What is statistics?

INTRODUCTION TO STATISTICS IN PYTHON

Maggie Matsui
Content Developer, DataCamp

datacamp

What is statistics?

- **The field of statistics** - the practice and study of collecting and analyzing data
- **A summary statistic** - a fact about or summary of some data

What can statistics do?

What is statistics?

- **The field of statistics** - the practice and study of collecting and analyzing data
- **A summary statistic** - a fact about or summary of some data

What can statistics do?

- How likely is someone to purchase a product? Are people more likely to purchase it if they can use a different payment system?
- How many occupants will your hotel have? How can you optimize occupancy?
- How many sizes of jeans need to be manufactured so they can fit 95% of the population? Should the same number of each size be produced?
- A/B tests: Which ad is more effective in getting people to purchase a product?

What can't statistics do?

- *Why* is *Game of Thrones* so popular?

Instead...

- Are series with more violent scenes viewed by more people?

But...

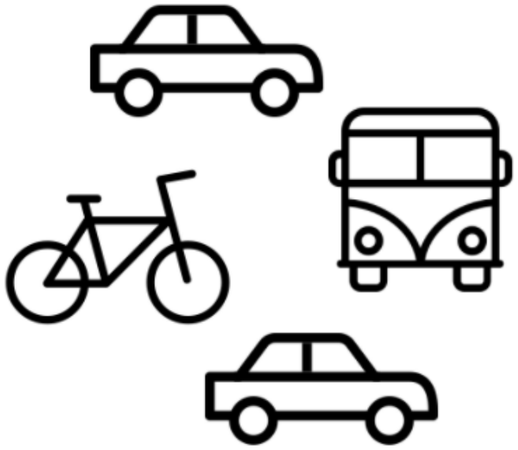
- Even so, this can't tell us if more violent scenes lead to more views

Types of statistics

take data from all

Descriptive statistics

- *Describe* and summarize data

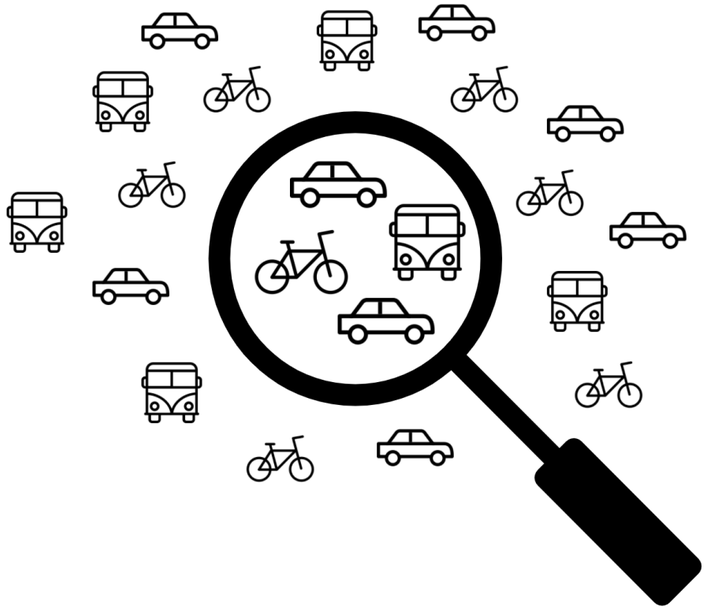


- 50% of friends drive to work
- 25% take the bus
- 25% bike

take data from a small portion

Inferential statistics

- Use a sample of data to make *inferences* about a larger population



What percent of people drive to work?

Types of data

Numeric (Quantitative)

- **Continuous (Measured)**
  - Airplane speed
  - Time spent waiting in line
- **Discrete (Counted)**
  - Number of pets
  - Number of packages shipped

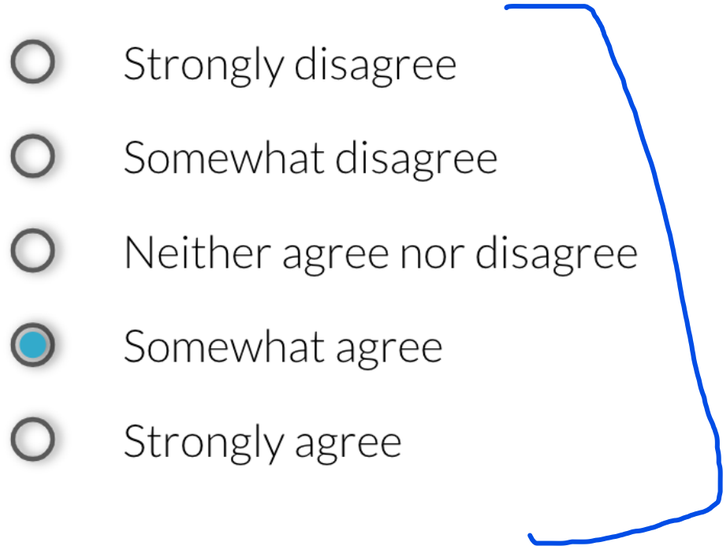
float values / continuous

only int value

Categorical (Qualitative)

- **Nominal (Unordered)**
  - Married/unmarried
  - Country of residence
- **Ordinal (Ordered)**

no value / category / string



ordered options

Categorical data can be represented as numbers

Nominal (Unordered)

- Married/unmarried (`1` / `0`)
- Country of residence (`1` , `2` , ...)

Ordinal (Ordered)

- Strongly disagree (`1`)
- Somewhat disagree (`2`)
- Neither agree nor disagree (`3`)
- Somewhat agree (`4`)
- Strongly agree (`5`)

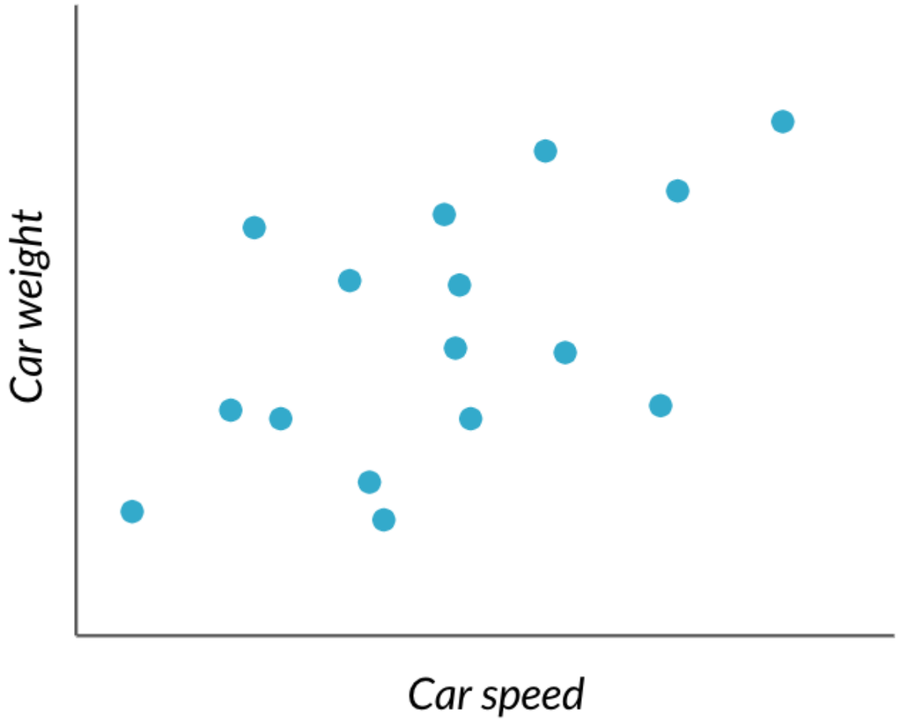
Why does data type matter?

Summary statistics

```
import numpy as np
np.mean(car_speeds['speed_mph'])
```

```
40.09062
```

Plots



Why does data type matter?

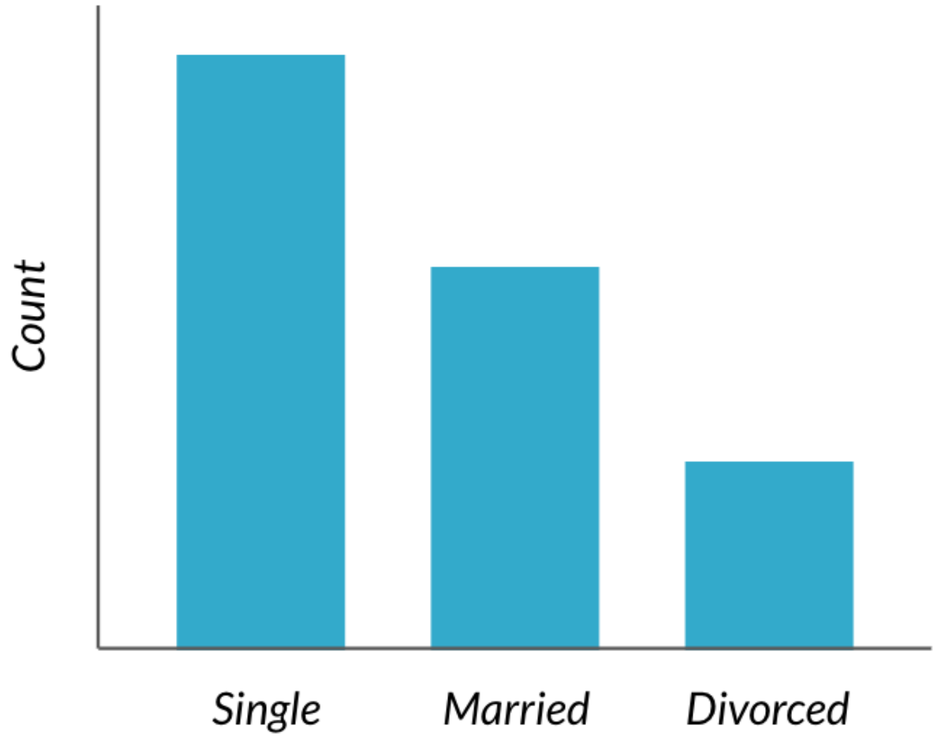
Summary statistics

```
demographics['marriage_status'].value_counts()
```

```
single      188
married     143
divorced    124
dtype: int64
```

occ of each entry in col

Plots



Let's practice!

INTRODUCTION TO STATISTICS IN PYTHON

Measures of center

INTRODUCTION TO STATISTICS IN PYTHON

Maggie Matsui
Content Developer, DataCamp

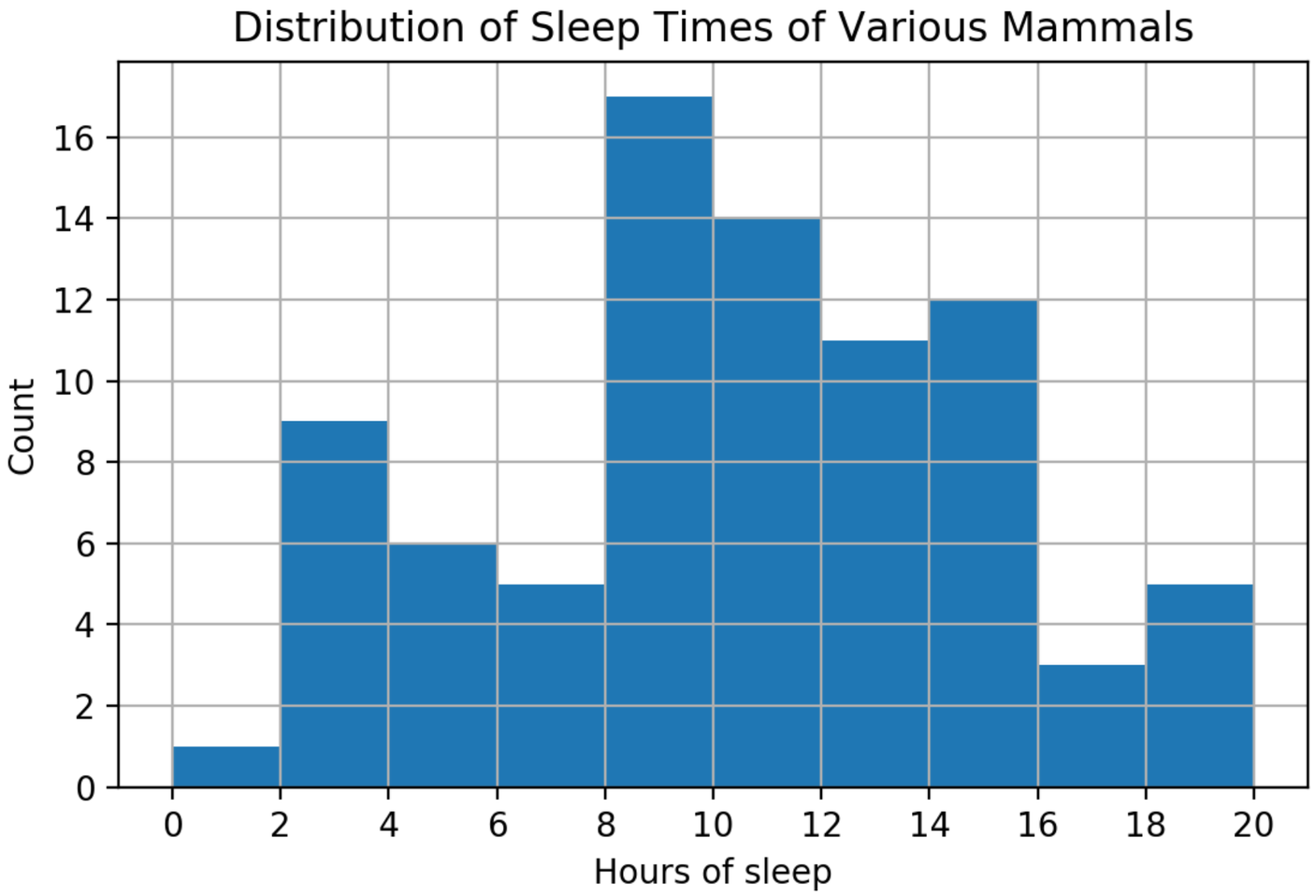
datacamp

Mammal sleep data

```
print(msleep)
```

```
                 name       genus   vore         order  ... sleep_cycle  awake  brainwt   bodywt
1             Cheetah    Acinonyx  carni     Carnivora  ...         NaN   11.9      NaN   50.000
2          Owl monkey       Aotus   omni      Primates  ...         NaN    7.0  0.01550    0.480
3     Mountain beaver  Aplodontia  herbi      Rodentia  ...         NaN    9.6      NaN    1.350
4 Greater short-ta...     Blarina   omni  Soricomorpha  ...    0.133333    9.1  0.00029    0.019
5                 Cow         Bos  herbi  Artiodactyla  ...    0.666667   20.0  0.42300  600.000
..                ...         ...    ...           ...  ...         ...    ...      ...      ...
79         Tree shrew       Tupaia   omni    Scandentia  ...    0.233333   15.1  0.00250    0.104
80 Bottle-nosed do...     Tursiops  carni       Cetacea  ...         NaN   18.8      NaN  173.330
81              Genet     Genetta  carni     Carnivora  ...         NaN   17.7  0.01750    2.000
82         Arctic fox       Vulpes  carni     Carnivora  ...         NaN   11.5  0.04450    3.380
83            Red fox       Vulpes  carni     Carnivora  ...    0.350000   14.2  0.05040    4.230
```

Histograms


Distribution of Sleep Times of Various Mammals
Count
0
2
4
6
8
10
12
14
16
0
2
4
6
8
10
12
14
16
18
20
Hours of sleep

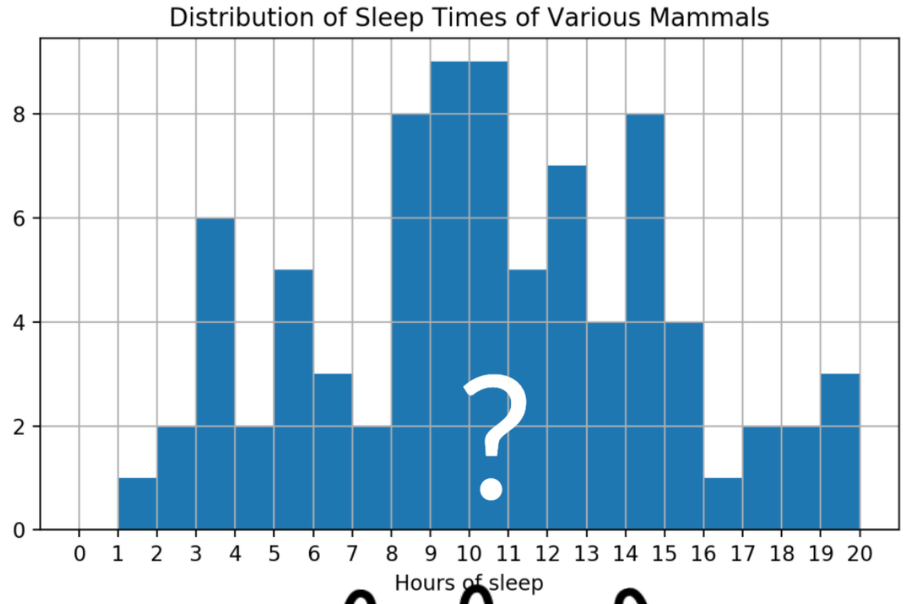
How long do mammals in this dataset typically sleep?

What's a typical value?

Where is the center of the data?

- Mean
- Median
- Mode

Mode → Most Freq. Occ



Measures of center: mean

	name	sleep_total
1	Cheetah	12.1
2	Owl monkey	17.0
3	Mountain beaver	14.4
4	Greater short-t...	14.9
5	Cow	4.0
..	...	...

```
import numpy as np
np.mean(msleep['sleep_total'])
```

```
10.43373
```

$$\text{Mean sleep time} = \frac{12.1 + 17.0 + 14.4 + 14.9 + \ldots}{83} = 10.43$$

Measures of center: median

```
msleep['sleep_total'].sort_values()
```

```
29     1.9
30     2.7
22     2.9
9      3.0
23     3.1
      ...
19    18.0
61    18.1
36    19.4
21    19.7
42    19.9
```

```
msleep['sleep_total'].sort_values().iloc[41]
```

```
10.1
```

middle element after sort

```
np.median(msleep['sleep_total'])
```

```
10.1
```

Measures of center: mode

Most frequent value

```
msleep['sleep_total'].value_counts()
```

```
12.5    4
10.1    3
14.9    2
11.0    2
8.4     2
...
14.3    1
17.0    1
Name: sleep_total, Length: 65, dtype: int64
```

```
msleep['vore'].value_counts()
```

```
herbi      32
omni       20
carni      19
insecti     5
Name: vore, dtype: int64
```

```
import statistics
statistics.mode(msleep['vore'])
```

```
'herbi'
```

the most frequently occurring value in the 'vore' column.

Adding an outlier

```
# Subset msleep to select rows where 'vore' equals 'insecti'
msleep[msleep['vore'] == 'insecti']
```

	name	genus	vore	order	sleep_total
22	Big brown bat	Eptesicus	insecti	Chiroptera	19.7
43	Little brown bat	Myotis	insecti	Chiroptera	19.9
62	Giant armadillo	Priodontes	insecti	Cingulata	18.1
67	Eastern american mole	Scalopus	insecti	Soricomorpha	8.4

Adding an outlier

```
msleep[msleep['vore'] == "insecti"]['sleep_total'].agg([np.mean, np.median])
```

```
mean      16.53
median    18.9
Name: sleep_total, dtype: float64
```

Adding an outlier

```
msleep[msleep['vore'] == 'insecti']
```

	name	genus	vore	order	sleep_total
22	Big brown bat	Eptesicus	insecti	Chiroptera	19.7
43	Little brown bat	Myotis	insecti	Chiroptera	19.9
62	Giant armadillo	Priodontes	insecti	Cingulata	18.1
67	Eastern american mole	Scalopus	insecti	Soricomorpha	8.4
84	Mystery insectivore	...	insecti	...	0.0

Adding an outlier

```
msleep[msleep['vore'] == "insecti"]['sleep_total'].agg([np.mean, np.median])
```

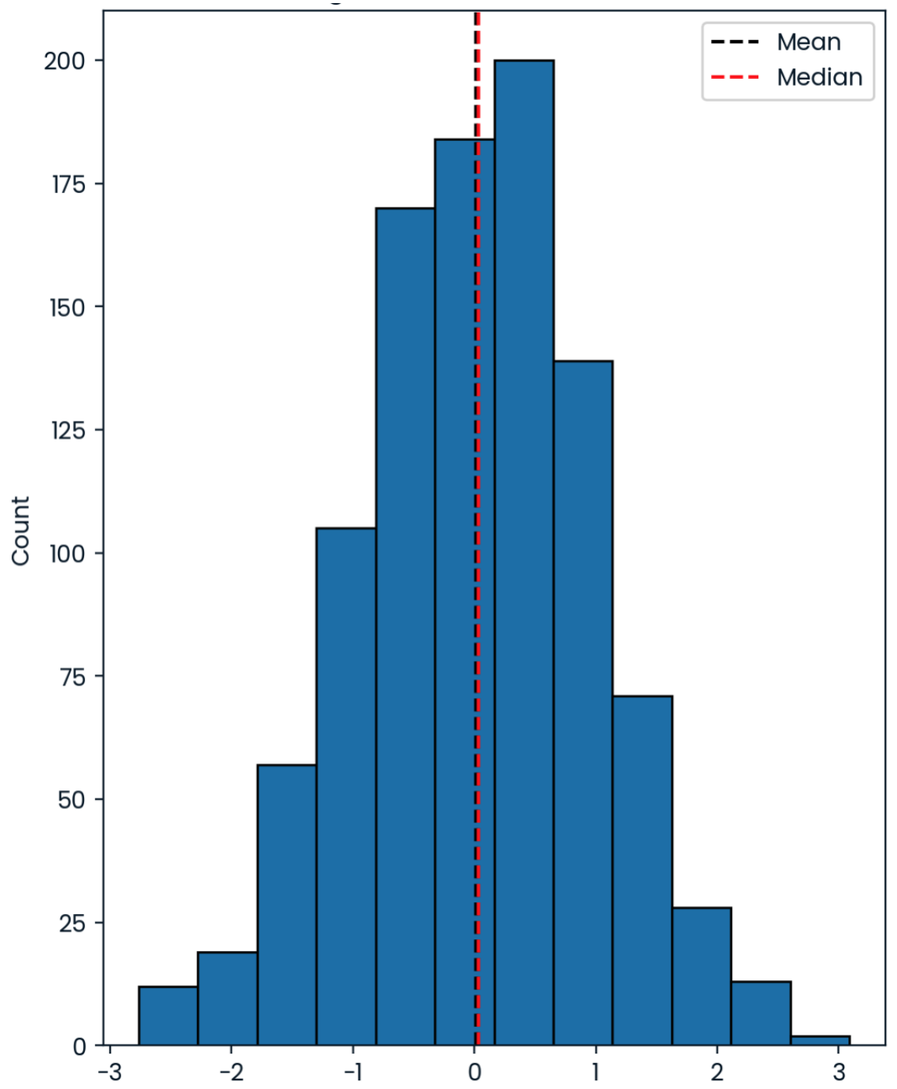
```
mean      13.22
median    18.1
Name: sleep_total, dtype: float64
```

Mean: 16.5 → 13.2

Median: 18.9 → 18.1

Which measure to use?

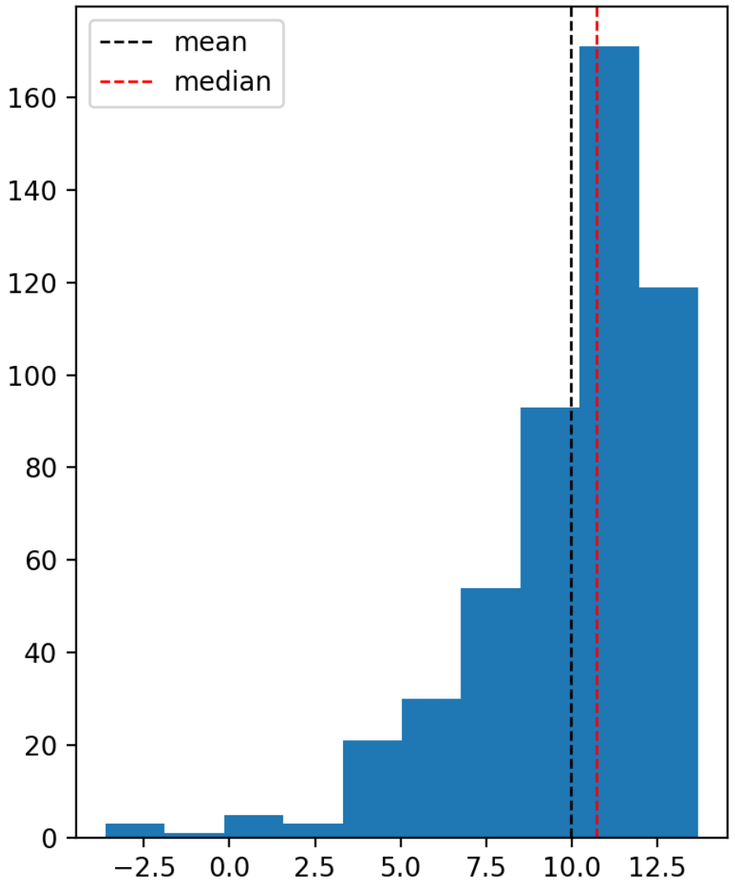
```
# Import matplotlib.pyplot with alias plt
import matplotlib.pyplot as plt

# Histogram of values
data['values'].hist()

# Show the plot
plt.show()
```



Skew

Example: Age at retirement (most people retire around 60–65, few retire much earlier)

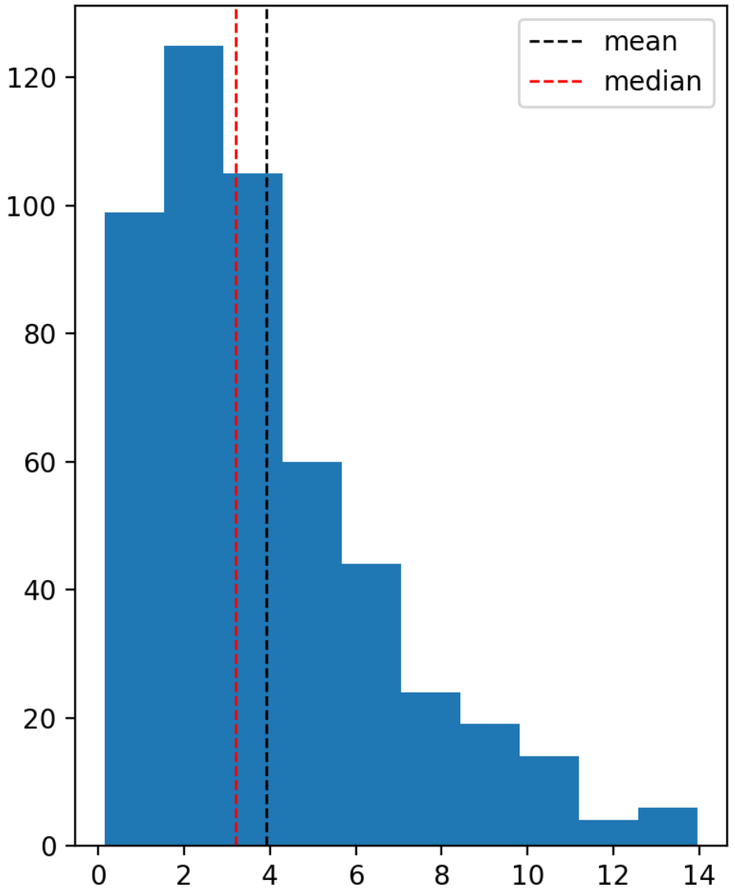
Left-skewed



Left-skewed: tail on the left, mean < median

Example: Income distribution (few very high earners pull the mean up)

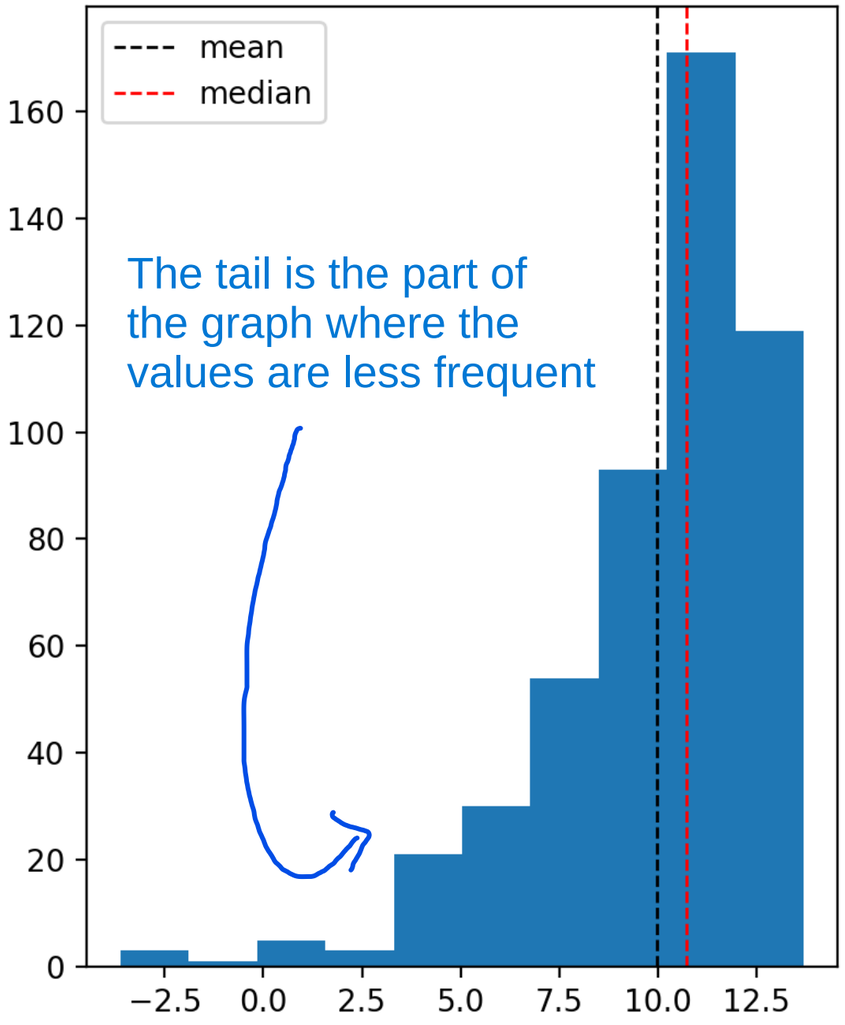
Right-skewed

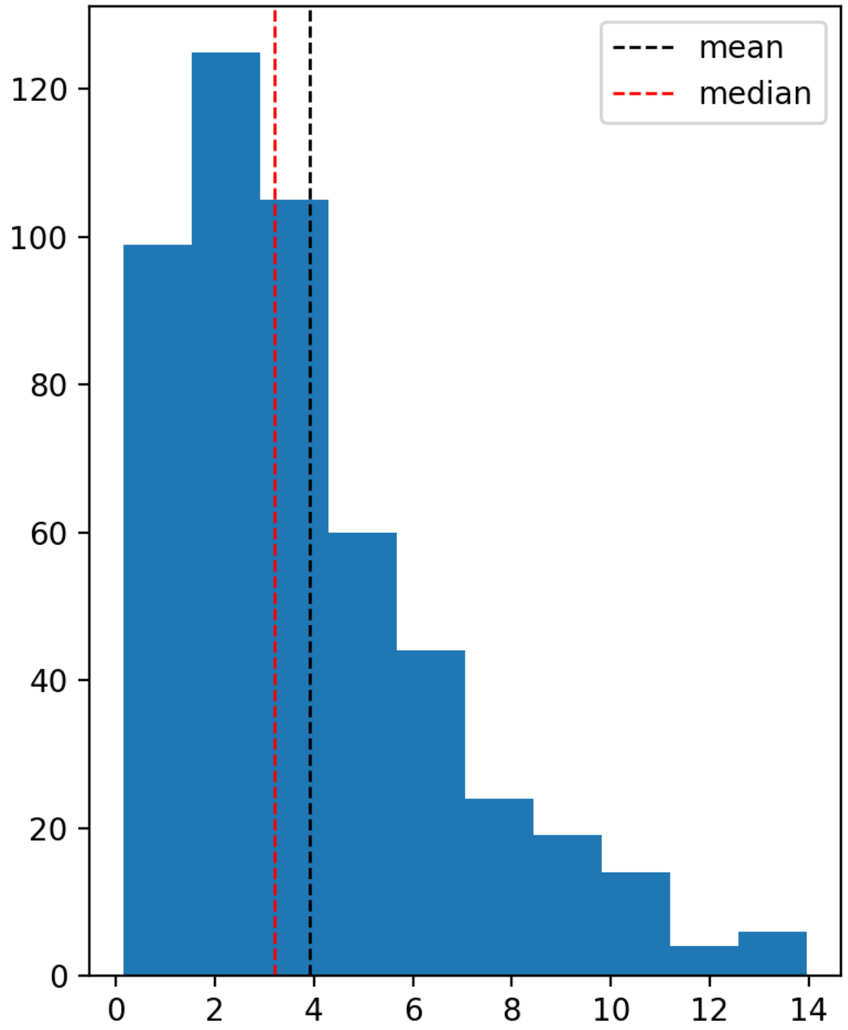


Right-skewed: tail on the right, mean > median

Which measure to use?

Use median if data is skewed, since it's less affected by outliers.





Let's practice!

INTRODUCTION TO STATISTICS IN PYTHON

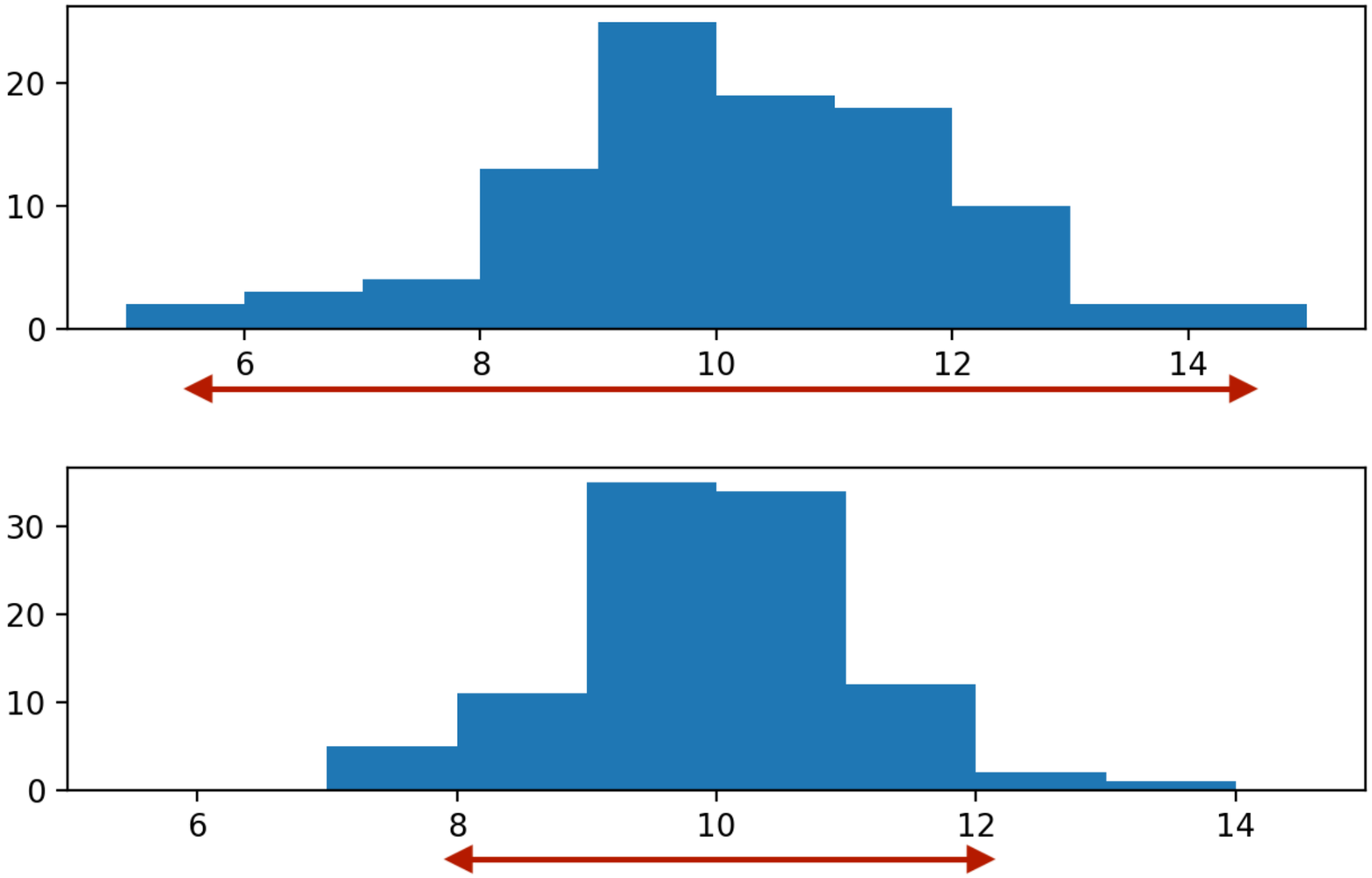
Measures of spread

INTRODUCTION TO STATISTICS IN PYTHON

Maggie Matsui
Content Developer, DataCamp

datacamp

What is spread?

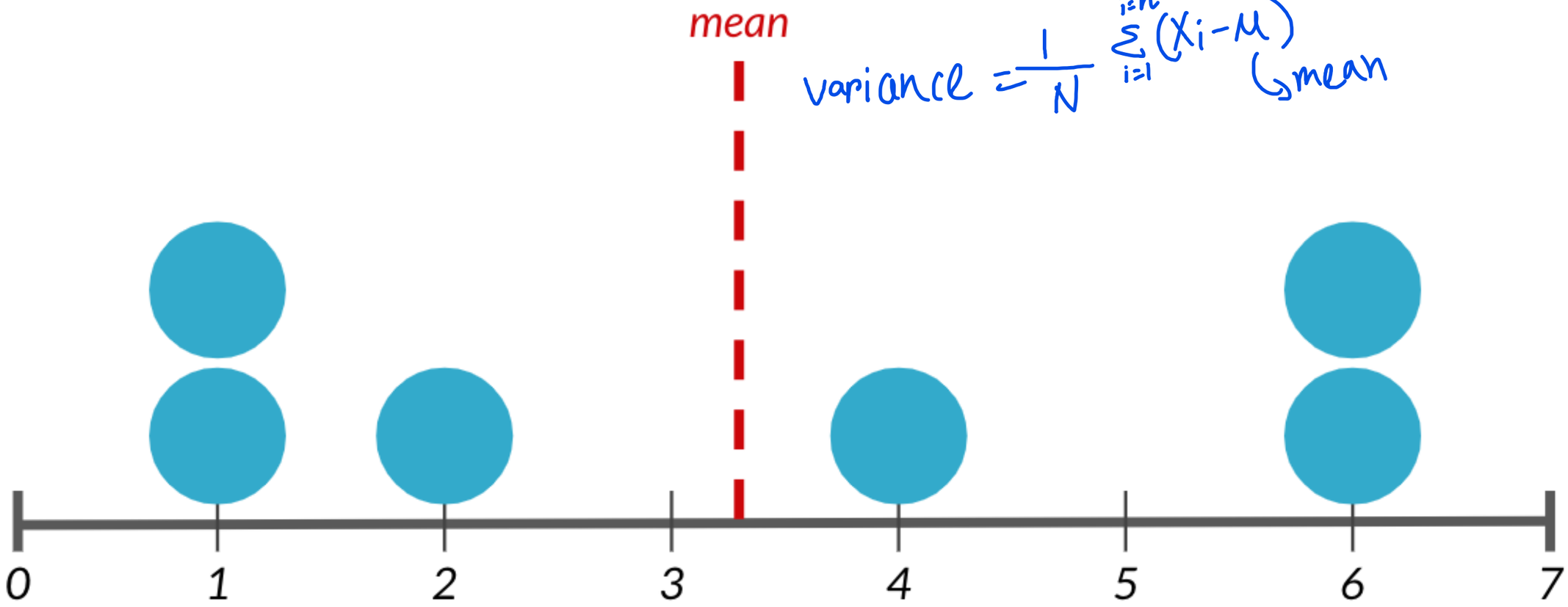


Variance ∝ data-spread

Average distance from each data point to the data's mean

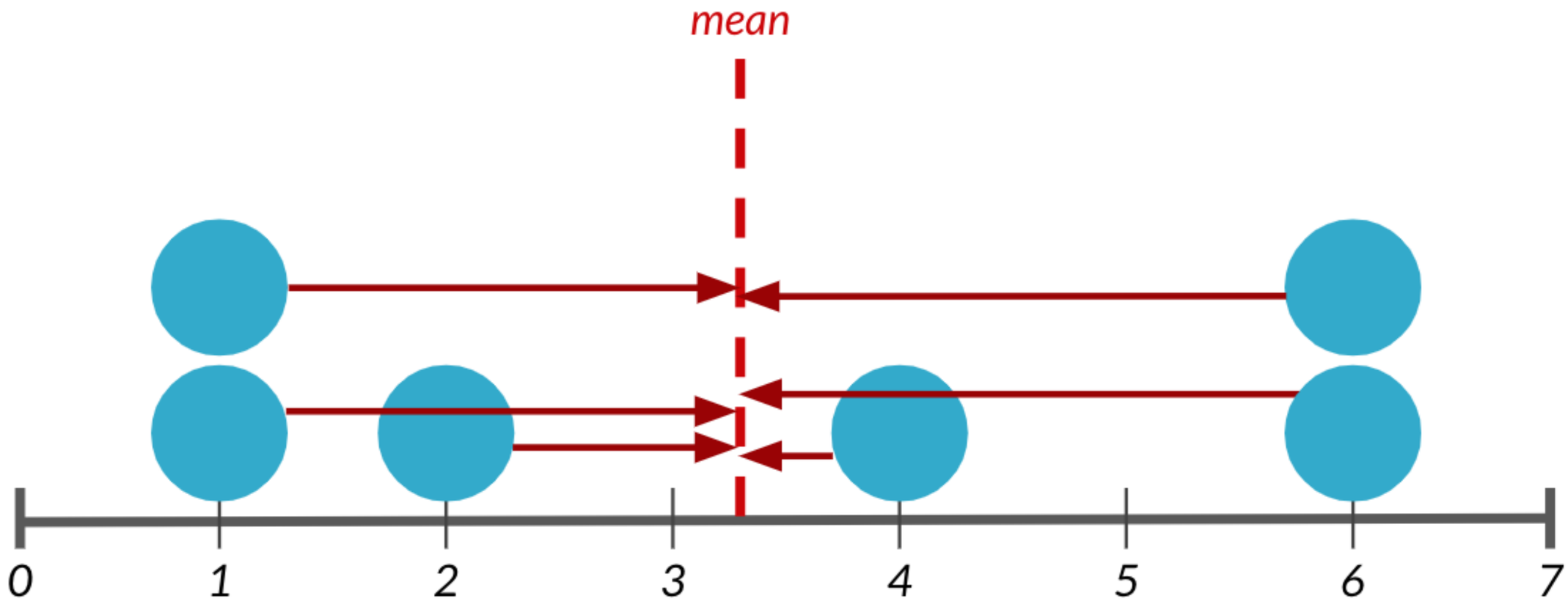
$$\text{variance} = \frac{1}{N}\sum_{i=1}^{i=n}(x_i - \mu)^2$$

↳ mean



Variance

Average distance from each data point to the data's mean



Calculating variance

1. Subtract mean from each data point

```
dists = msleep['sleep_total'] -
        np.mean(msleep['sleep_total'])
print(dists)
```

```
0      1.666265
1      6.566265
2      3.966265
3      4.466265
4     -6.433735
       ...
```

2. Square each distance

```
sq_dists = dists ** 2
print(sq_dists)
```

```
0       2.776439
1      43.115837
2      15.731259
3      19.947524
4      41.392945
       ...
```

Dividing by n: Good when you have data from entire population.
Dividing by n−1: Good when you're estimating population variance using a sample.

Calculating variance

ddof=1 tells NumPy to divide by n - 1 instead of n — which gives you the sample variance.

3. Sum squared distances

```
sum_sq_dists = np.sum(sq_dists)
print(sum_sq_dists)
```

```
1624.065542
```

4. Divide by number of data points - 1

```
variance = sum_sq_dists / (83 - 1)
print(variance)
```

```
19.805677
```

Use `np.var()`

```
np.var(msleep['sleep_total'], ddof=1)
```

```
19.805677
```

*Without `ddof=1` , **population variance** is calculated instead of **sample variance**:*

```
np.var(msleep['sleep_total'])
```

```
19.567055
```

divide by n , gives population variance

Standard deviation

```
np.sqrt(np.var(msleep['sleep_total'], ddof=1))
```

```
4.450357
```

```
np.std(msleep['sleep_total'], ddof=1)
```

```
4.450357
```

Standard deviation (often abbreviated as std dev) is a measure of how spread out the numbers in a dataset are.

$$std\_dev = \sqrt{var}$$

Mean absolute deviation

Deviation = $\sum$ (xi - mean)

```
dists = msleep['sleep_total'] - np.mean(msleep['sleep_total'])
np.mean(np.abs(dists))
```

```
3.566701
```

Standard deviation vs. mean absolute deviation

- Standard deviation squares distances, penalizing longer distances more than shorter ones.
- Mean absolute deviation penalizes each distance equally.
- One isn't better than the other, but SD is more common than MAD.

Quantiles

```
np.quantile(msleep['sleep_total'], 0.5)
```

```
10.1
```

0.5 quantile = median

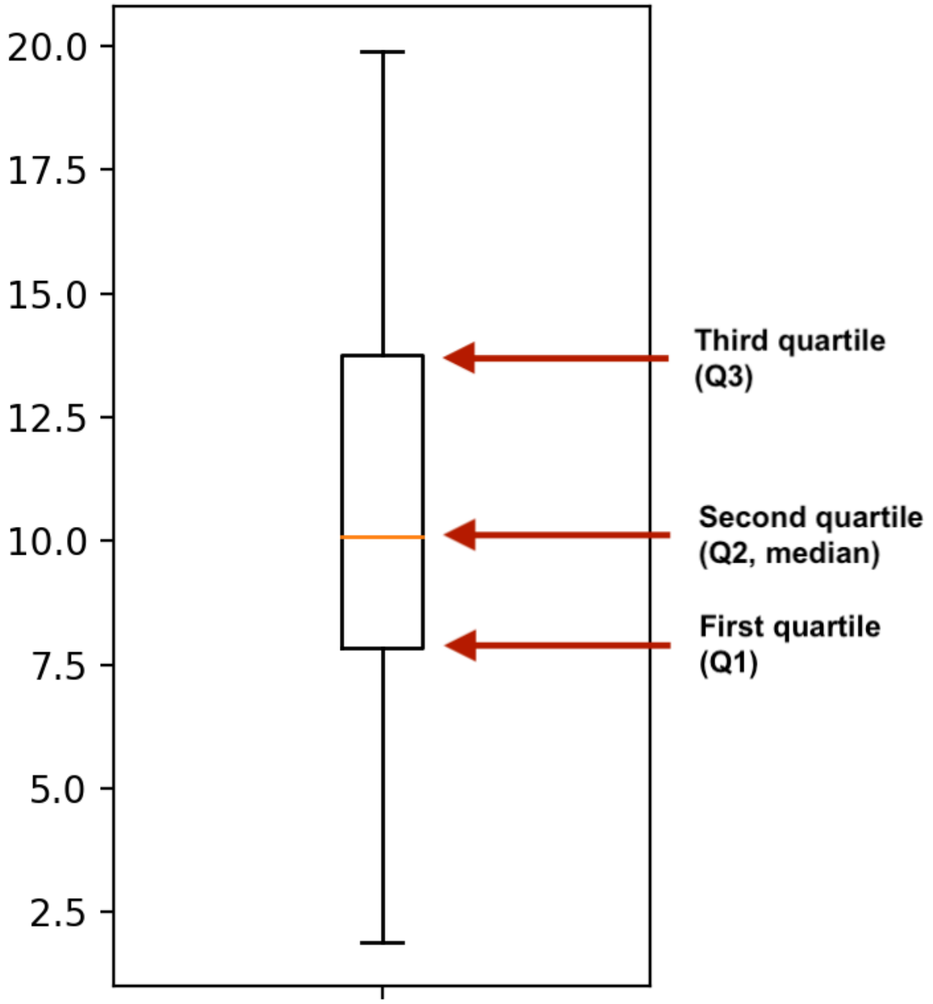
Quartiles:

```
np.quantile(msleep['sleep_total'], [0, 0.25, 0.5, 0.75, 1])
```

```
array([ 1.9 ,  7.85, 10.1 , 13.75, 19.9 ])
```

Boxplots use quartiles

```
import matplotlib.pyplot as plt
plt.boxplot(msleep['sleep_total'])
plt.show()
```



Quantiles using np.linspace()

```
np.quantile(msleep['sleep_total'], [0, 0.2, 0.4, 0.6, 0.8, 1])
```

```
array([ 1.9 ,  6.24,  9.48, 11.14, 14.4 , 19.9 ])
```


```
np.linspace(start, stop, num)
```

```
np.quantile(msleep['sleep_total'], np.linspace(0, 1, 5))
```

```
array([ 1.9 ,  7.85, 10.1 , 13.75, 19.9 ])
```

Interquartile range (IQR)

Height of the box in a boxplot

```
np.quantile(msleep['sleep_total'], 0.75) - np.quantile(msleep['sleep_total'], 0.25)
```

```
5.9
```

```
from scipy.stats import iqr
iqr(msleep['sleep_total'])
```

```
5.9
```

Outliers

Outlier: data point that is substantially different from the others

How do we know what a substantial difference is? A data point is an outlier if:

- $\text{data} < \text{Q1} - 1.5 \times \text{IQR}$ or
- $\text{data} > \text{Q3} + 1.5 \times \text{IQR}$

Formula

$Q1 = 0.25$, $Q3 = 0.75$

Finding outliers

```
from scipy.stats import iqr
iqr = iqr(msleep['bodywt'])
lower_threshold = np.quantile(msleep['bodywt'], 0.25) - 1.5 * iqr
upper_threshold = np.quantile(msleep['bodywt'], 0.75) + 1.5 * iqr
```

```
msleep[(msleep['bodywt'] < lower_threshold) | (msleep['bodywt'] > upper_threshold)]
```

```
                   name   vore  sleep_total    bodywt
4                   Cow  herbi          4.0   600.000
20      Asian elephant  herbi          3.9  2547.000
22               Horse  herbi          2.9   521.000
...
```

All in one go

```
msleep['bodywt'].describe()
```

```
count       83.000000
mean       166.136349
std        786.839732
min          0.005000
25%          0.174000
50%          1.670000
75%         41.750000
max       6654.000000
Name: bodywt, dtype: float64
```

quantile

25% has weight ≤ 0.174

Let's practice!

INTRODUCTION TO STATISTICS IN PYTHON