box plot
- Violin plot shows the full distribution of the data.

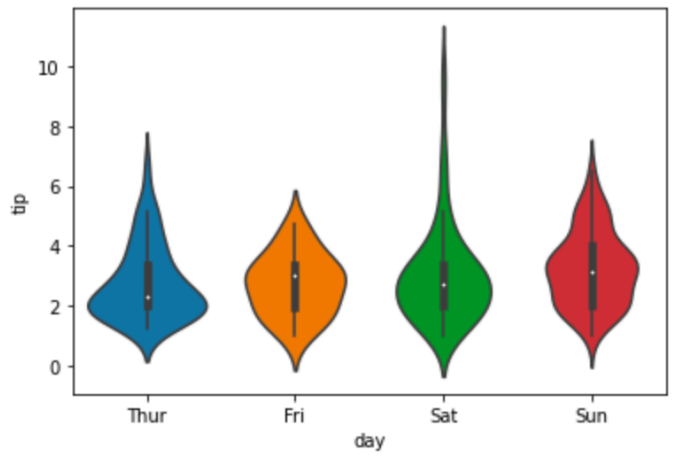
Let’s practice

```
sns.violinplot(data=categorical_data, x='day', y='tip')
```

Type of plot

```
sns.violinplot(data=categorical_data, x='day', y='tip')
```

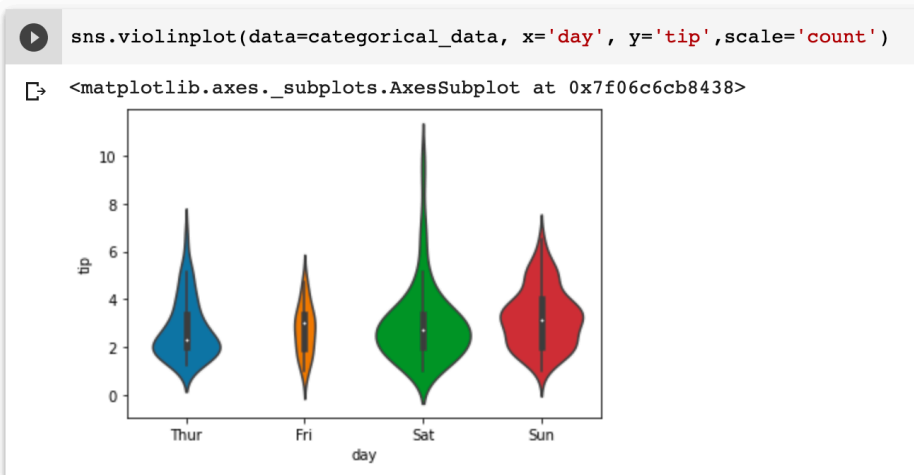
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c6d30f60>
```



Relative sample size

- The scale parameter changes effect used for width of each violin
- By default the area of each violin will be constant
- Width is scaled by the number of observations in each violin

```
sns.violinplot(data=categorical_data, x='day', y='tip',scale='count')
```



The inner parameter

- The inner parameter affects what the representation inside the violin
  - **box (default)**: A mini boxplot is drawn
  - **quartile**: Quartile lines are drawn
  - **stick or point**: Individual points drawn as sticks or points
  - **None**: Nothing inside

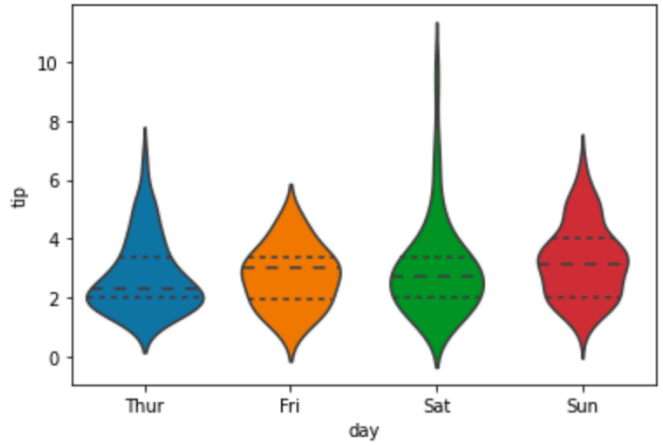
Let’s practice

```
sns.violinplot(data=categorical_data, x='day', y='tip',inner='quartile')
```

affects what the representation inside the violin

```
sns.violinplot(data=categorical_data, x='day', y='tip',inner='quartile')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c6b40780>
```

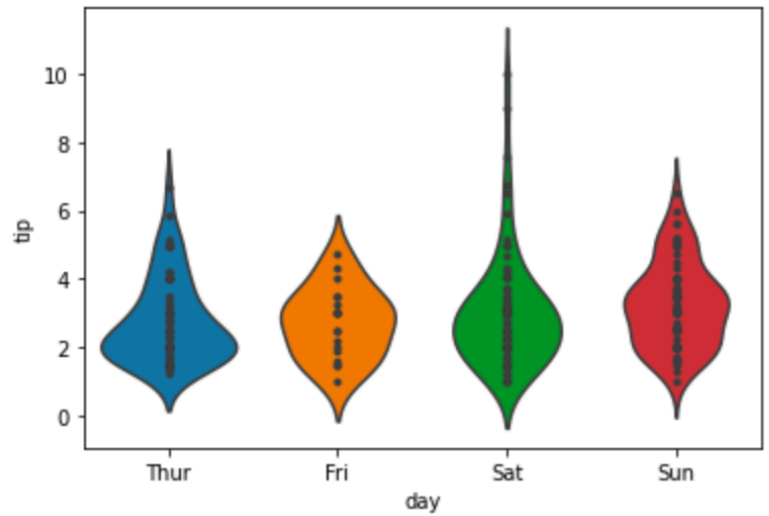


Let’s practice

```
sns.violinplot(data=categorical_data, x='day', y='tip',inner='point')
```

```
sns.violinplot(data=categorical_data, x='day', y='tip',inner='point')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c67fbd30>
```

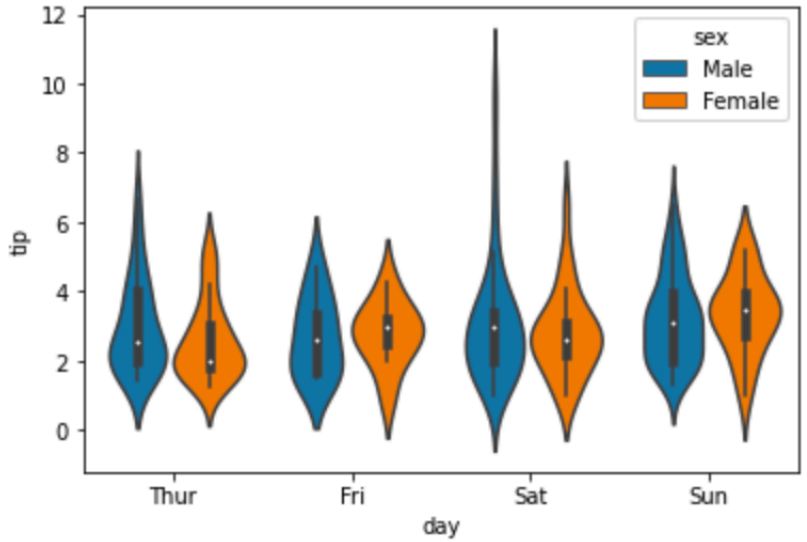


Violin plot with nested grouping by a two variable

```
sns.violinplot(data=categorical_data, x='day', y='tip',hue='sex')
```

```
sns.violinplot(data=categorical_data, x='day', y='tip',hue='sex')
```

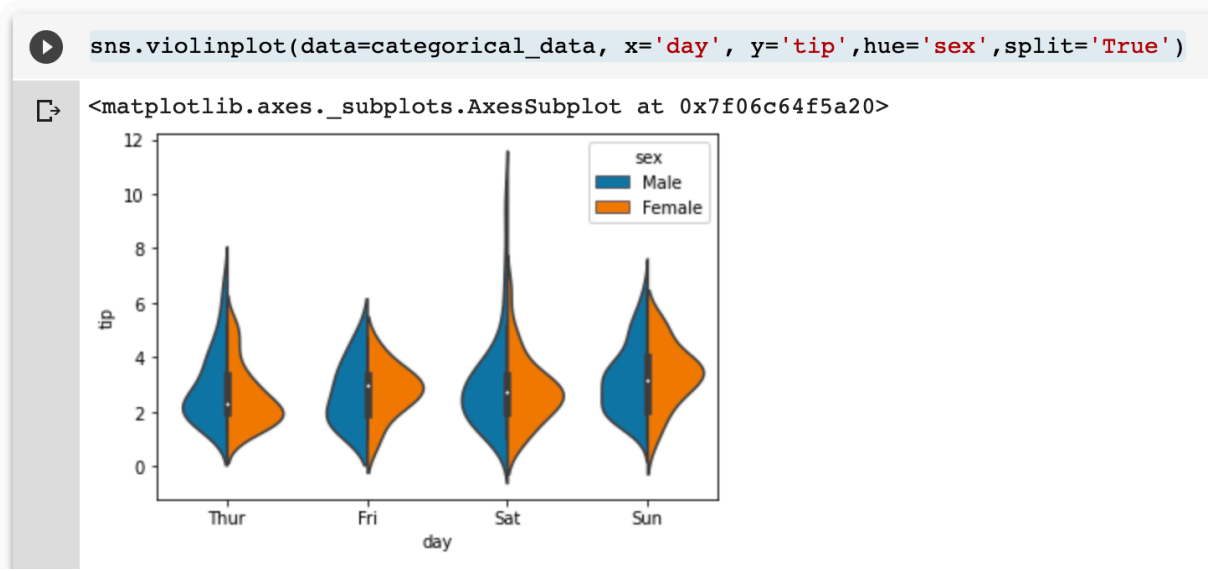
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c6759b70>
```



Split parameter

- Each violin will be split into two halves

```
sns.violinplot(data=categorical_data, x='day', y='tip',hue='sex',split='True')
```



Ordering plot elements

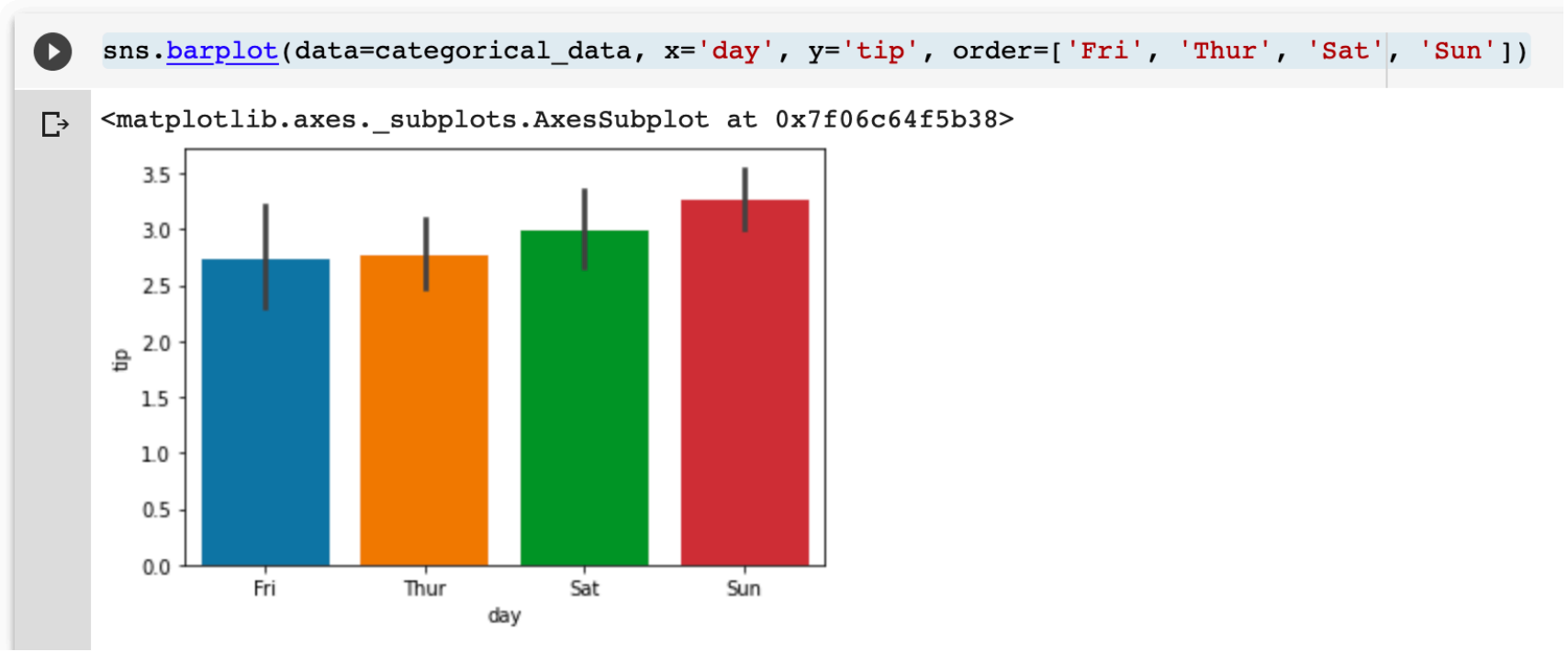
By default, levels inferred from the data

Explicitly setting orders can help keep consistency

To shorten plot functions, one list can be saved to a variable and called for each plot

Let’s practice

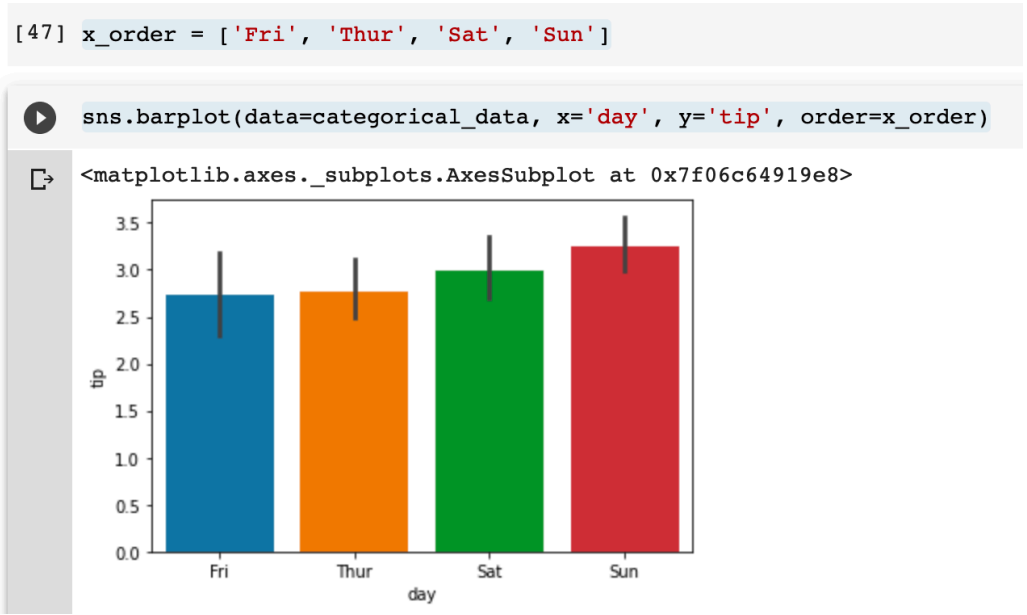
```
sns.barplot(data=categorical_data, x='day', y='tip', order=['Fri', 'Thur', 'Sat', 'Sun'])
```



Ordering plot elements

```
x_order = ['Fri', 'Thur', 'Sat', 'Sun']
```

```
sns.barplot(data=categorical_data, x='day', y='tip', order=x_order)
```

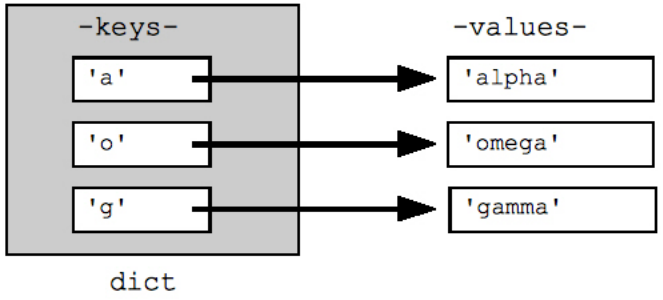


Define a pallet

- Define the pallet using dictionary data structure
- Only needs to be used once per notebook

Dictionary data structure

- A **dictionary** is a general-purpose **data structure** for storing a group of objects. A **dictionary** has a set of keys and each key has a single associated value



keys

values

```
color_dict=dict({'Thur':'purple','Fri':'orange','Sat':'brown','Sun':'gray'})
```

Let’s practice

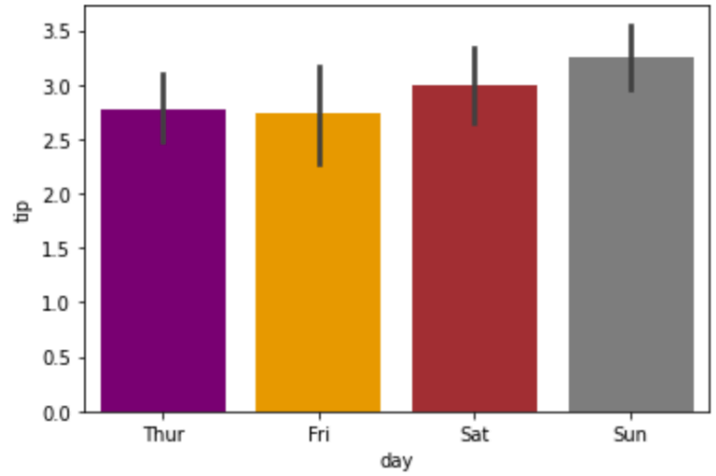
Provide custom palette

```
sns.barplot(data=categorical_data, x='day', y='tip',palette=color_dict)
```

```
[ ]  color_dict=dict({'Thur':'purple','Fri':'orange','Sat':'brown','Sun':'gray'})
```

```
sns.barplot(data=categorical_data, x='day', y='tip',palette=color_dict)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f7455b75d30>
```



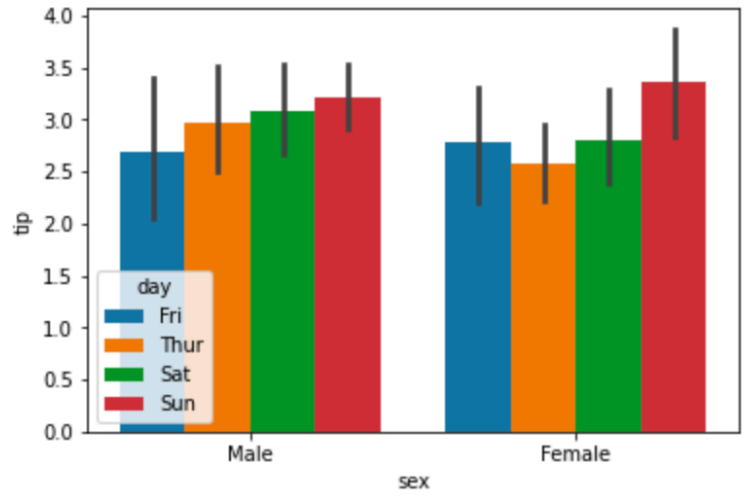
Ordering plot elements

- The hue_order parameter affects the hue categories

```
sns.barplot(data=categorical_data, x='sex', y='tip', hue_order=x_order,hue='day')
```

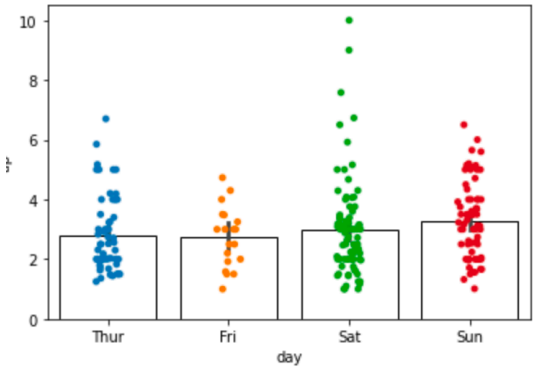
```
sns.barplot(data=categorical_data, x='sex', y='tip', hue_order=x_order,hue='day')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c61650b8>
```



Combining categorical plots

Oftentimes it is useful to combine multiple plots on one set of axes to reduce the hidden information

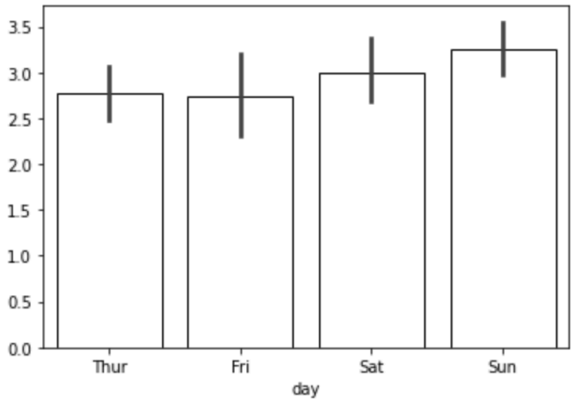


A bar plot and strip plot combine the point distribution with an estimator

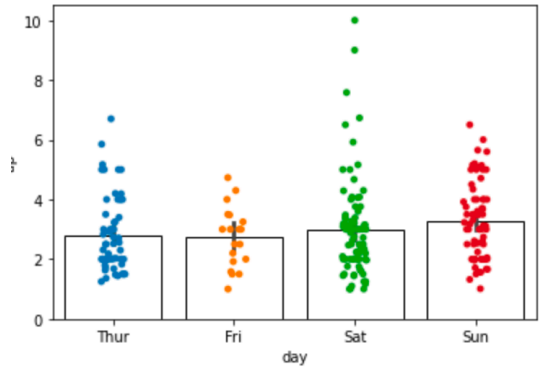
Let’s practice

```
sns.barplot(data=categorical_data, x='day',
y='tip',edgecolor='black',facecolor='white')
```

Color inside the bar



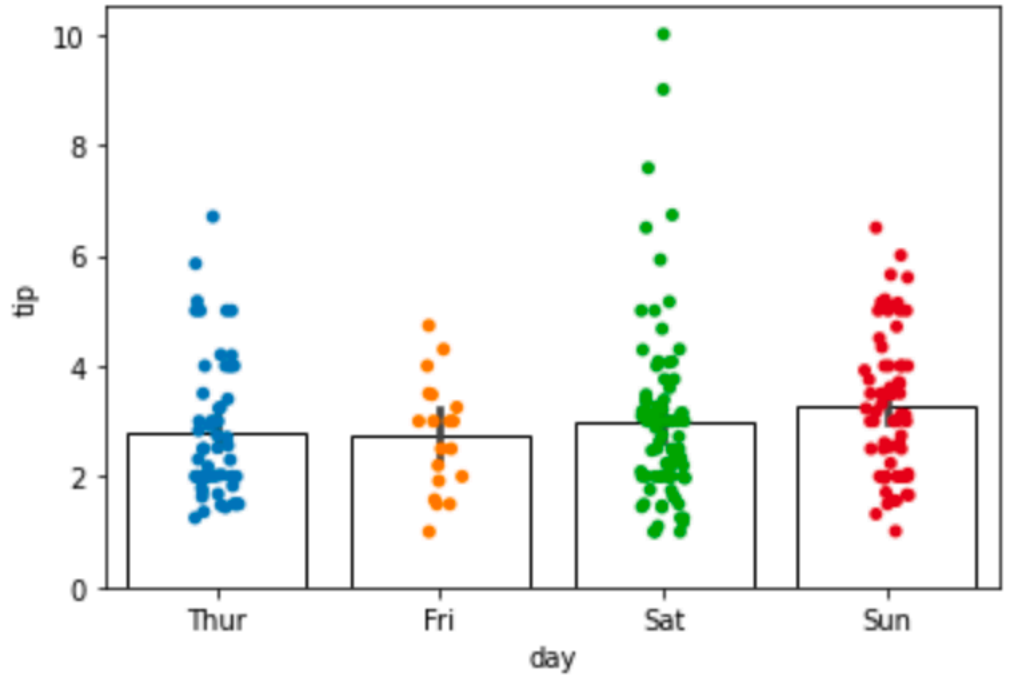

```
sns.stripplot(data=categorical_data,
x='day', y='tip')
```



Let’s practice

```
sns.barplot(data=categorical_data, x='day', y='tip',edgecolor='black',facecolor='white')
sns.stripplot(data=categorical_data, x='day', y='tip')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c591d5c0>
```



Improve the aesthetics and clarity

```
sns.barplot(data=categorical_data, x='day',
y='tip',edgecolor='black',facecolor='white',capsize=.3)
```

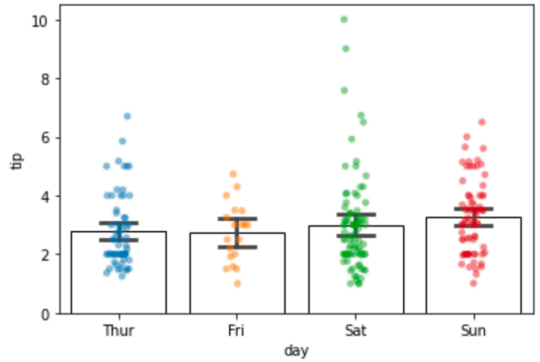
Make error bars more visible

```
sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
```

Adjust transparency

```
sns.barplot(data=categorical_data, x='day', y='tip',edgecolor='black',facecolor='white',capsize=.3)
sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f06c567fa90>
```



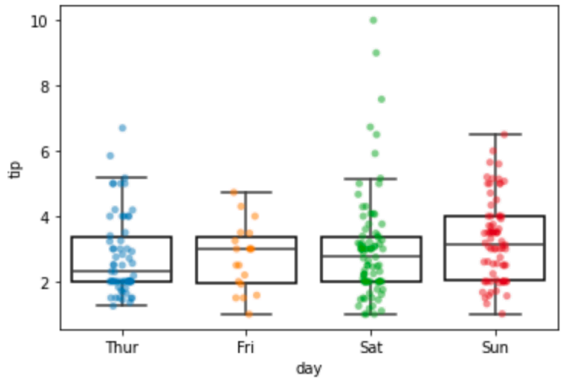
Combining categorical plots

```
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0,boxprops=dict({'edgecolor': 'black', 'facecolor': (1,1,1,0)}))
```

```
sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
```

```
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0,boxprops=dict({'edgecolor': 'black', 'facecolor': (1,1,1,0)}))
sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f74559e67b8>
```



Read about boxprops here https://matplotlib.org/api/_as_gen/matplotlib.axes.Axes.boxplot.html#matplotlib.axes.Axes.boxplot

Relational plots

- Plots where we want to compare the relationship between two variables
- Typically axes are made of two numerical variables

Test data

- For these examples we will use the “mpg” dataset

```
relational_data = sns.load_dataset('mpg')
```

```
relational_data = sns.load_dataset('mpg')
relational_data.head()
```

	mpg	cylinders	displacement	horsepower	weight	acceleration	model_year	origin	name
0	18.0	8	307.0	130.0	3504	12.0	70	usa	chevrolet chevelle malibu
1	15.0	8	350.0	165.0	3693	11.5	70	usa	buick skylark 320
2	18.0	8	318.0	150.0	3436	11.0	70	usa	plymouth satellite
3	16.0	8	304.0	150.0	3433	12.0	70	usa	amc rebel sst
4	17.0	8	302.0	140.0	3449	10.5	70	usa	ford torino

Line plots

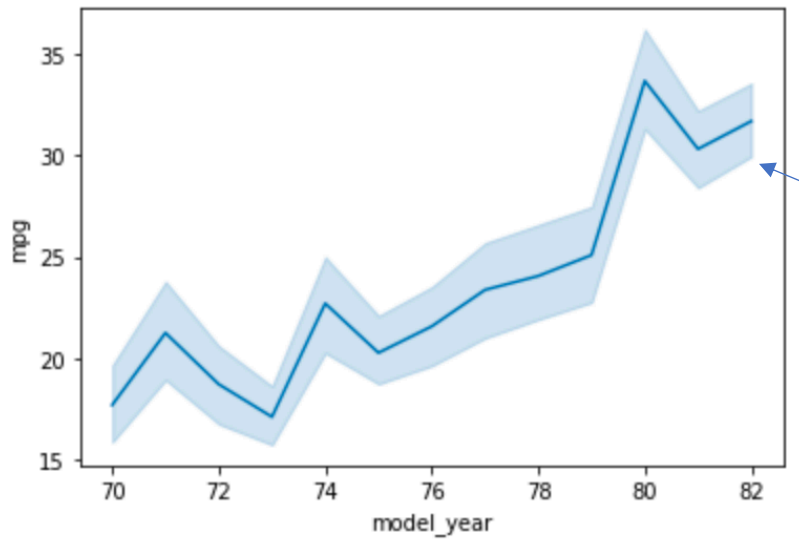
- Can be used to compare means or medians over the span of the x-axis
- Does not convey distribution nor sample size

```
sns.lineplot(data=relational_data, x='model_year', y='mpg')
```

Let’s practice

```
sns.lineplot(data=relational_data, x='model_year', y='mpg')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f74554d1c88>
```

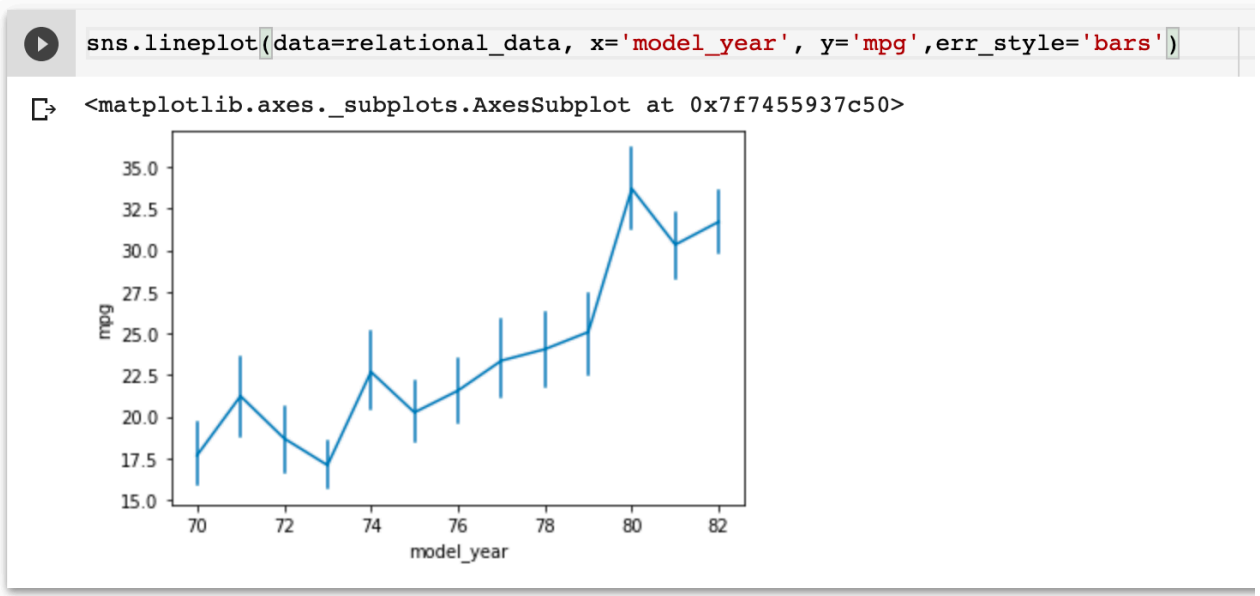


By default the distribution is drawn as bands around the line.

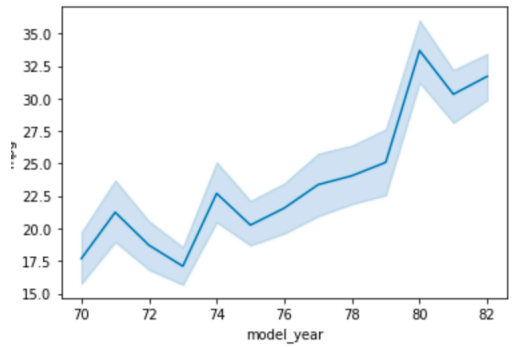
Error bars

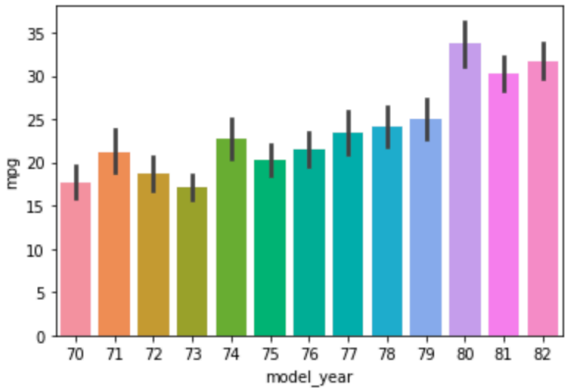
- Error bars can be added with the err_style parameter

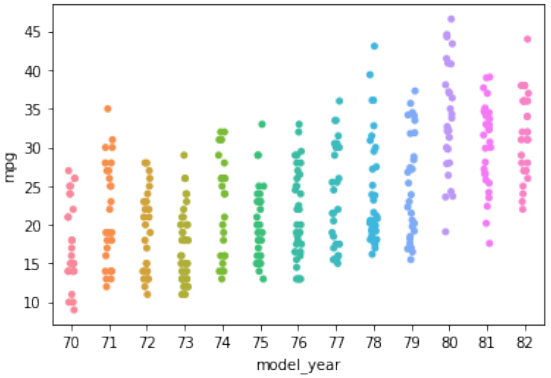
```
sns.lineplot(data=relational_data, x='model_year', y='mpg',err_style='bars')
```

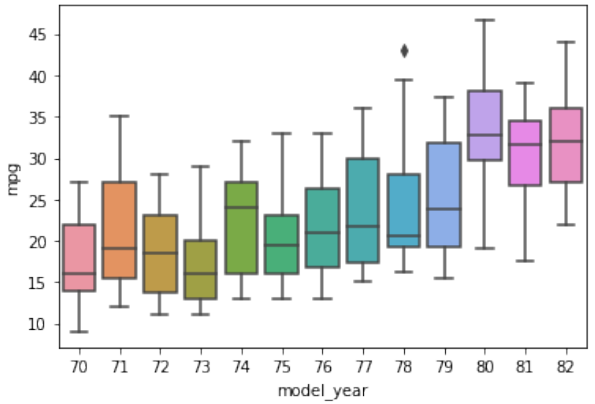


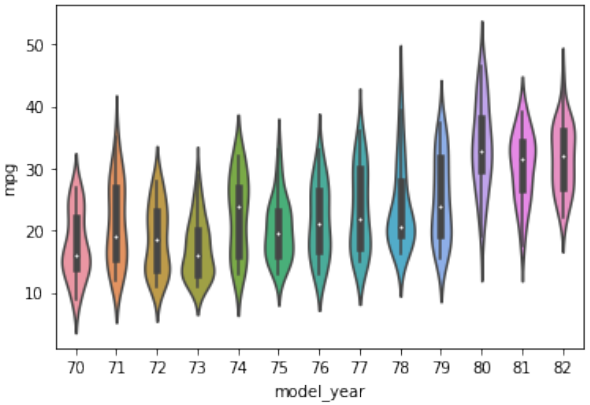
Line plot can be represented as a categorical plot











bar
strip
box
violin

```
sns._plot(data=relational_data, x='model_year', y='mpg')
```

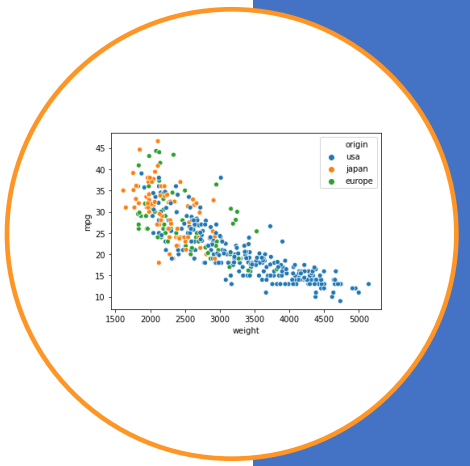
More option for line plot

- ci
- hue

Read more about line plot at https://seaborn.pydata.org/generated/seaborn.lineplot.html

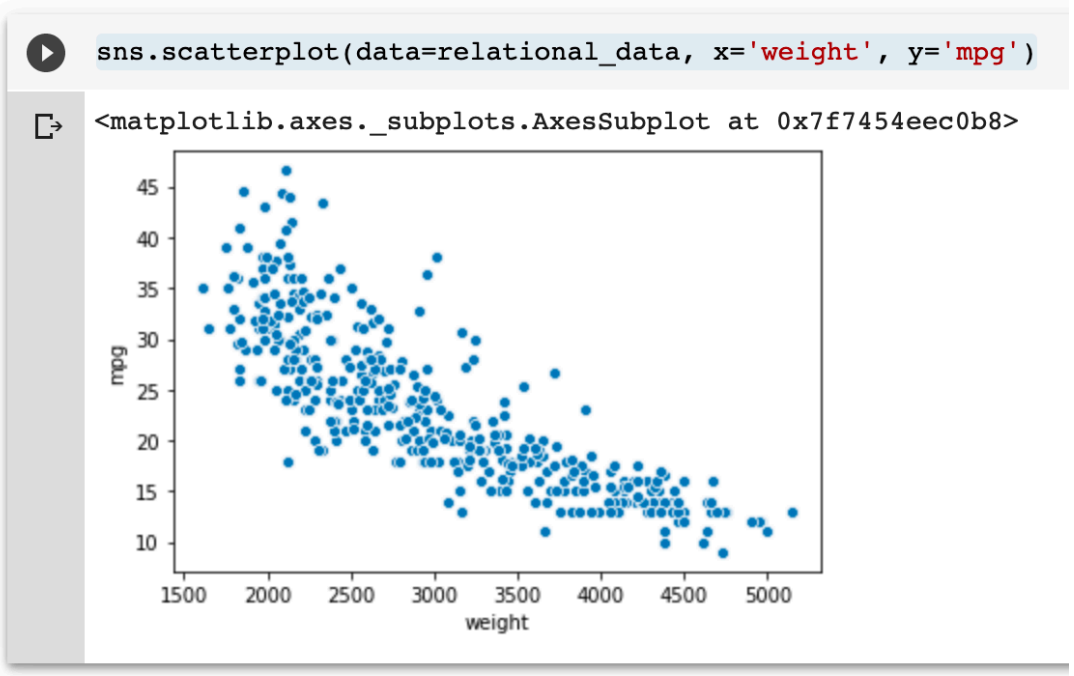
Scatter plots

- Visualizes the relationship between two numerical variables
- Clearly displays sample size
- Does not convey estimators like mean or median



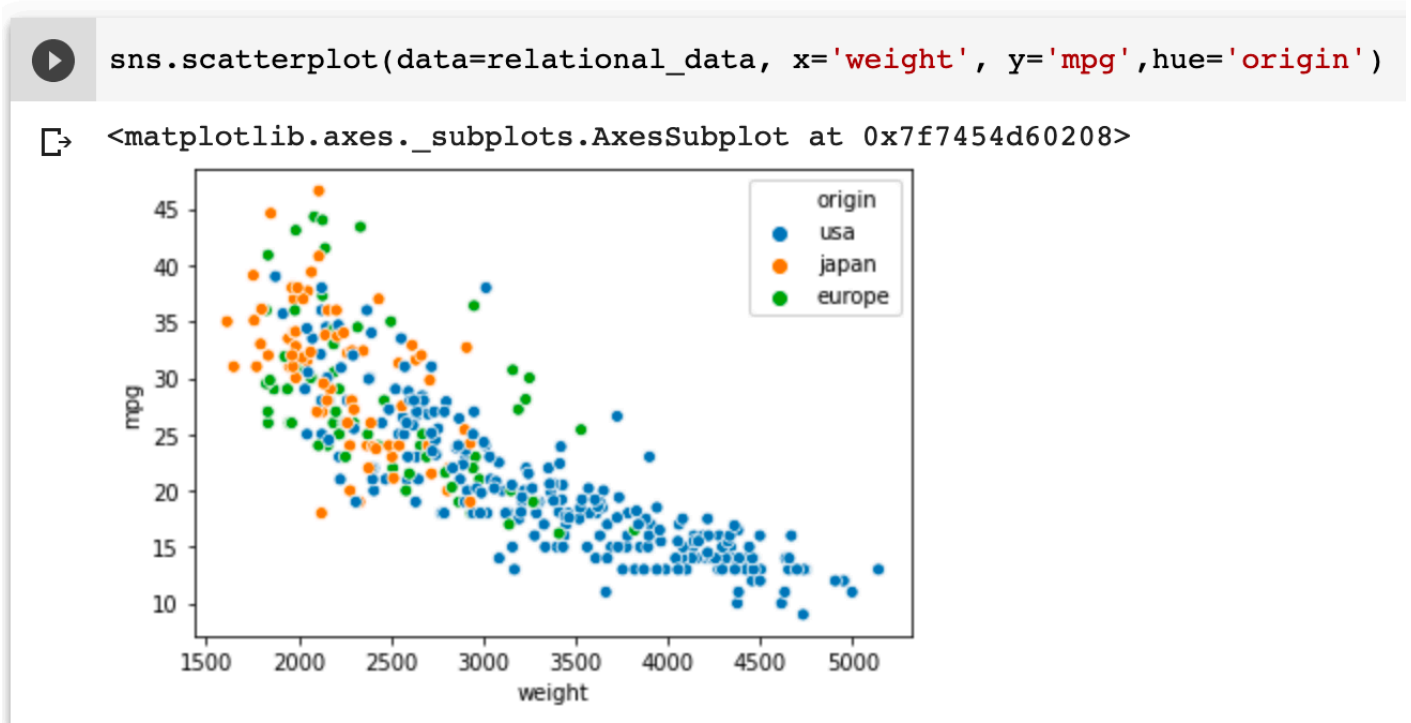
Scatter plots using seaborn

```
sns.scatterplot(data=relational_data, x='weight', y='mpg')
```



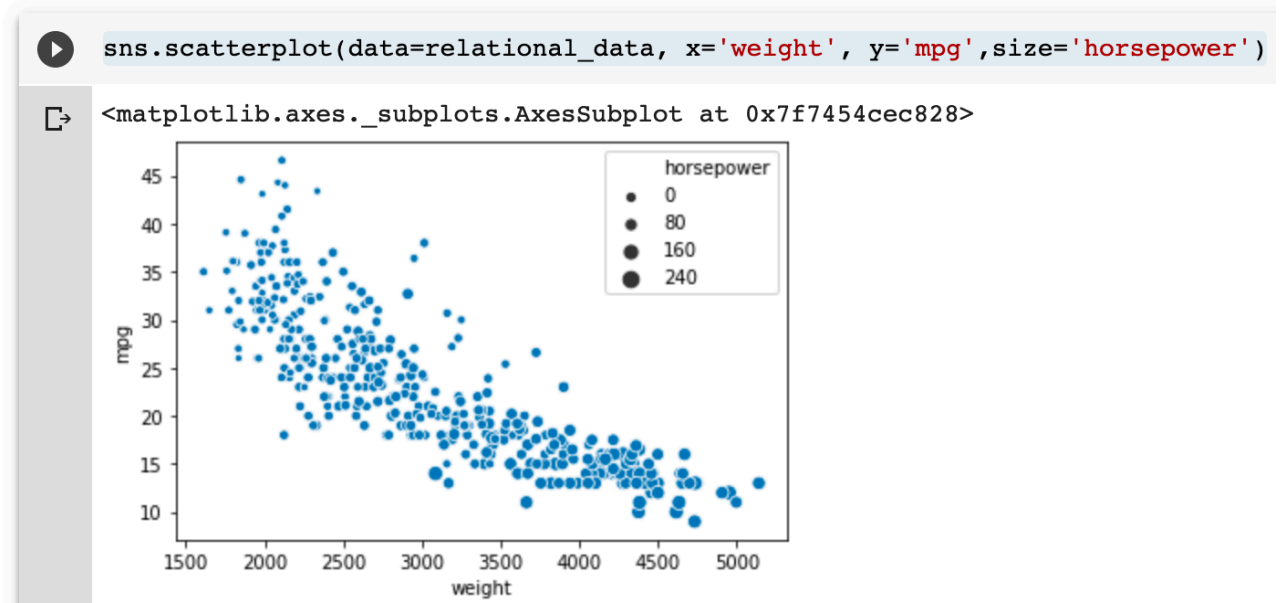
Hue option for scatter plots

```
sns.scatterplot(data=relational_data, x='weight', y='mpg',hue='origin')
```



Size of data points

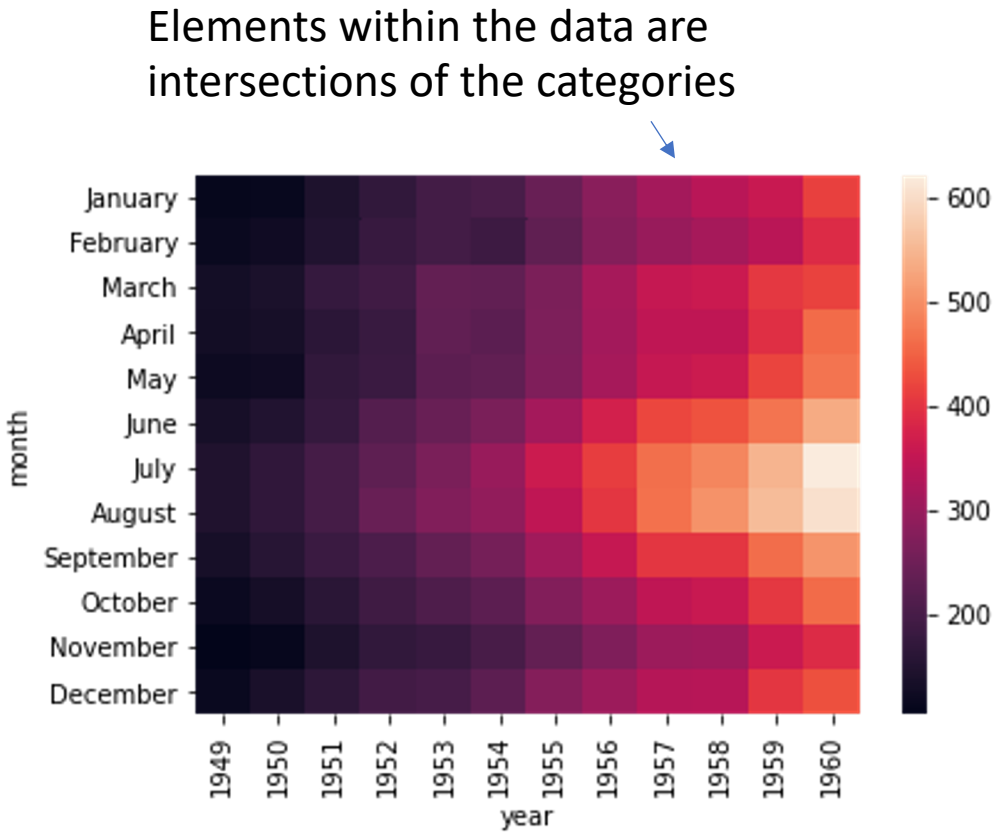
```
sns.scatterplot(data=relational_data, x='weight', y='mpg',size='horsepower')
```



Read more about scatter plots at

Heatmaps

- Plots specifically designed to display rectangular data
- What the plot displays depends on the value calculated in each intersection
- Particularly useful since many journals do not allow tables as part of multi-panel figures
- Only able to show one of sample size, median, or mean



Test dataset

- We will use the “flights” dataset
- However, this will need to be transformed to be rectangular

```
matrix_data = sns.load_dataset('flights')
```

```
matrix_data = sns.load_dataset('flights')
matrix_data.head()
```

	year	month	passengers
0	1949	January	112
1	1949	February	118
2	1949	March	132
3	1949	April	129
4	1949	May	121

Input data from heatmap

- Requires some work before plotting to get data into the correct shape

	year	month	passengers
0	1949	January	112
1	1949	February	118
2	1949	March	132
3	1949	April	129
4	1949	May	121

year	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
month												
January	112	115	145	171	196	204	242	284	315	340	360	417
February	118	126	150	180	196	188	233	277	301	318	342	391
March	132	141	178	193	236	235	267	317	356	362	406	419
April	129	135	163	181	235	227	269	313	348	348	396	461
May	121	125	172	183	229	234	270	318	355	363	420	472

The pivot function

- In Pandas, the pivot table function takes simple data frame as input, and performs grouped operations that provides a multidimensional summary of the data.

```
matrix_data = matrix_data.pivot('month', 'year', 'passengers')
```

```
matrix_data = sns.load_dataset('flights')
matrix_data = matrix_data.pivot('month', 'year', 'passengers')
matrix_data.head()
```

year	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
month												
January	112	115	145	171	196	204	242	284	315	340	360	417
February	118	126	150	180	196	188	233	277	301	318	342	391
March	132	141	178	193	236	235	267	317	356	362	406	419
April	129	135	163	181	235	227	269	313	348	348	396	461
May	121	125	172	183	229	234	270	318	355	363	420	472

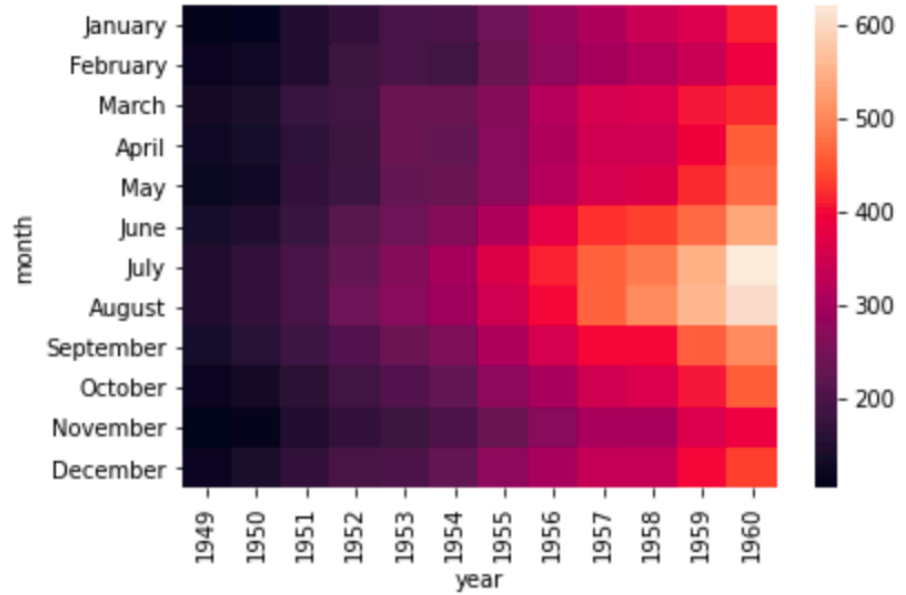
https://cmdlinetips.com/2018/12/pivot-table-in-python-pandas/

Heatmap

```
sns.heatmap(data=matrix_data)
```

```
sns.heatmap(data=matrix_data)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f74553fbdd8>
```

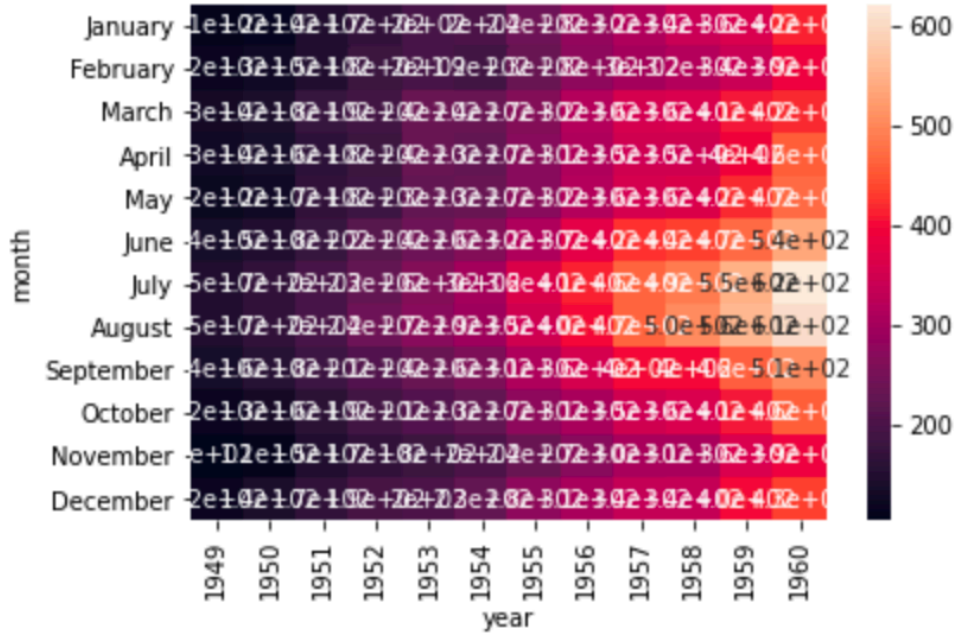


Display the raw values in heatmap

```
sns.heatmap(data=matrix_data, annot=True)
```

```
sns.heatmap(data=matrix_data, annot=True)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f74537c9390>
```



fmt parameter

fmt='d'

- 'd' is for a decimal integer

fmt='.*n*f'

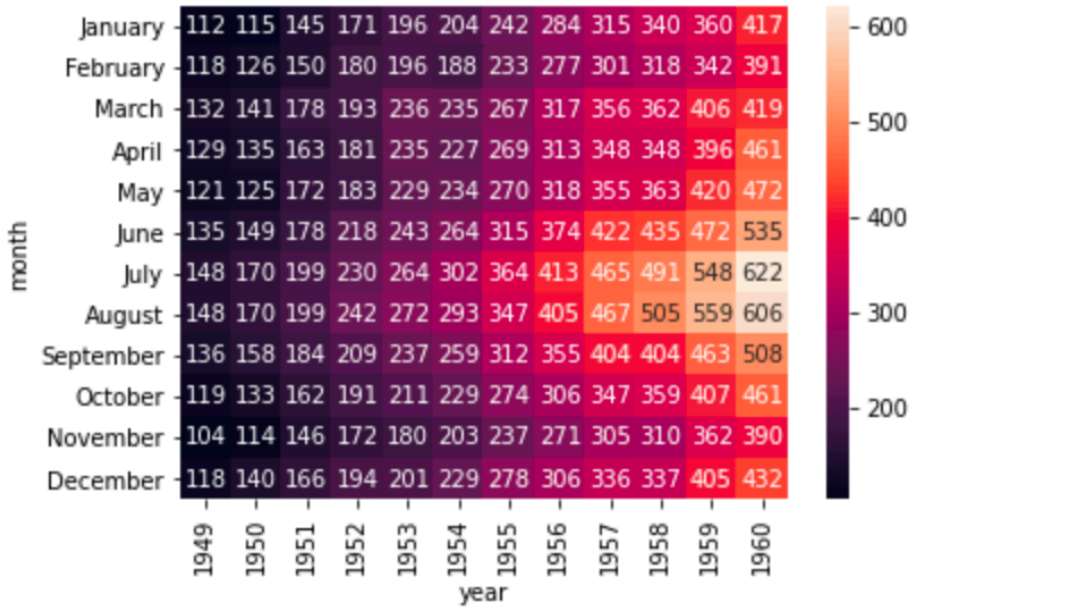
- *n* is the number of sig figs to include on either side of the decimal point
- '.1f' would create 602.0

Let’s practice

```
sns.heatmap(data=matrix_data, annot=True,fmt='d')
```

```
sns.heatmap(data=matrix_data, annot=True,fmt='d')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f7451c8aa20>
```



Customizing color palette

- Every plot has the option of changing the color palette
  - Seaborn/Matplotlib have a variety of premade palettes to choose from
    - https://seaborn.pydata.org/tutorial/color_palettes.html
- It is also possible to create your own palette
  - Simplest way is to use the hex codes of colors you'd like to use (e.g. 000000', '#f7941f', '#00b9f2', '#00a875', '#ecde38', '#f15a22', '#da6fab')
  - It is highly recommended you use a color-blind friendly palette like this one

Color	Color name	RGB (1–255)	CMYK (%)	P	D
	Black	0, 0, 0	0, 0, 0, 100		
	Orange	230, 159, 0	0, 50, 100, 0		
	Sky blue	86, 180, 233	80, 0, 0, 0		
	Bluish green	0, 158, 115	97, 0, 75, 0		
	Yellow	240, 228, 66	10, 5, 90, 0		
	Blue	0, 114, 178	100, 50, 0, 0		
	Vermillion	213, 94, 0	0, 80, 100, 0		
	Reddish purple	204, 121, 167	10, 70, 0, 0		

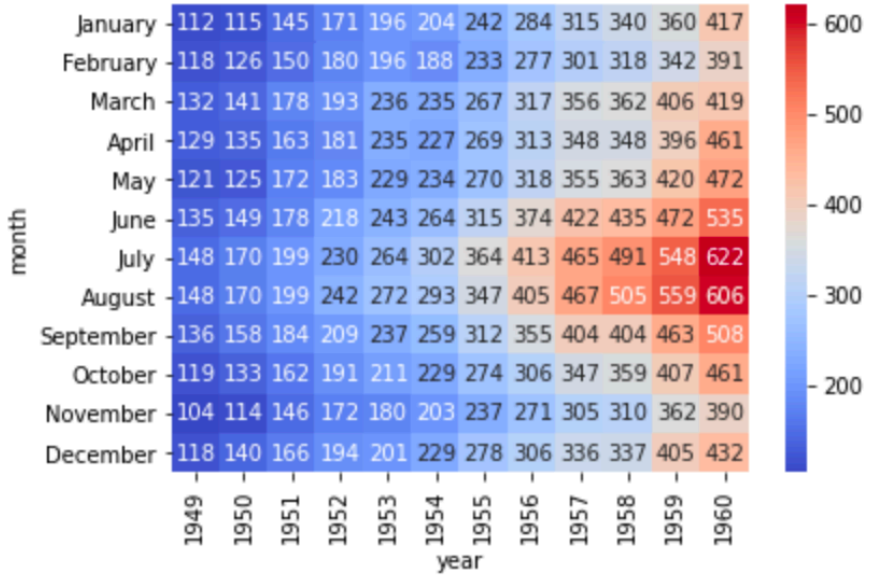
Wong, B. Points of view: Color blindness. *Nat Methods* 8, 441 (2011). https://doi.org/10.1038/nmeth.1618

Customizing color palette

```
sns.heatmap(data=matrix_data, annot=True,fmt='d',cmap='coolwarm')
```

```
sns.heatmap(data=matrix_data, annot=True,fmt='d',cmap='coolwarm')
```

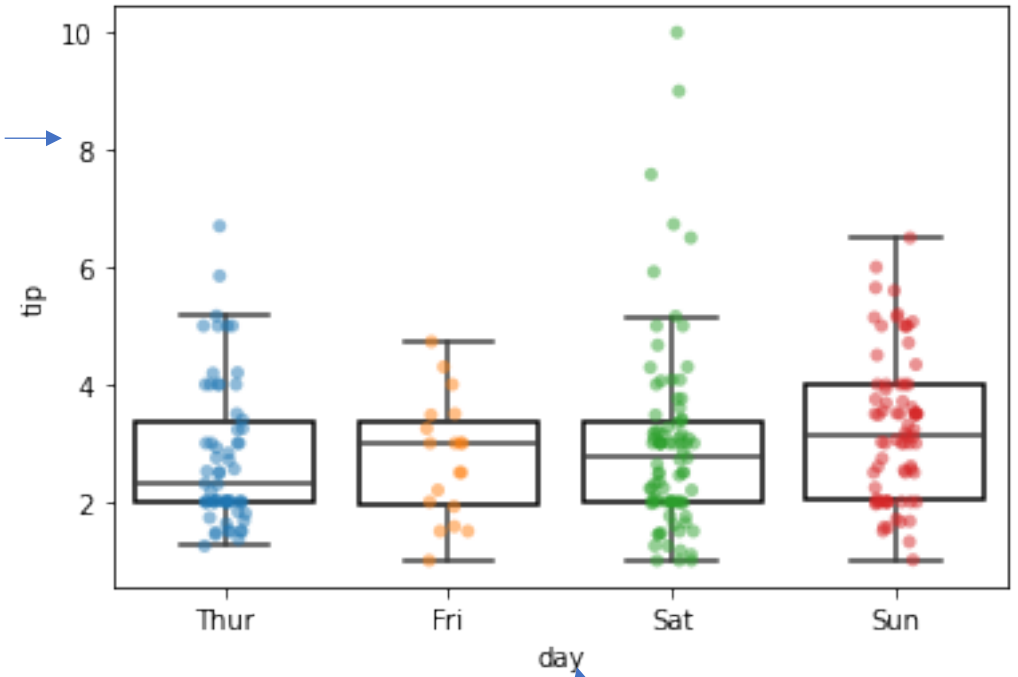
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f7451a3c780>
```



Aesthetics of figure

remove the top and right spines from the plot

size of labels



increase text

Parameters to improve aesthetics

- sns.set_style('*style_name*')
  - These styles impact the aesthetics of the plot (primarily the axes and background)
  - Options include 'darkgrid', 'whitegrid', 'dark', 'white', and 'ticks'
- sns.set_context('*context_name*')
  - These contexts impact the size of labels, lines and other elements
  - Options include 'paper', 'notebook', 'talk', and 'poster'
- sns.despine()
  - This is not global, but is a nice utility to use on individual plots
  - It removes the top and right spines from the plot

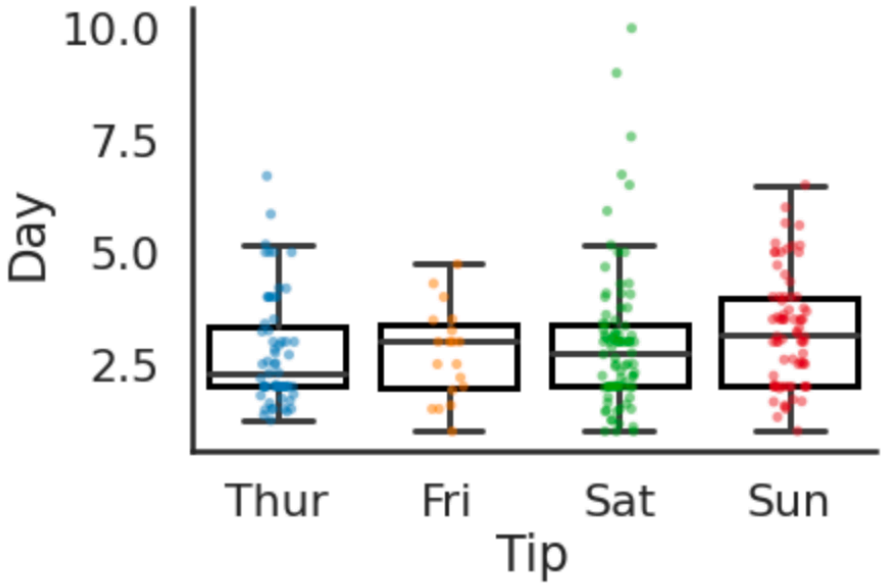
Let’s practice

```
g=sns.set_style("white")
g=sns.set_context("poster")
g=sns.boxplot(data=categorical_data, x='day',
y='tip',fliersize=0,boxprops=dict({'edgecolor': 'black', 'facecolor': (1,1,1,0)}))
g=sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
g.set(xlabel='Tip', ylabel='Day')
g=sns.despine()
```


Editing axis titles to change the label text (make it more descriptive)

Let’s practice

```
g=sns.set_style("white")
g=sns.set_context("poster")
g=sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0,boxprops=dict({'edgecolor': 'black', 'facecolor': (1,1,1,0)}))
g=sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
g.set(xlabel='Tip', ylabel='Day')
g=sns.despine()
```



Saving plots to a file

- Once you are satisfied with your figure, you can save it to a file
- This is done with the matplotlib savefig function, which requires the filename as an argument

Format of file

The file extension you use in your filename determines the filetype it is saved as

In Google Colab, you must specify the path in your filename

PNG vs PDF

- While PNG and PDF both are formats you can save a figure as, they have different properties
  - PNG files are rasterized, meaning that it's already been converted to pixels
  - PDF files are vector images, meaning they are still defined as vectors on a cartesian plane
- Why does this distinction matter?
  - If you save a file as a raster image, it is no longer editable
    - Increasing the size of the image increases the size of the pixels
  - A vector image is still editable
    - increasing the size of the image will properly scale the entire plane accordingly
- It is recommended to always save plots as vector images, if possible, so that it can be edited/scaled as necessary later

Import `matplotlib`

```
import matplotlib.pyplot as plt
```

Let’s practice

Import matplotlib

```
import matplotlib.pyplot as plt
sns.set_style("white")
sns.set_context("poster")
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0,boxprops=dict({'edgecolor':
'black', 'facecolor': (1,1,1,0)}))
g=sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
g.set(xlabel='Tip', ylabel='Day')
sns.despine()
plt.savefig("/content/drive/My Drive/data_science_workshop/boxplot.pdf")
```

Path to Google Drive
Make sure rive already mounted

Directory you created in your Google Drive

Pdf file to be created with the figure

```
from google.colab import drive
drive.mount('/content/drive')
```

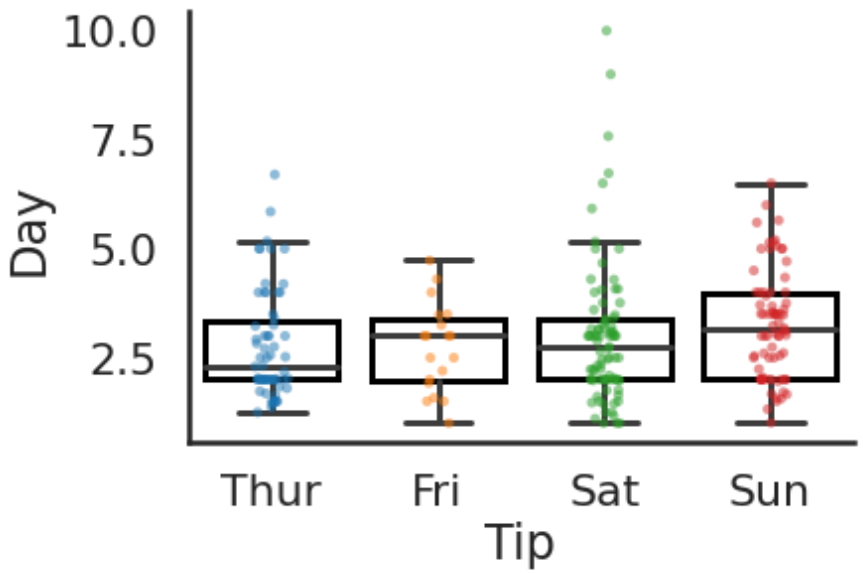
Let’s practice

```
import matplotlib.pyplot as plt
sns.set_style("white")
sns.set_context("poster")
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0,boxprops=dict({'edgecolor':
'black', 'facecolor': (1,1,1,0)}))
g=sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
g.set(xlabel='Tip', ylabel='Day')
sns.despine()
plt.savefig("/content/drive/My Drive/data_science_workshop/boxplot.pdf")
```

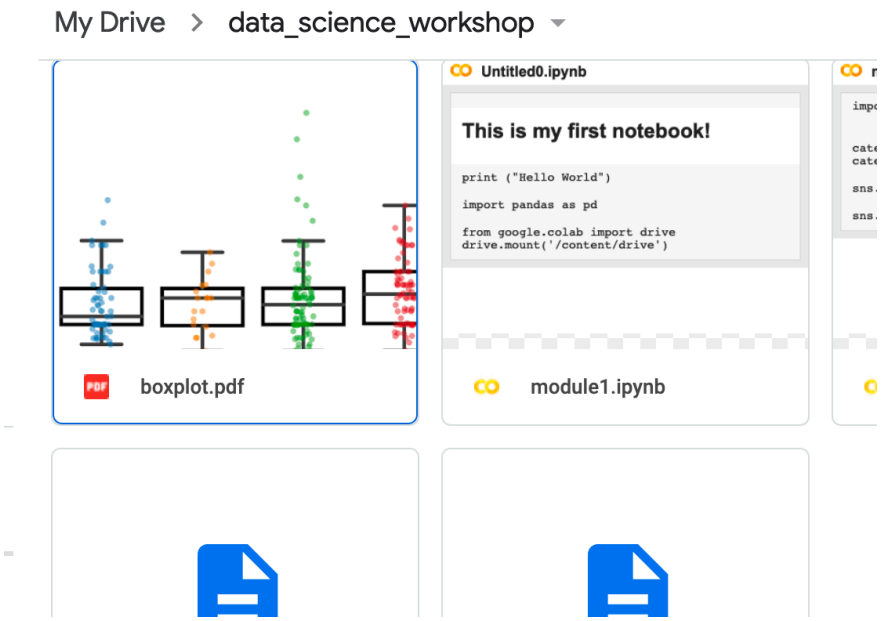
- The **set** function is used to assign value to some parameters of the plot (e.g., xlabel, ylabel, title, etc)
- **Set** is applied to an Axes object, which is returned by the functions **sns.barplot** and **sns.stripplot**
  - In the example, the variable **g** stores the Axes object when we run the **sns.stripplot** function
  - Then we **set** the values of the **xlabel** and **ylabel** calling the function set at the variable **g**
  - Creating the variable **g** at the **sns.boxplot** line would also work

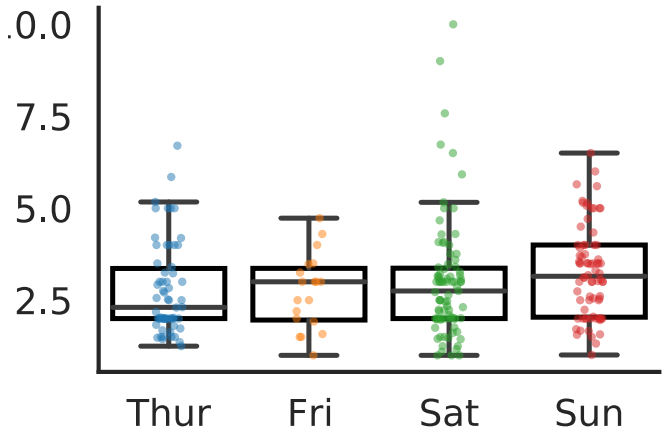
Let’s practice

```
import matplotlib.pyplot as plt
sns.set_style("white")
sns.set_context("poster")
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0,boxprops=dict({'edgecolor': 'black', 'facecolor': (1,1,1,0)}))
g = sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
g.set(xlabel='Tip', ylabel='Day')
sns.despine()
plt.savefig("/content/drive/My Drive/data_science_workshop/boxplot.pdf")
```



Let’s open the file





Fit the issues of truncated figure

```
g.set(xlabel='Tip', ylabel='Day')
```

- If you customize your plot legend to be outside of that range, or if you have plot elements that extend beyond that range, they can be cut out of the saved figure.

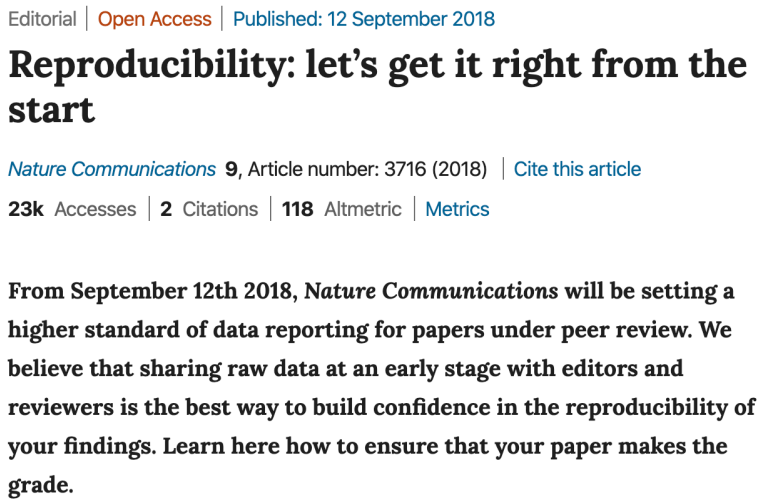
- By using bbox_inches='tight' , you will make sure to encapsulate all plot elements in the tightest bbox possible. This makes sure those elements aren't cut out.

```
import matplotlib.pyplot as plt
sns.set_style("white")
sns.set_context("poster")
sns.boxplot(data=categorical_data, x='day', y='tip',fliersize=0,boxprops=dict({'edgecolor': 'black', 'facecolor': (1,1,1,0)}))
g = sns.stripplot(data=categorical_data, x='day', y='tip',alpha=.5)
g.set(xlabel='Tip', ylabel='Day')
sns.despine()
plt.savefig("/content/drive/My Drive/data_science_workshop/boxplot.pdf",bbox_inches='tight')
```

Added

Nature Requirements: Reporting Summary

- Required with submission to any Nature family journal
- Sets out guidelines for submitting reproducible work
- This impacts how we must produce and share data and visualizations



Editorial | Open Access | Published: 12 September 2018

Reproducibility: let's get it right from the start

Nature Communications **9**, Article number: 3716 (2018) | Cite this article

23k Accesses | **2** Citations | **118** Altmetric | Metrics

From September 12th 2018, *Nature Communications* will be setting a higher standard of data reporting for papers under peer review. We believe that sharing raw data at an early stage with editors and reviewers is the best way to build confidence in the reproducibility of your findings. Learn here how to ensure that your paper makes the grade.

https://www.nature.com/articles/s41467-018-06012-8

Steps to comply with requirements and beyond

1

Share data filtering and preprocessing of the data

2

Use effective visualization to show distribution and underlying data points

3

Share the code and data to make it reproducible