Data visualization with Matplotlib and Seaborn

Aprendizaje Automático para la Robótica
Máster Universitario en Ingeniería Industrial

Departamento de Automática

Universidad de Alcalá
ISG

Objectives

1. Motivate the importance of data visualization
2. Avoid some common mistakes in data visualization
3. Choose the proper visualization technique
4. Overview Matplotlib
5. Introduce Seaborn

Bibliography

Jake VanderPlas. *Python Data Science Handbook*. Chapters 4. O'Reilly. (Link).

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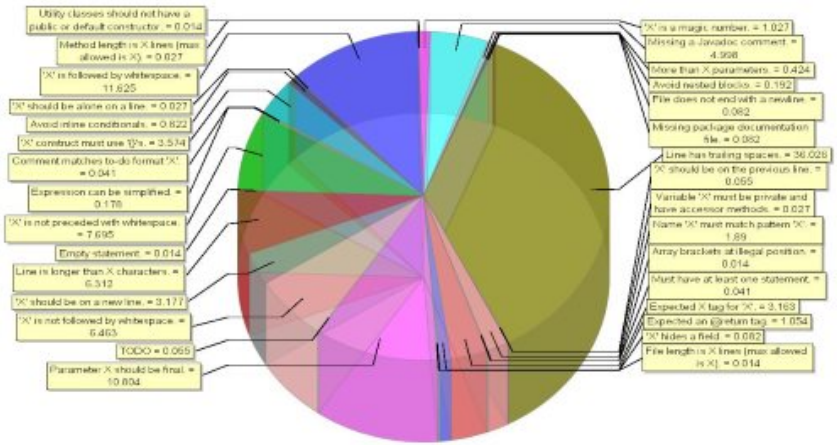
Visualization examples (I)



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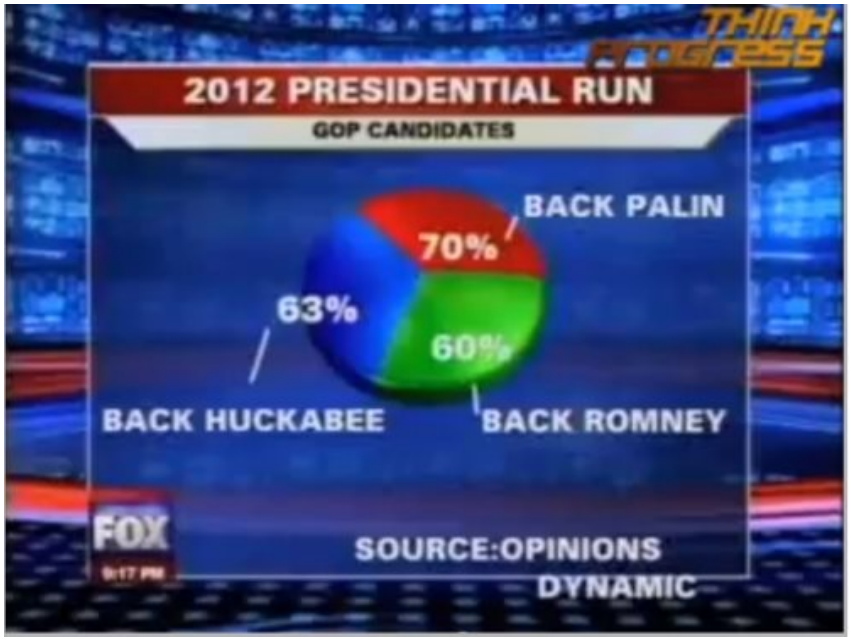

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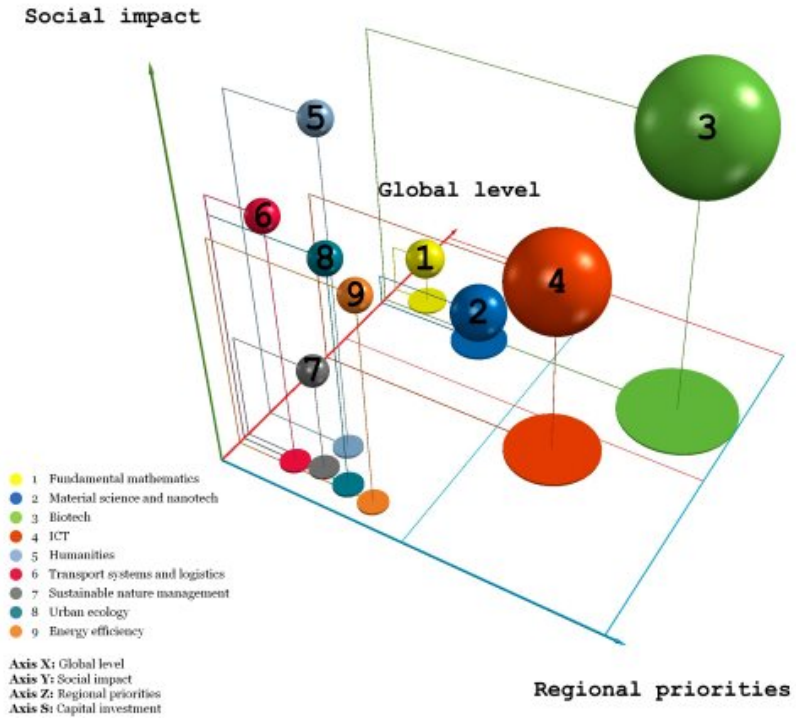
Visualization examples (II)



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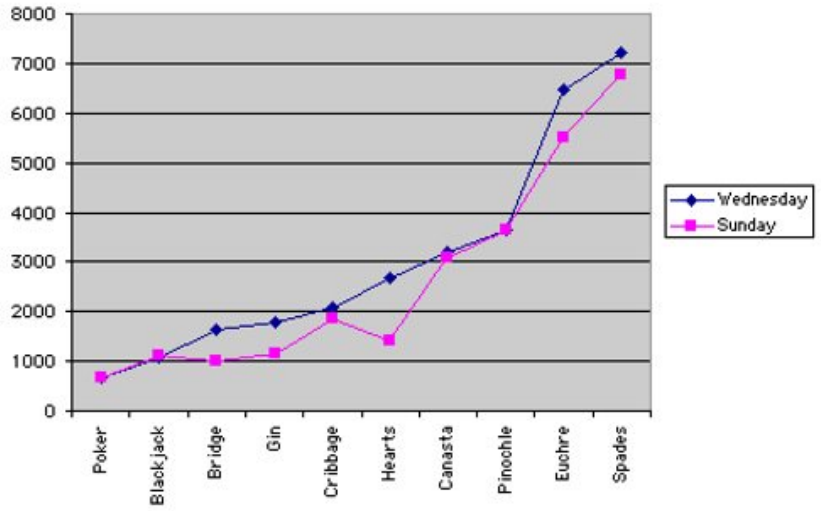

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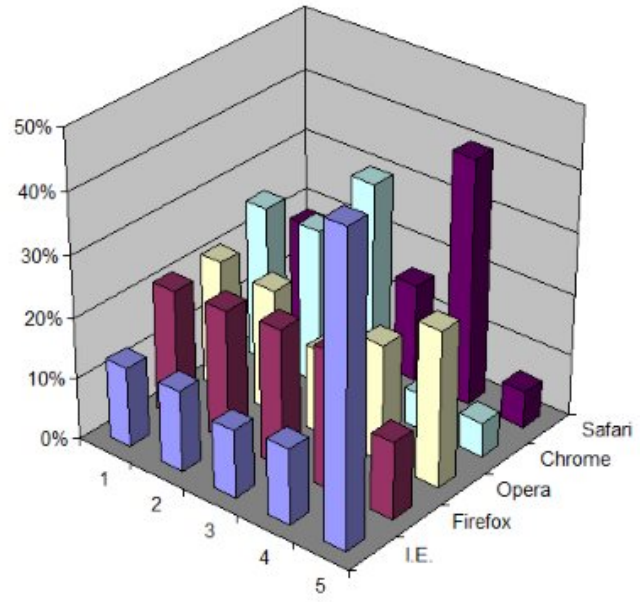
Visualization examples (III)



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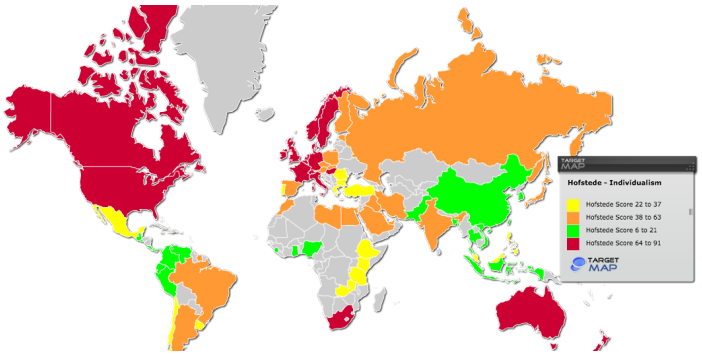

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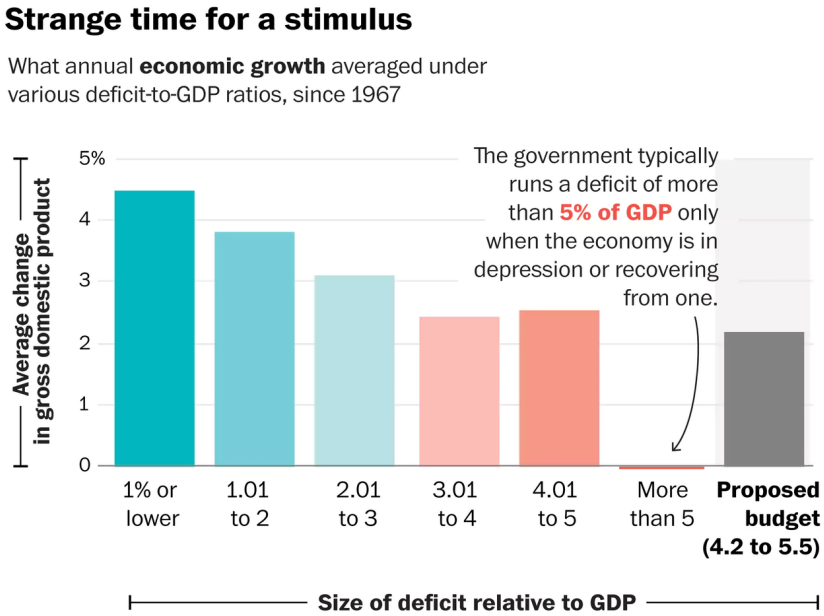
Visualization examples (IV)



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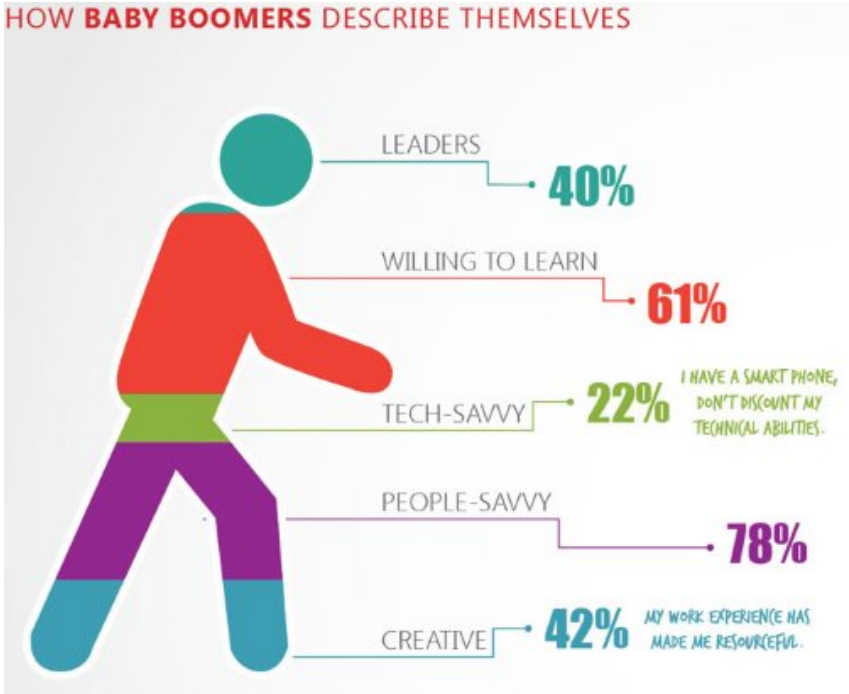

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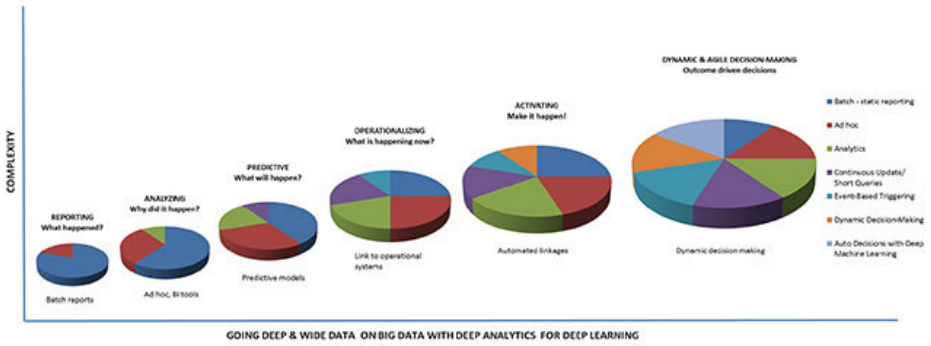
Visualization examples (V)



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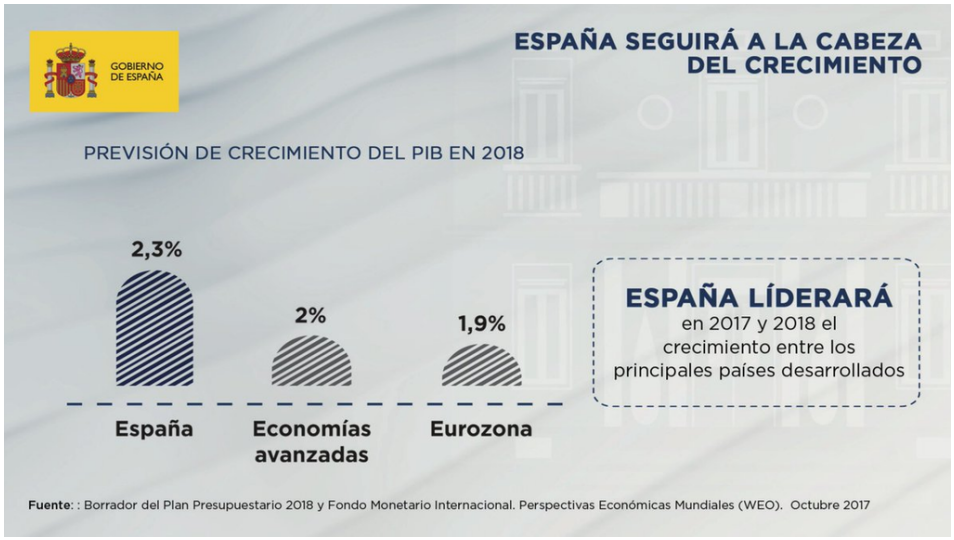


(Source)

Motivation (I)

Efficient data visualization tips

- **Define your story**
- The chart must tell the story
- Don't distract from your story (with irrelevant data or visual elements)
- One story, one chart
- Put the story comprension in first term
- Better several simple charts than one complex chart
- Choose colors wisely (color scale or high contrast)
- Elements order must support the story (leyend, bars, etc)
- There is life beyond pies and bars
- Keep it simple, stupid!

Motivation (II)

Know your data

- Categorical or numerical
- Number of dimensions to represent (1D, 2D, 3D, more dimensions)

Can you use other representation?

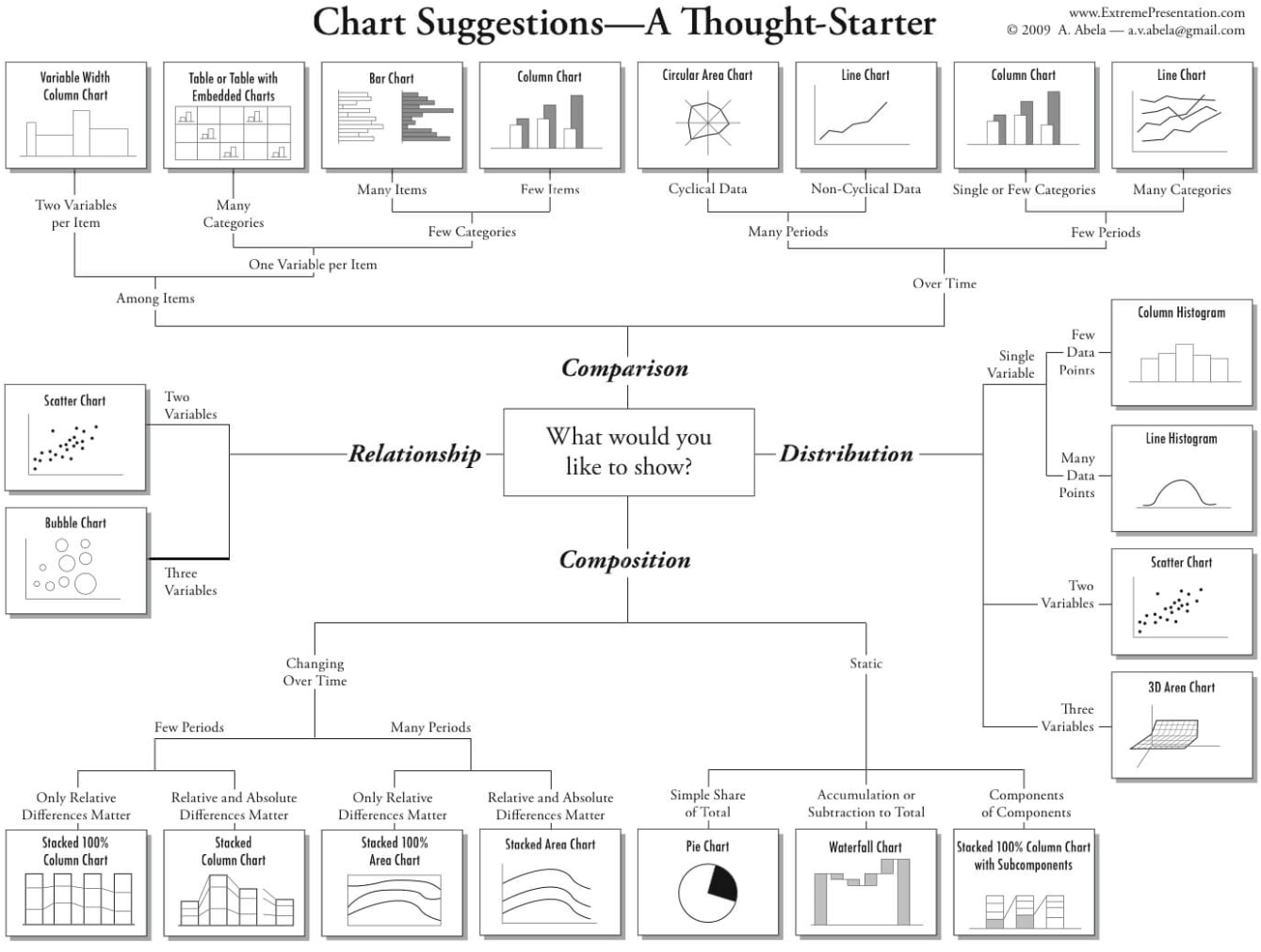
- Chart better than table? ...
- ... that depends

What do you want to represent?

- Distribution, relationship, comparison or composition

Look for templates: (`https://python-graph-gallery.com/`)

Motivation (III)



(Source)

(Alternative resource)

Matplotlib (I)

Matplotlib is a Python package

- Based on NumPy
- Imitates Matlab

Three operation modes

- Scripts.
  Must use `plt.show()` to enter event loop. Use it once!
- IPython shell.
  Must use `%matplotlib`
- IPython notebook. Two modes
  - `%matplotlib inline`
  - `%matplotlib notebook`

Convention

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

myplot.py

```
import matplotlib.pyplot as plt
import numpy as np

x = np.linspace(0, 10, 100)

plt.plot(x, np.sin(x))
plt.plot(x, np.cos(x))

plt.show()
```

Matplotlib (II)

Matplotlib comes with two interfaces

- Matlab-like. Old-fashioned function-oriented API.
- Object-oriented. Object-oriented and more powerfull API.

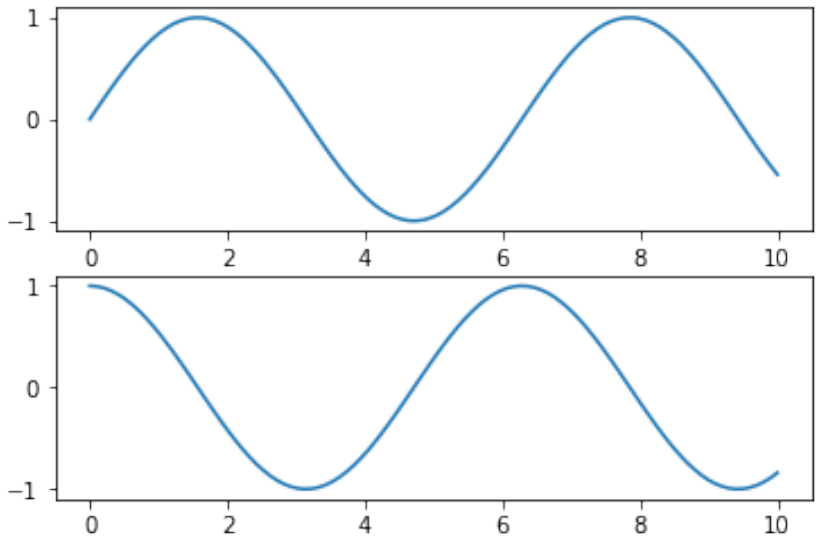
Matlab API

```
plt.figure()  # create a plot

# create the first of two panels
    and set current axis
plt.subplot(2, 1, 1) # (rows,
    columns, panel number)
plt.plot(x, np.sin(x))

# create the second panel and
    set current axis
plt.subplot(2, 1, 2)
plt.plot(x, np.cos(x));
```

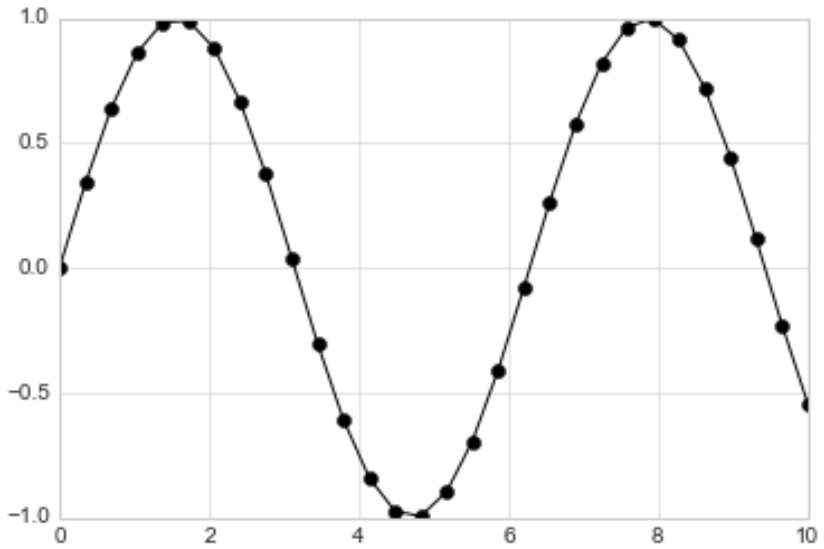
OO API

```
# First create a grid of plots
# ax will be an array of two
    Axes objects
fig, ax = plt.subplots(2)

# Call plot() method on the
    appropriate object
ax[0].plot(x, np.sin(x))
ax[1].plot(x, np.cos(x));
```

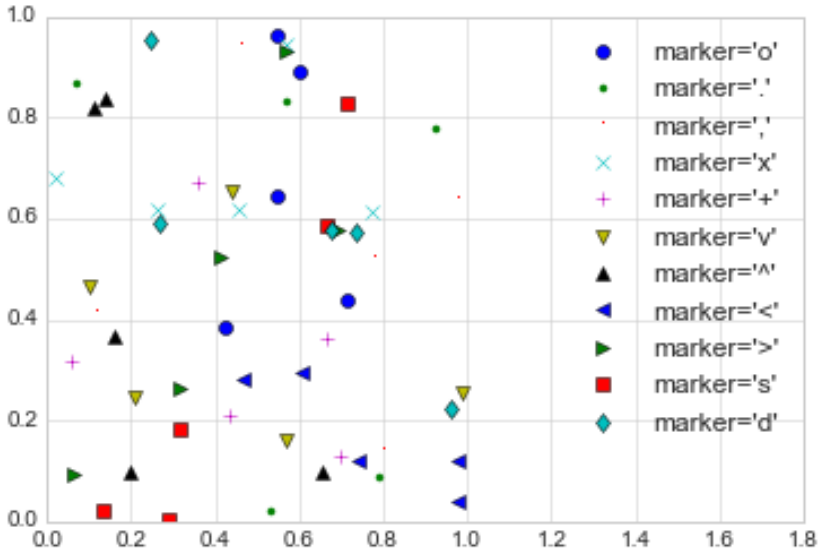
Matplotlib (III)



Matplotlib (IV)

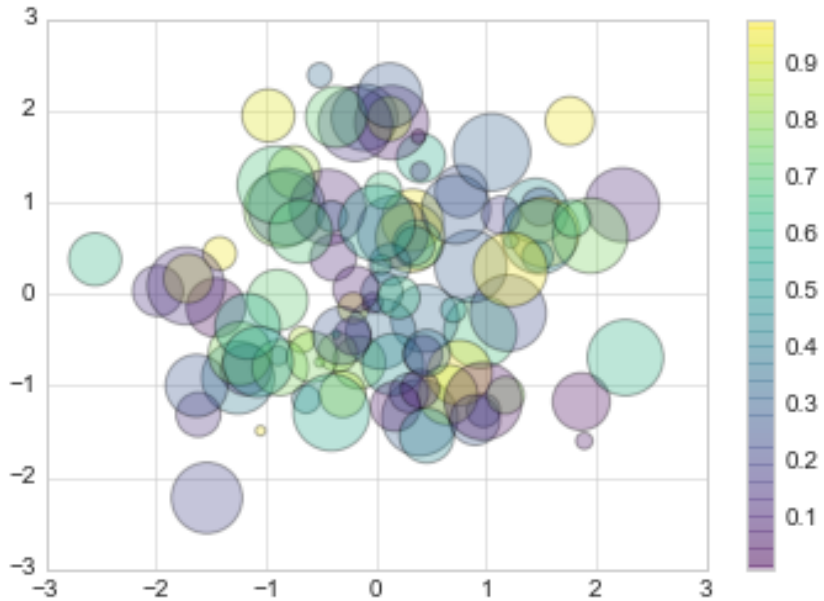



```
plt.plot(x, np.sin(x), '-ok',
         color='black')
```

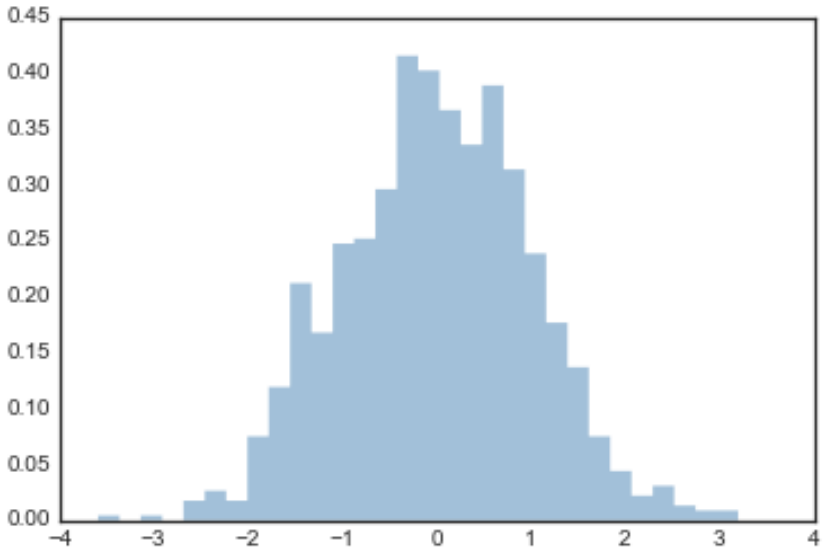



```
for marker in ['o', '.', ',', 'x', '+', 'v', '^', '
    <', '>', 's', 'd']:
    plt.plot(rng.rand(5), rng.rand(5), marker,
        label="marker='{0}'".format(marker))
plt.legend(numpoints=1)
plt.xlim(0, 1.8);
```

Matplotlib (V)



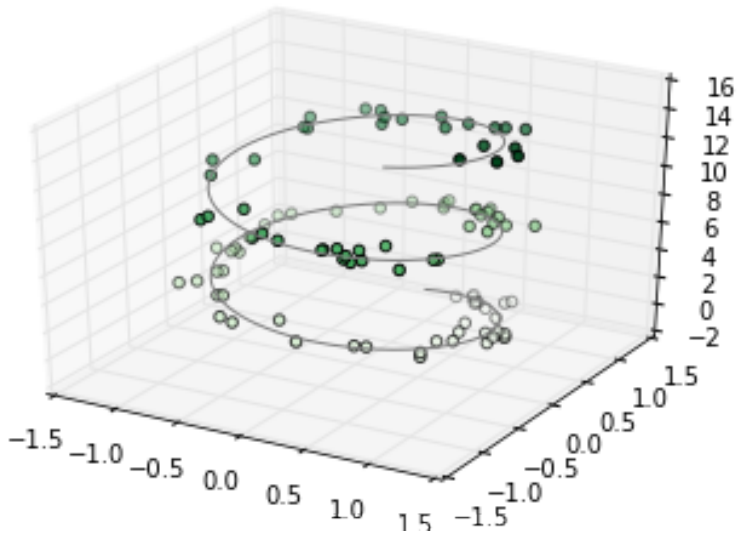

```
rng = np.random.RandomState(0)
x = rng.randn(100)
y = rng.randn(100)
colors = rng.rand(100)
sizes = 1000 * rng.rand(100)

plt.scatter(x, y, c=colors, s=sizes, alpha=0.3,
    cmap='viridis')
plt.colorbar();  # show color scale
```




```
data = np.random.randn(1000)

plt.hist(data, bins=30, normed=True, alpha=0.5,
     histtype='stepfilled', color='steelblue',
     edgecolor='none');
```

Matplotlib (VI)

```
ax = plt.axes(projection='3d')

# Data for a three-dimensional line
zline = np.linspace(0, 15, 1000)
xline = np.sin(zline)
yline = np.cos(zline)
ax.plot3D(xline, yline, zline, 'gray')

# Data for three-dimensional scattered points
zdata = 15 * np.random.random(100)
xdata = np.sin(zdata) + 0.1 * np.random.randn(100)
ydata = np.cos(zdata) + 0.1 * np.random.randn(100)
ax.scatter3D(xdata, ydata, zdata, c=zdata, cmap='
      Greens');
```



Matplotlib

Matplotlib notebook

Matplotlib notebook

(Link to notebook)

Seaborn (I)

Seaborn is a modern data-visualization Python package

- Based on matplotlib
- ... it uses matplotlib indeed
- Pandas-aware
- High level
- Advanced visualizations
- Easy to use

Still under development!

Convention

```
import seaborn as sns
```

This documentation is for Seaborn 0.9 or newer

Seaborn (II)

Display initialization

- `plt.show()`
- `%matplotlib`

Style initialization

- Default Seaborn style `sns.set()`
- By default, same style than matplotlib

Several functions ...

- ... similar parameters

Parameters

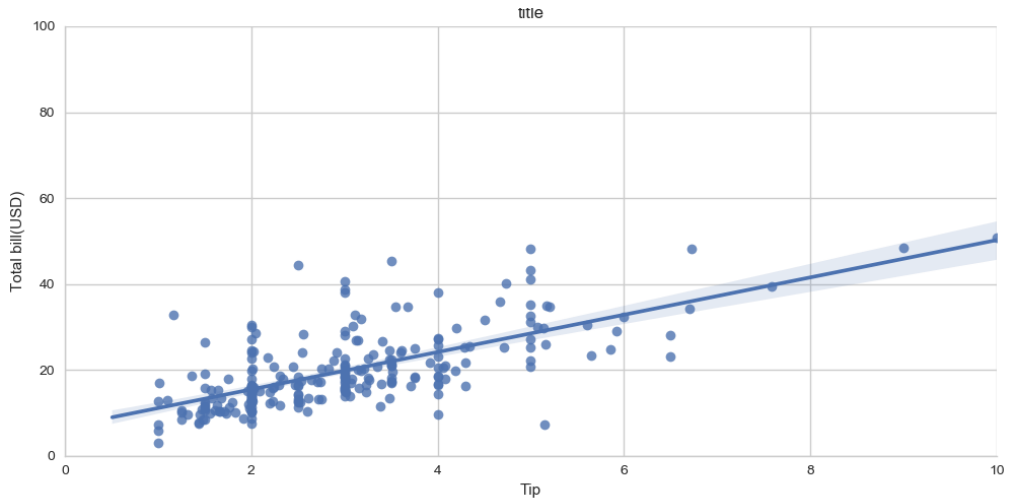
- x: Data axis x
- y: Data axis Y
- data: Dataframe name
- hue: Color
- style: Style
- sizes: Size
- kind: Alternate representation

Seaborn (III)

Typical Seaborn usage

1. Prepare data
2. Set up aesthetics
3. Plot
4. Customize the plot

```
import matplotlib.pyplot as plt
import seaborn as sns
# Prepare data
tips = sns.load_dataset("tips")
# Set up aesthetics
sns.set_style("whitegrid")
# Plot
g = sns.lmplot(x="tip",y="total_bill", data=tips,aspect=2)
# Plot customization
g = (g.set_axis_labels("Tip","Total bill(USD)").set(xlim
    =(0,10),ylim=(0,100)))
plt.title("title")
plt.show(g)
```



Seaborn

Datasets (I)

Seaborn comes with several dummy datasets

- `sns.load_dataset('name')`

We will use two datasets

- 'iris': The classical iris dataset, numerical
- 'tips': Numeric and categorical variables

Tips dataset

```
»> tips = sns.load_dataset('tips')
»> print(tips.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

Datasets (II)

Iris dataset

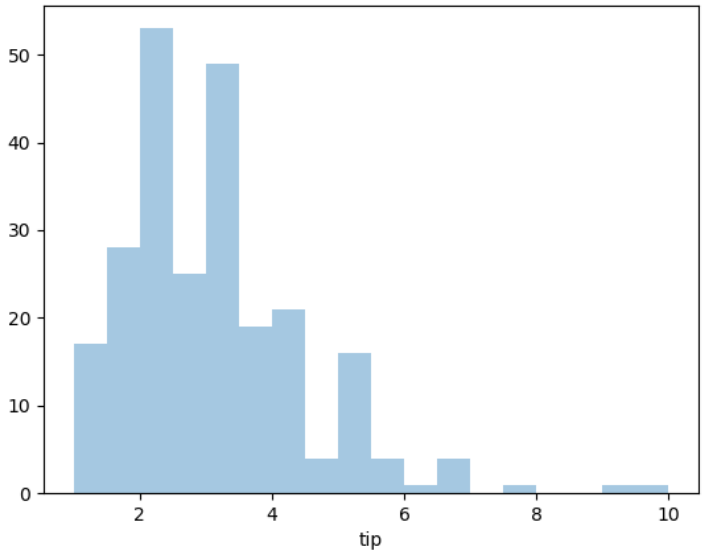
```
»> iris = sns.load_dataset('iris')
»> print(iris.head())
```

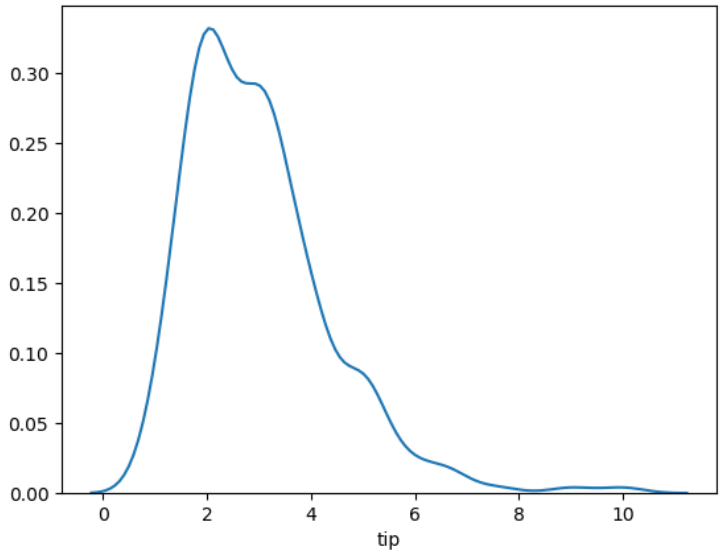
	sepal_length	sepal_width	petal_length	petal_width	species
0	5.1	3.5	1.4	0.2	setosa
1	4.9	3.0	1.4	0.2	setosa
2	4.7	3.2	1.3	0.2	setosa
3	4.6	3.1	1.5	0.2	setosa
4	5.0	3.6	1.4	0.2	setosa

(Source)

Seaborn

Distributions (I)





Histogram

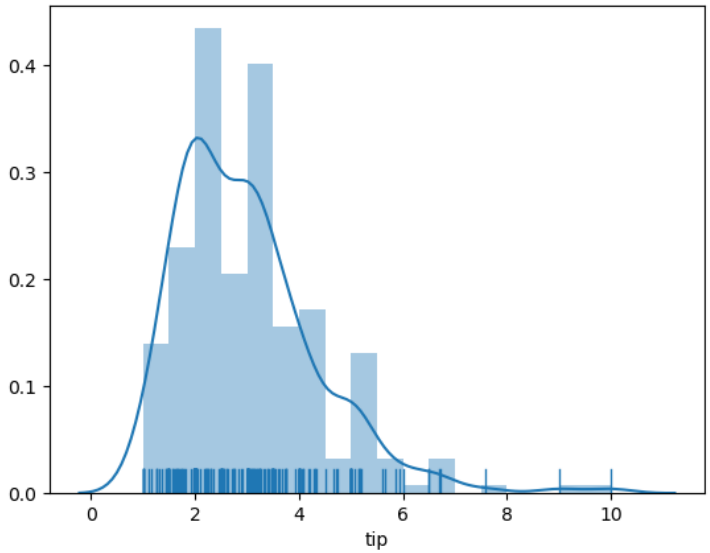
```
sns.distplot(tips['tip'],
    kde=False)
```

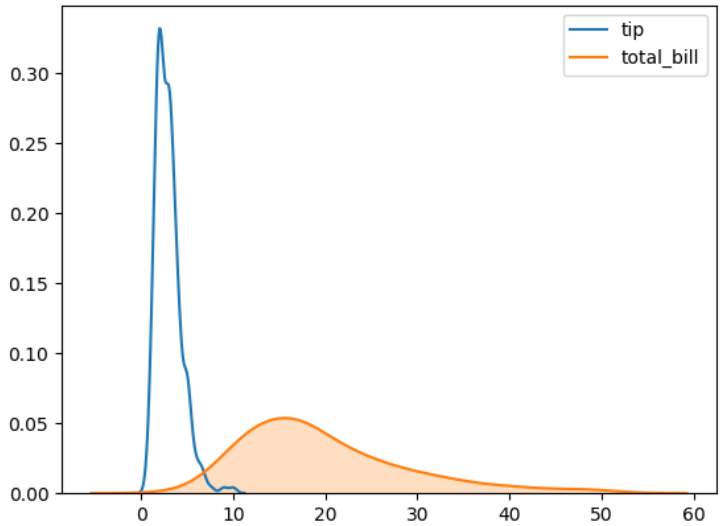
Density plot

```
sns.distplot(tips['tip'],
    hist=False)
```

Seaborn

Distributions (II)





Histogram + density plot

```
sns.distplot(tips['tip'],
    rug=True)
```

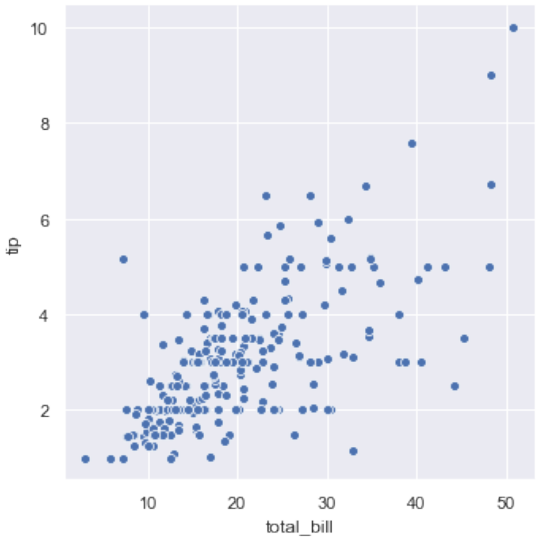
Density plot

```
sns.kdeplot(tips['tip'])
sns.kdeplot(tips['total_bill
    '], shade=True)
```

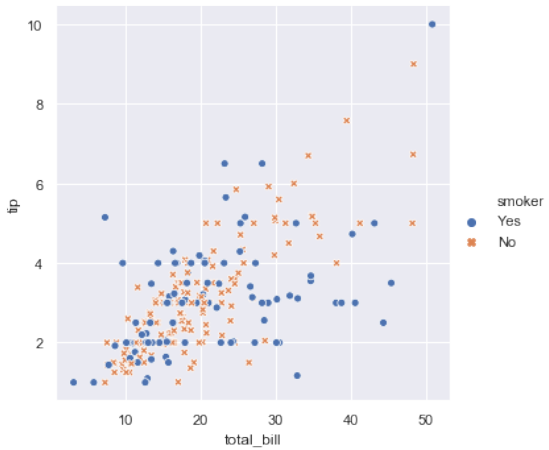
Seaborn

Relationships (I)

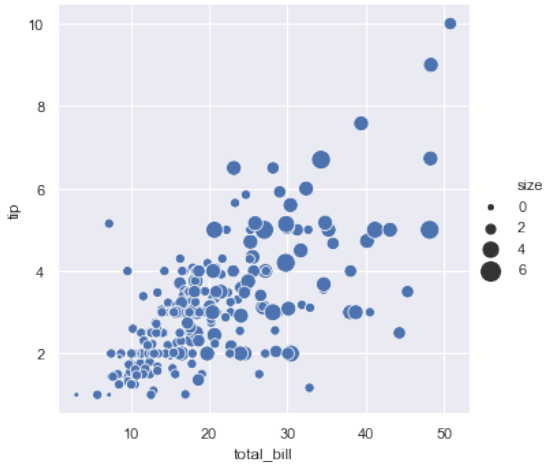
Scatterplots




```
sns.relplot(x="total_bill", y="
    tip", data=tips)
```



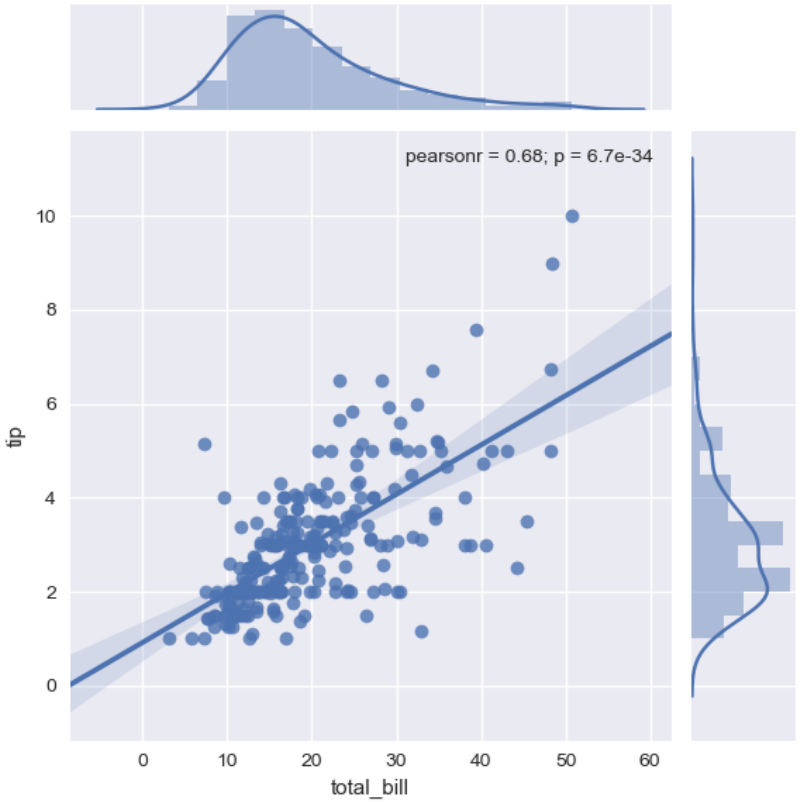

```
sns.relplot(x="total_bill", y="
    tip", hue="smoker", style="
    smoker", data=tips)
```

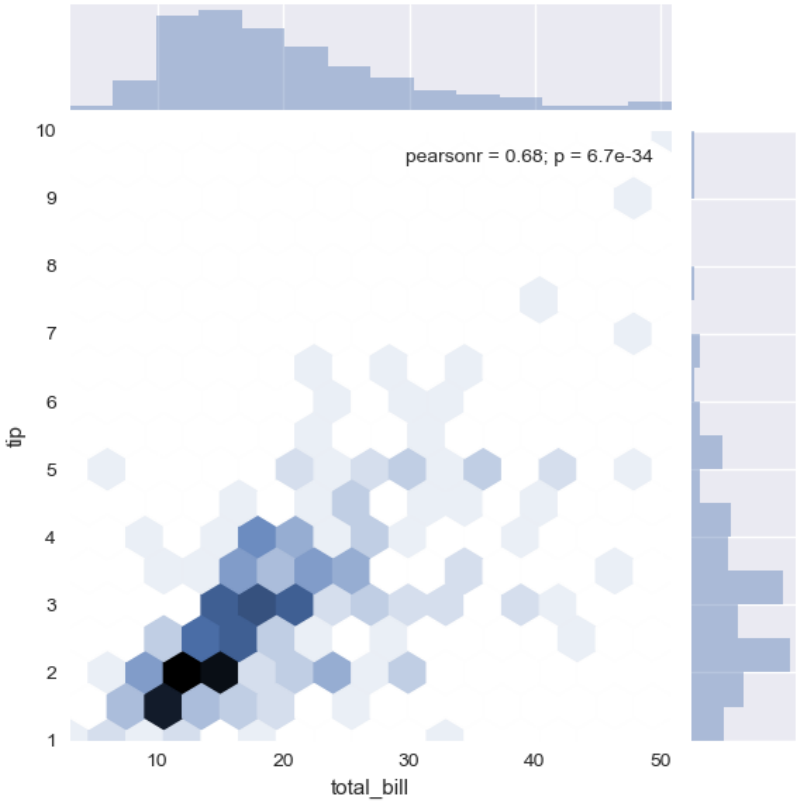



```
sns.relplot(x="total_bill", y="
    tip", size="size", sizes
    =(15, 200), data=tips);
```

Seaborn

Relationships (II)



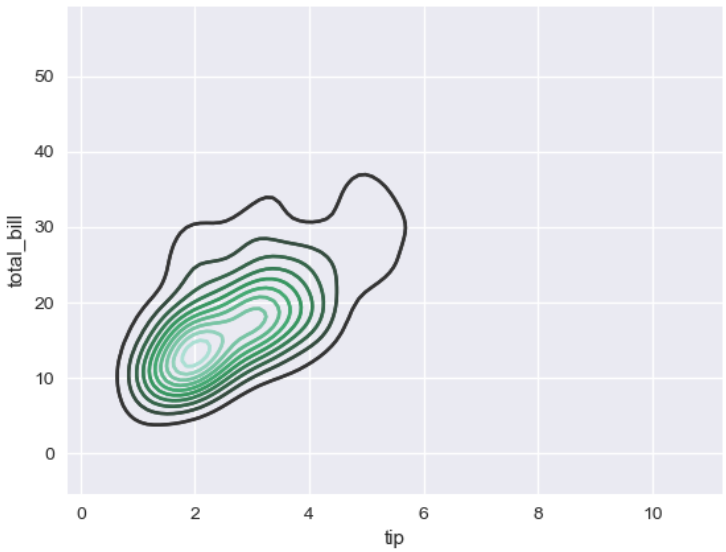



```
sns.jointplot("total_bill", "tip", tips, kind="reg")
```

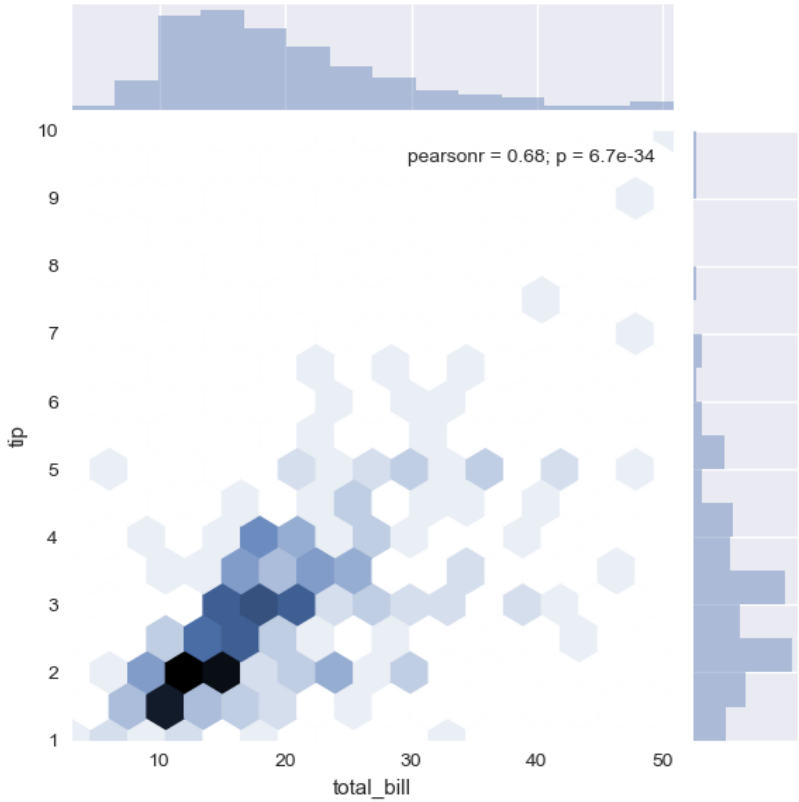
```
sns.jointplot("total_bill", "tip", tips, kind="hex")
```

Seaborn

Relationships (III)



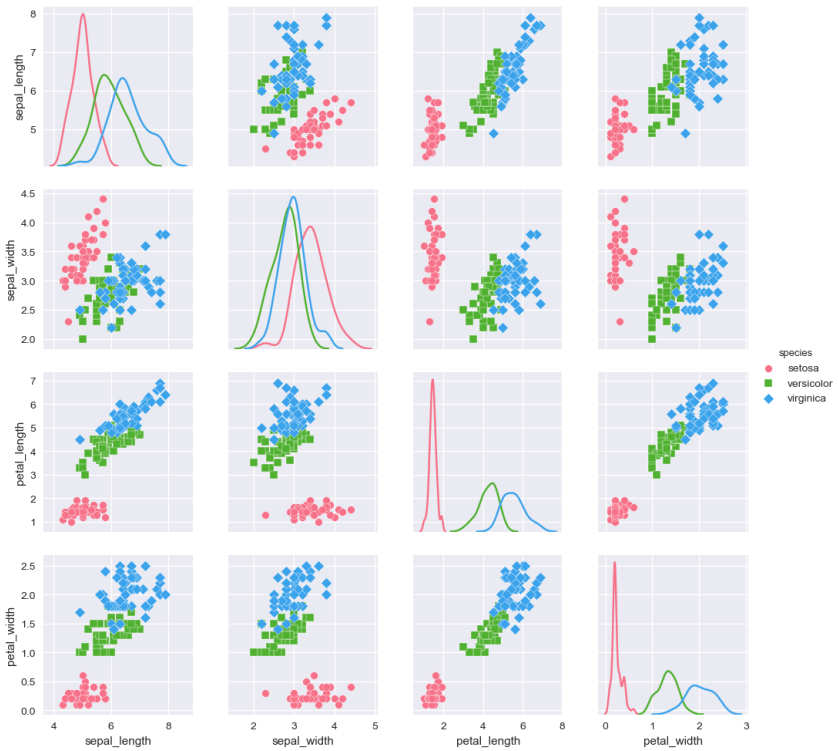

```
sns.kdeplot(tips['tip'], tips['total_bill'])
```




```
sns.jointplot("total_bill", "tip", tips , kind="hex")
```

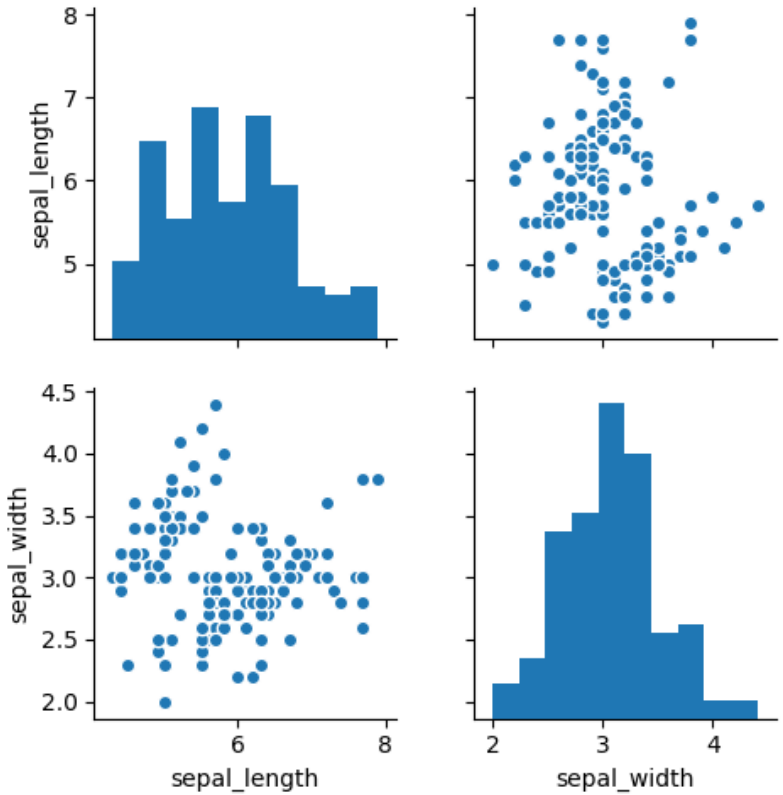
Seaborn

Relationships (IV)



Scatterplot matrix

```
sns.pairplot(iris, hue="species", palette="husl",
             markers=["o", "s", "D"], diag_kind='kde')
```

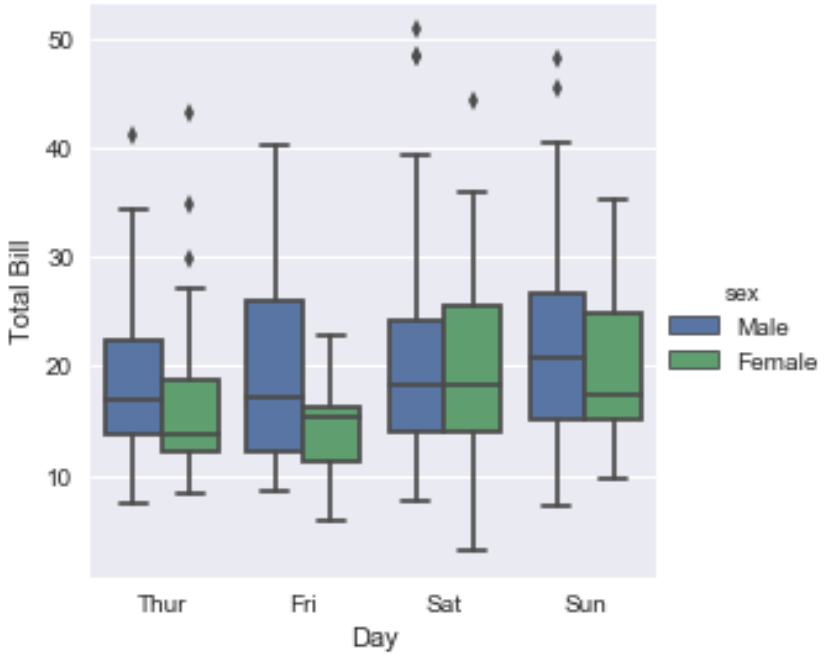


Scatterplot matrix

```
sns.pairplot(iris, vars=["sepal_length", "
             sepal_width"])
```

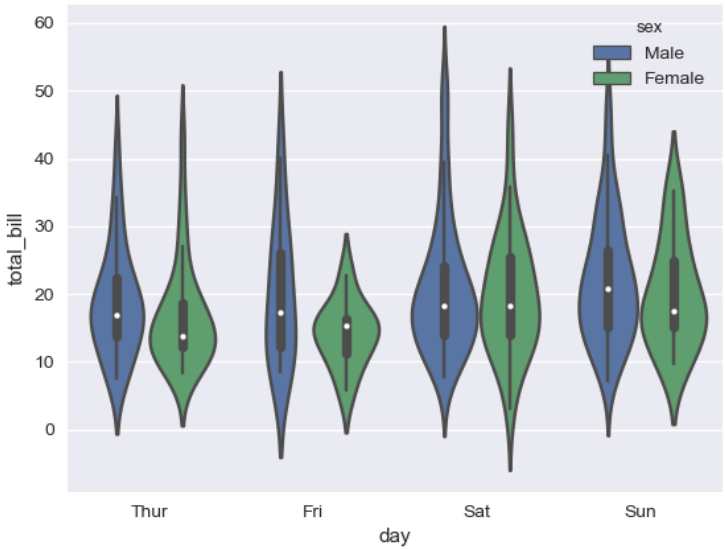
Seaborn

Comparisons (I)



Boxplot

```
with sns.axes_style(style='ticks'):
    g = sns.factorplot("day", "total_bill", "sex",
            data=tips, kind="box")
g.set_axis_labels("Day", "Total Bill")
```

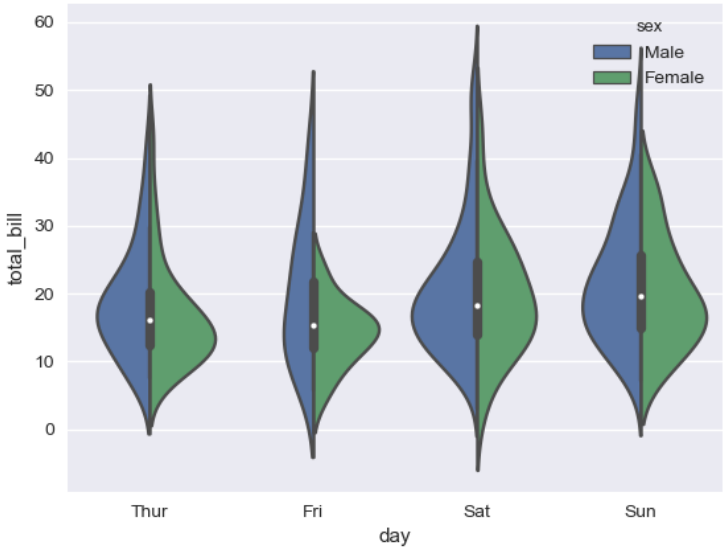


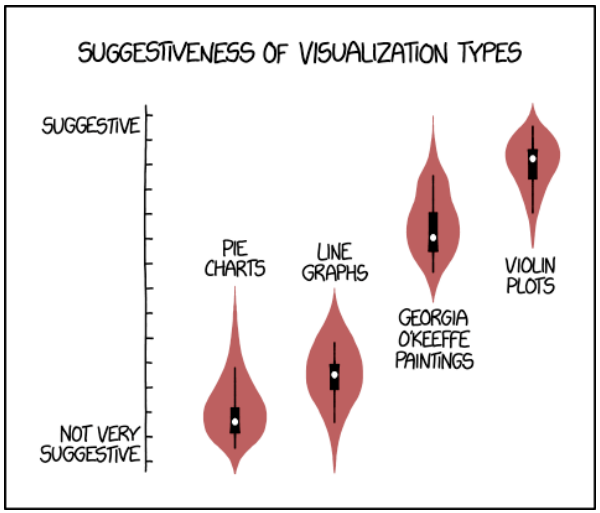
Violin plot

```
sns.violinplot("day", "total_bill", "sex", data=
    tips)
```

Seaborn

Comparisons (II)





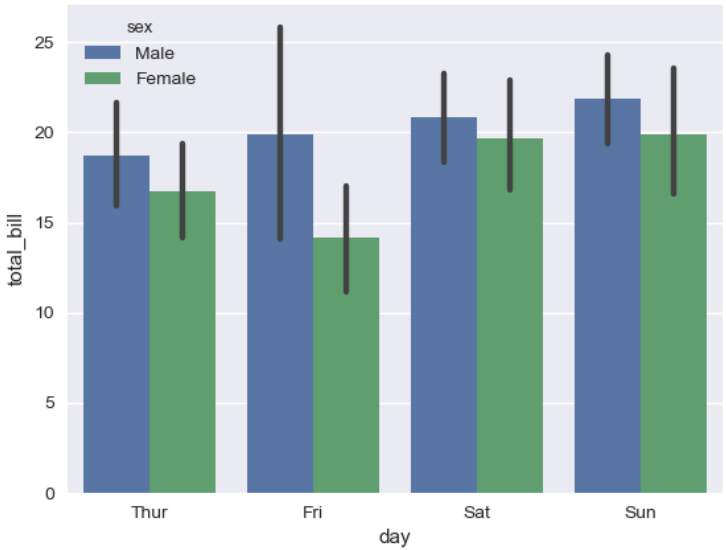
(Source)

Violin plot

```
sns.violinplot(x="day", y="total_bill", hue="sex",
        data=tips, split=True)
```

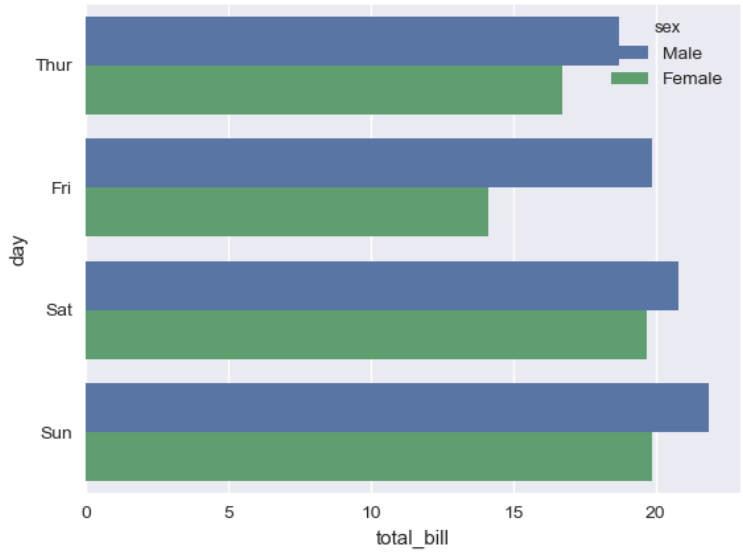
Seaborn

Barplots



Barplot

```
sns.barplot(x="day", y="total_bill", hue="sex",
        data=tips)
```

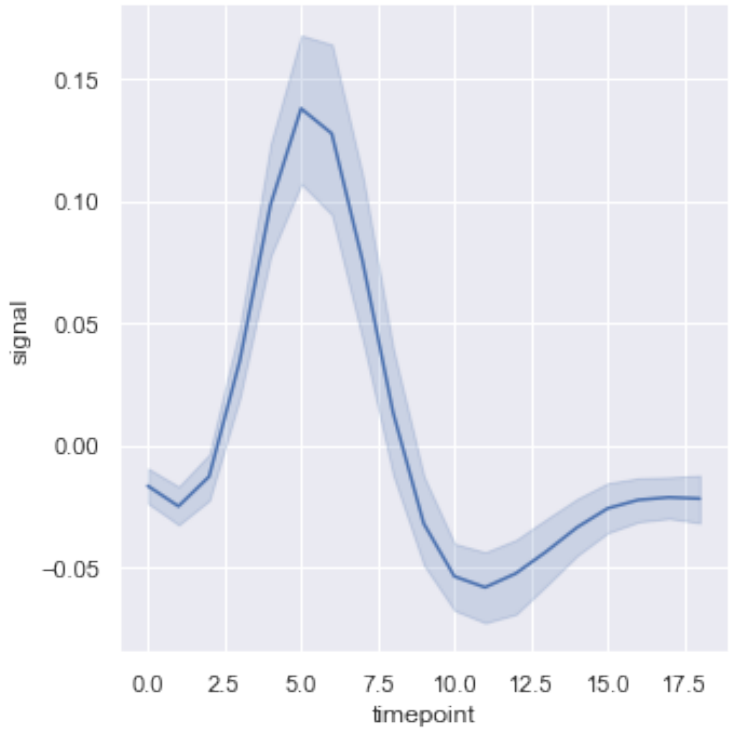


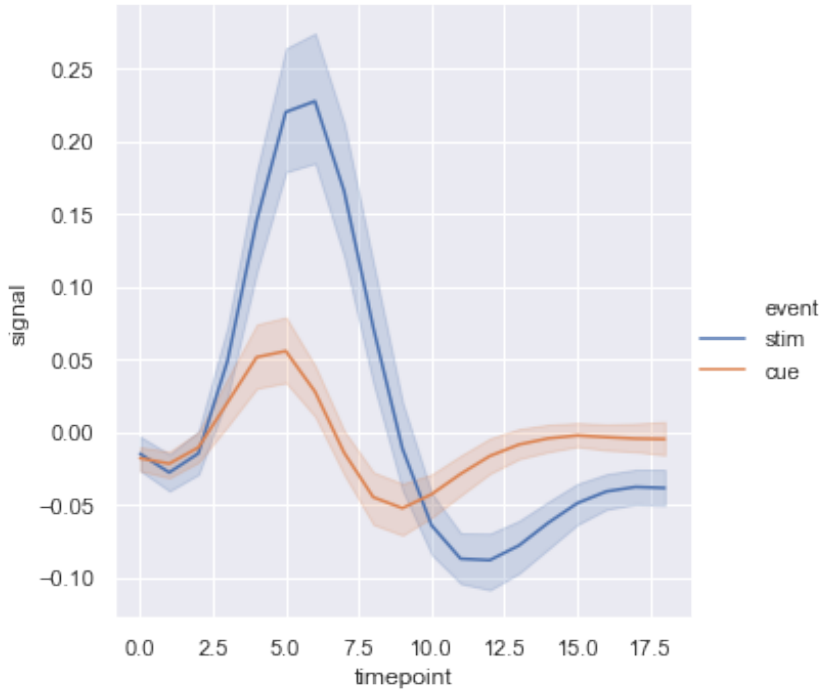
Barplot

```
sns.barplot(x="total_bill", y="day", hue="sex",
        data=tips, ci=None)
```

Seaborn

Continuity



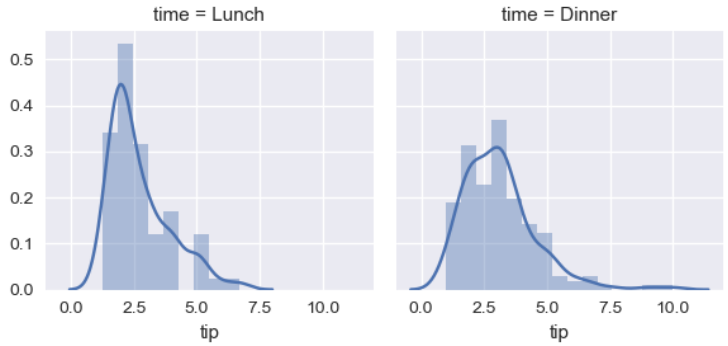



```
fmri = sns.load_dataset("fmri")
sns.relplot(x="timepoint", y="signal", kind="line",
            data=fmri)
```

```
sns.relplot(x="timepoint", y="signal", hue="event",
            kind="line", data=fmri)
```

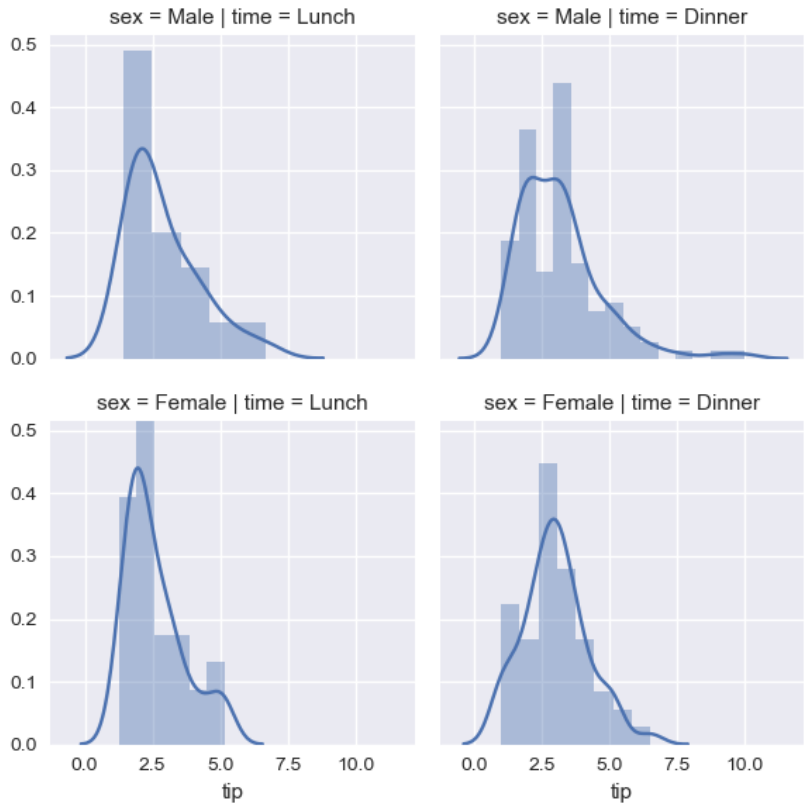
Seaborn

FacetGrid

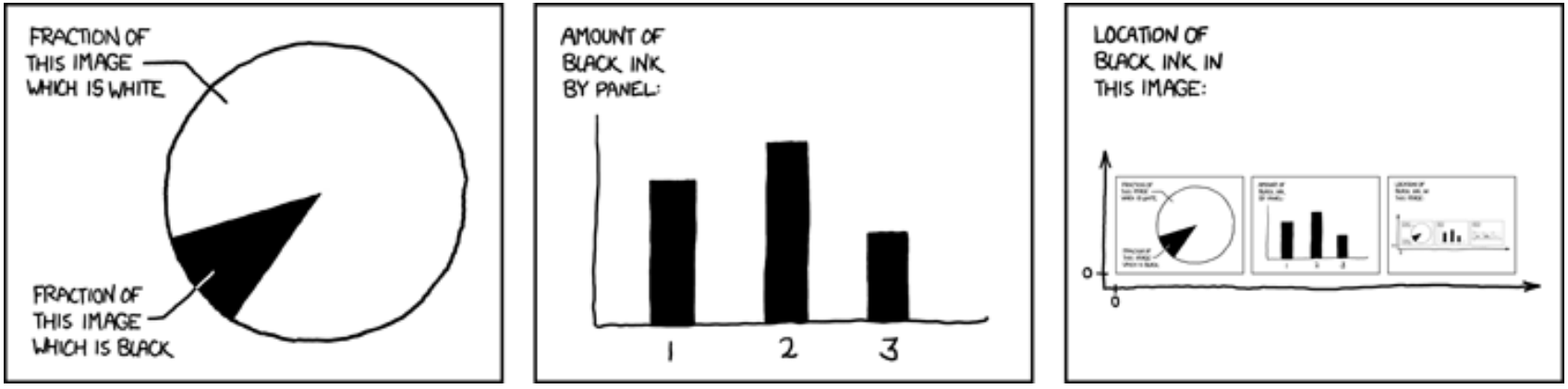



```
fmri = sns.load_dataset("fmri")
sns.relplot(x="timepoint", y="signal", kind="line",
            data=fmri)
```

Seaborn >= 0.9




```
g = sns.FacetGrid(tips, col="time", row="sex")
g.map(sns.distplot, "tip")
```


FRACTION OF THIS IMAGE WHICH IS WHITE
FRACTION OF THIS IMAGE WHICH IS BLACK
AMOUNT OF BLACK INK BY PANEL:
1
2
3
LOCATION OF BLACK INK IN THIS IMAGE:
0
0

(Source)

Seaborn

Seaborn notebook

Seaborn notebook

(Link to notebook)