

What is statistics?

INTRODUCTION TO STATISTICS IN PYTHON



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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?

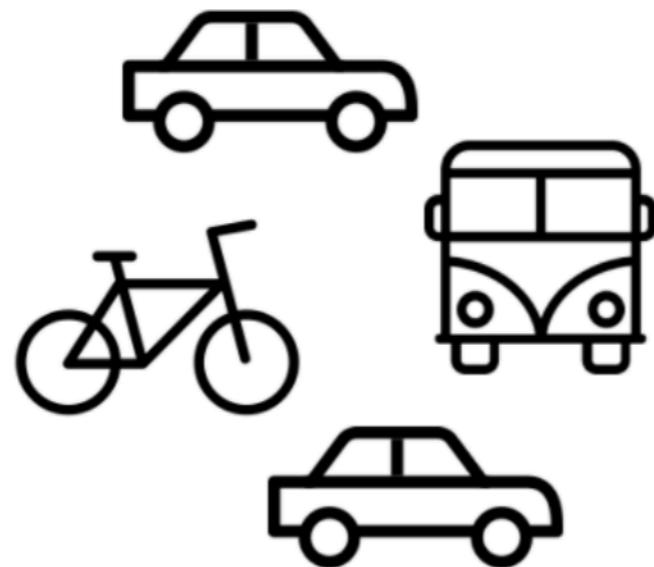
But...

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

Types of statistics

Descriptive statistics

- *Describe* and summarize data



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

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

Categorical (Qualitative)

- Nominal (Unordered)
 - Married/unmarried
 - Country of residence
- Ordinal (Ordered)
 - Strongly disagree
 - Somewhat disagree
 - Neither agree nor disagree
 - Somewhat agree
 - Strongly agree

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)

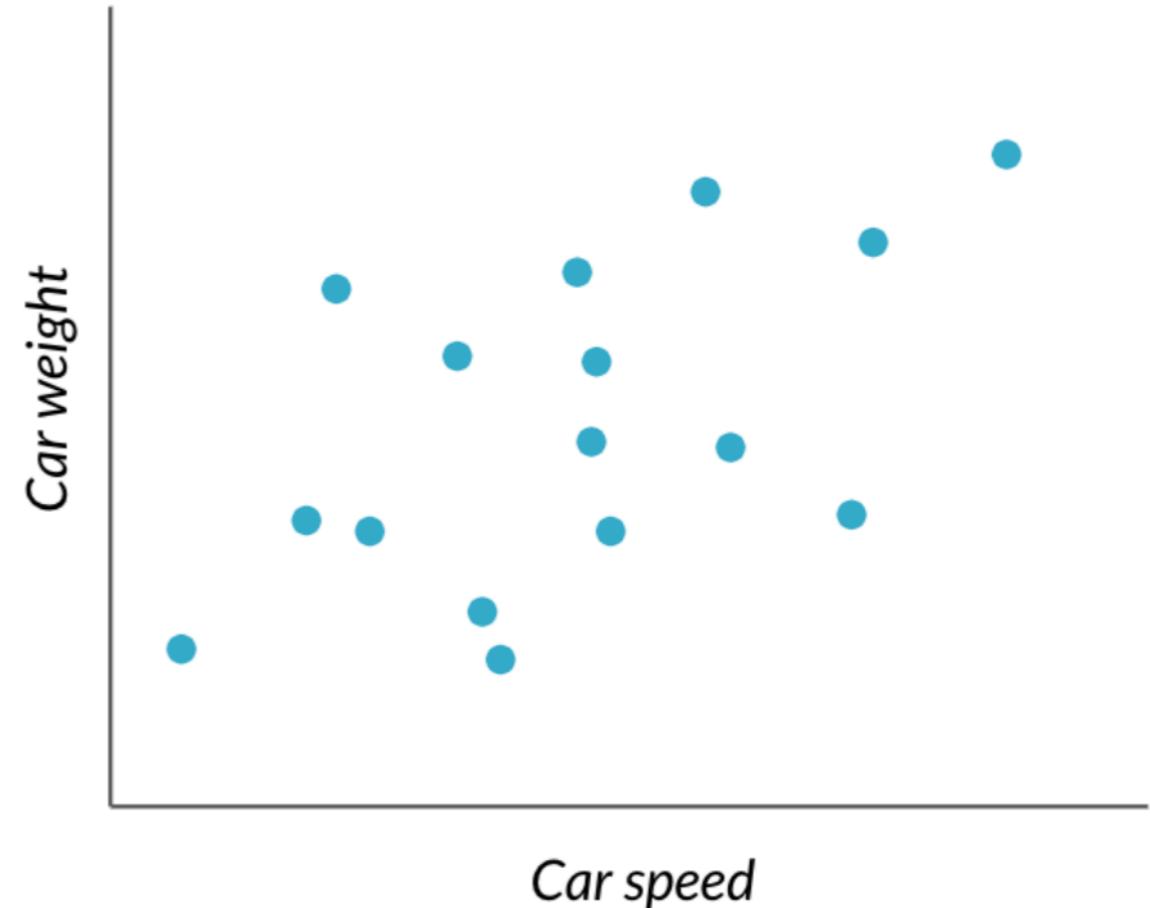
Why does data type matter?

Summary statistics

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

40.09062

Plots



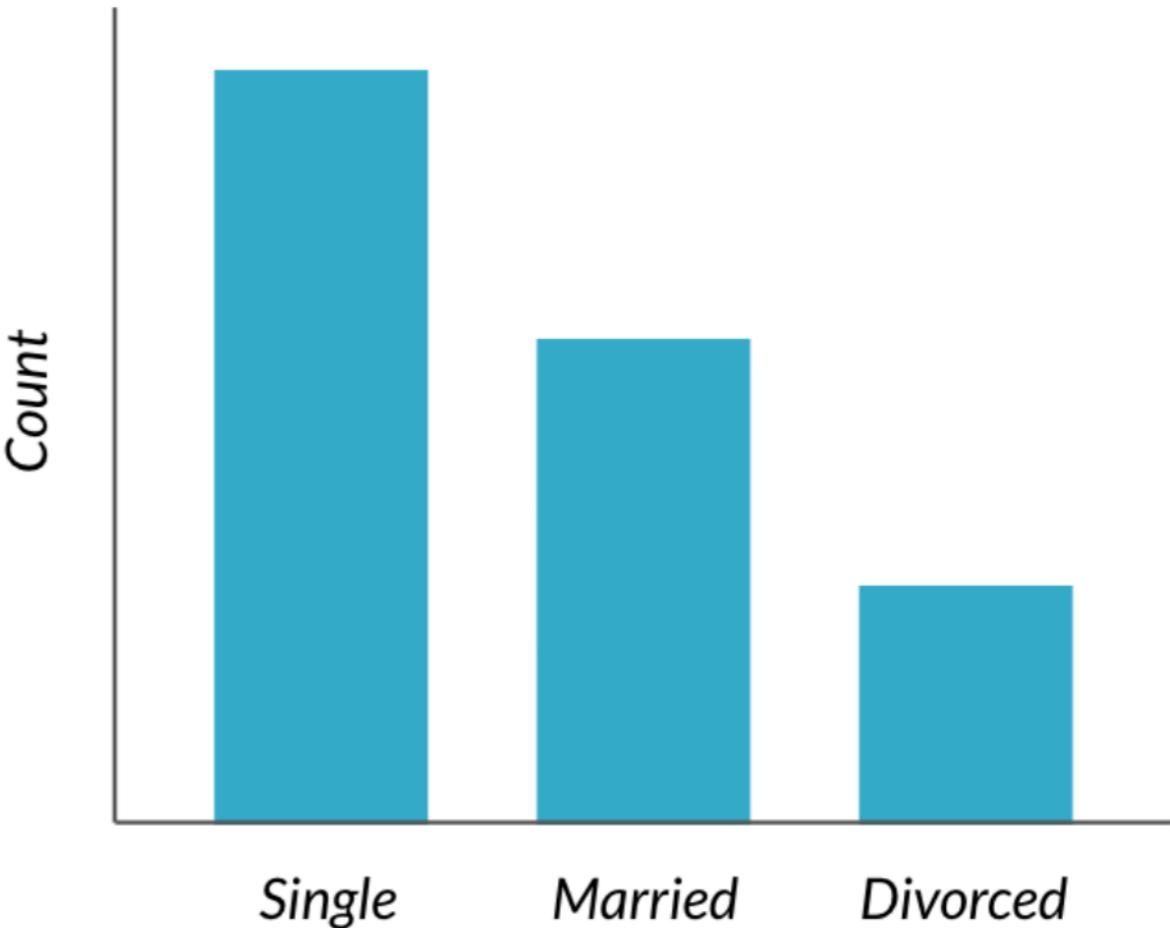
Why does data type matter?

Summary statistics

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

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

Plots



Let's practice!

INTRODUCTION TO STATISTICS IN PYTHON

Measures of center

INTRODUCTION TO STATISTICS IN PYTHON



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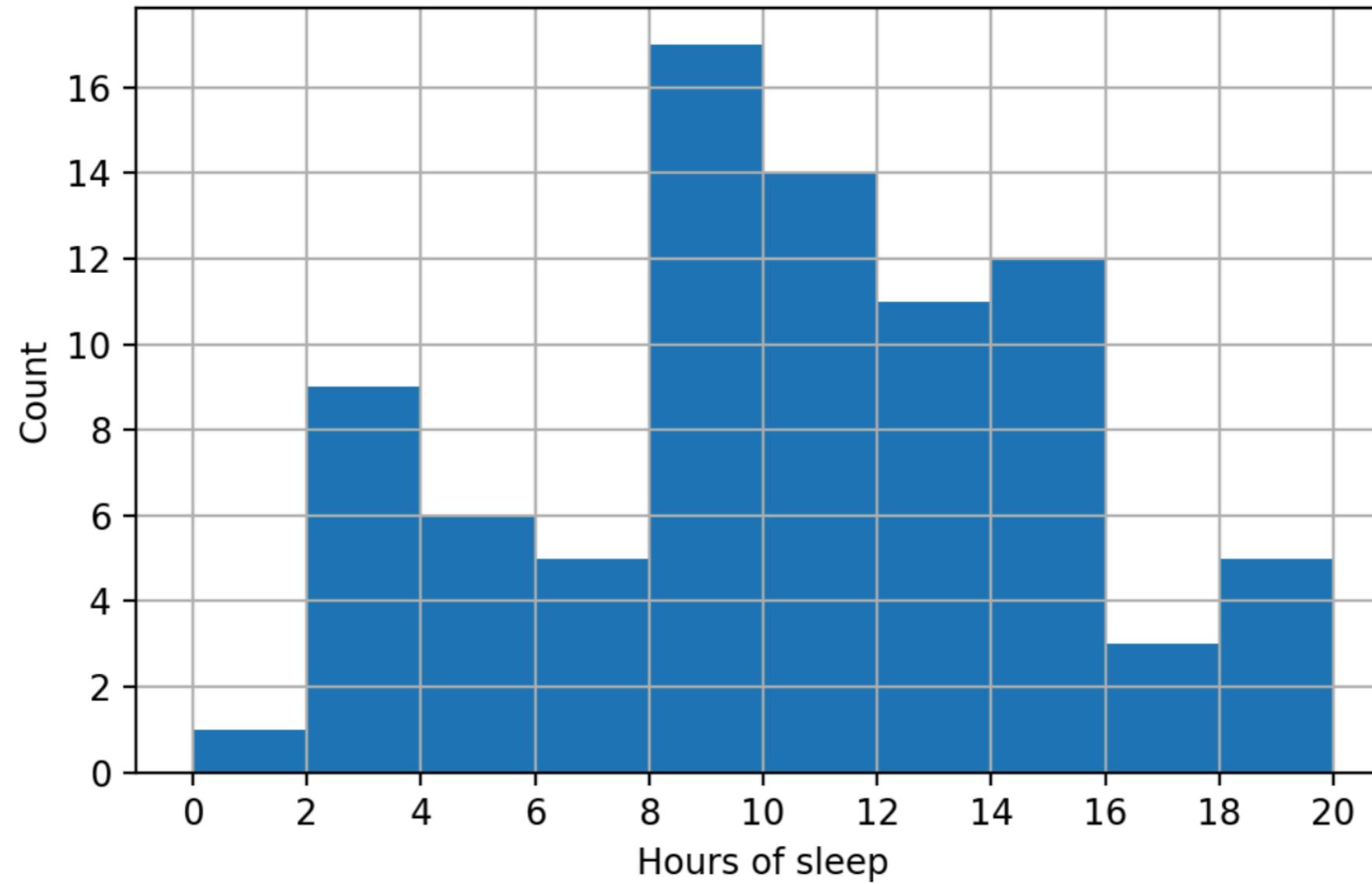
Mammal sleep data

```
print(msleep)
```

	name	genus	vore	order	...	sleep_cycle	awake	brainwt	bodywt
1	Cheetah	Acinonyx	carni	Carnivora	...		NaN	11.9	NaN
2	Owl monkey	Aotus	omni	Primates	...		NaN	7.0	0.01550
3	Mountain beaver	Aplodontia	herbi	Rodentia	...		NaN	9.6	NaN
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
81	Genet	Genetta	carni	Carnivora	...		NaN	17.7	0.01750
82	Arctic fox	Vulpes	carni	Carnivora	...		NaN	11.5	0.04450
83	Red fox	Vulpes	carni	Carnivora	...	0.350000	14.2	0.05040	4.230

Histograms

Distribution of Sleep Times of Various Mammals

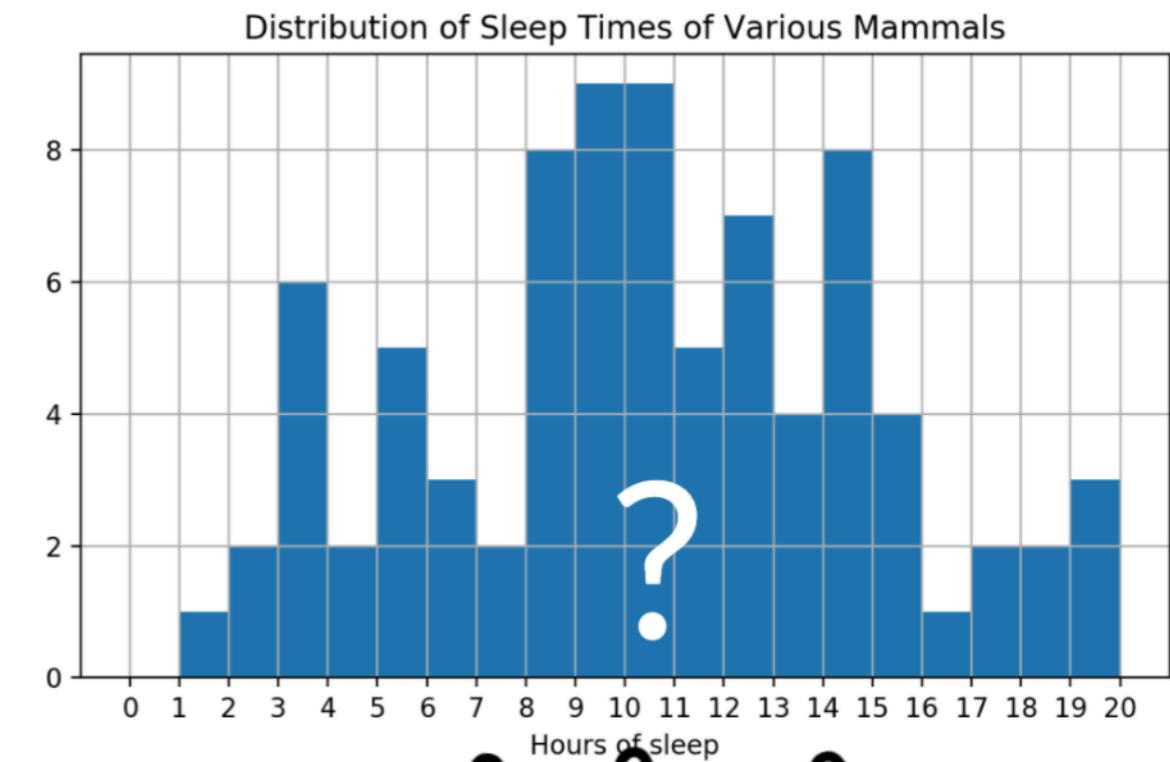


How long do mammals in this dataset typically sleep?

What's a typical value?

Where is the center of the data?

- Mean
- Median
- Mode



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
```

Mean sleep time =

$$\frac{12.1 + 17.0 + 14.4 + 14.9 + \dots}{83} = 10.43$$

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
```

```
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'
```

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'] == "insectivore"]['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'] == "insectivore"]['sleep_total'].agg([np.mean, np.median])
```

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

Mean: 16.5 → 13.2

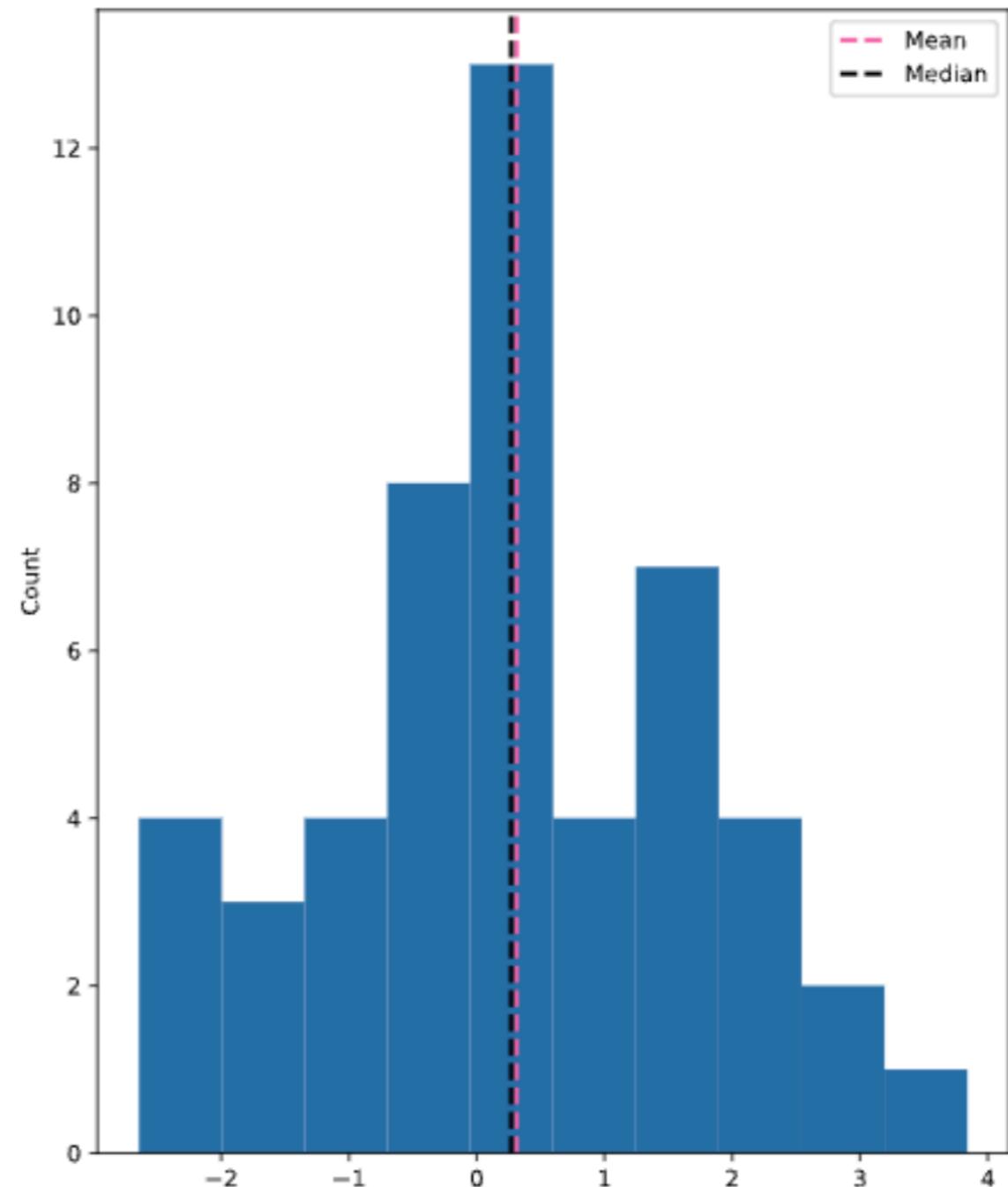
Median: 18.9 → 18.1

Which measure to use?

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

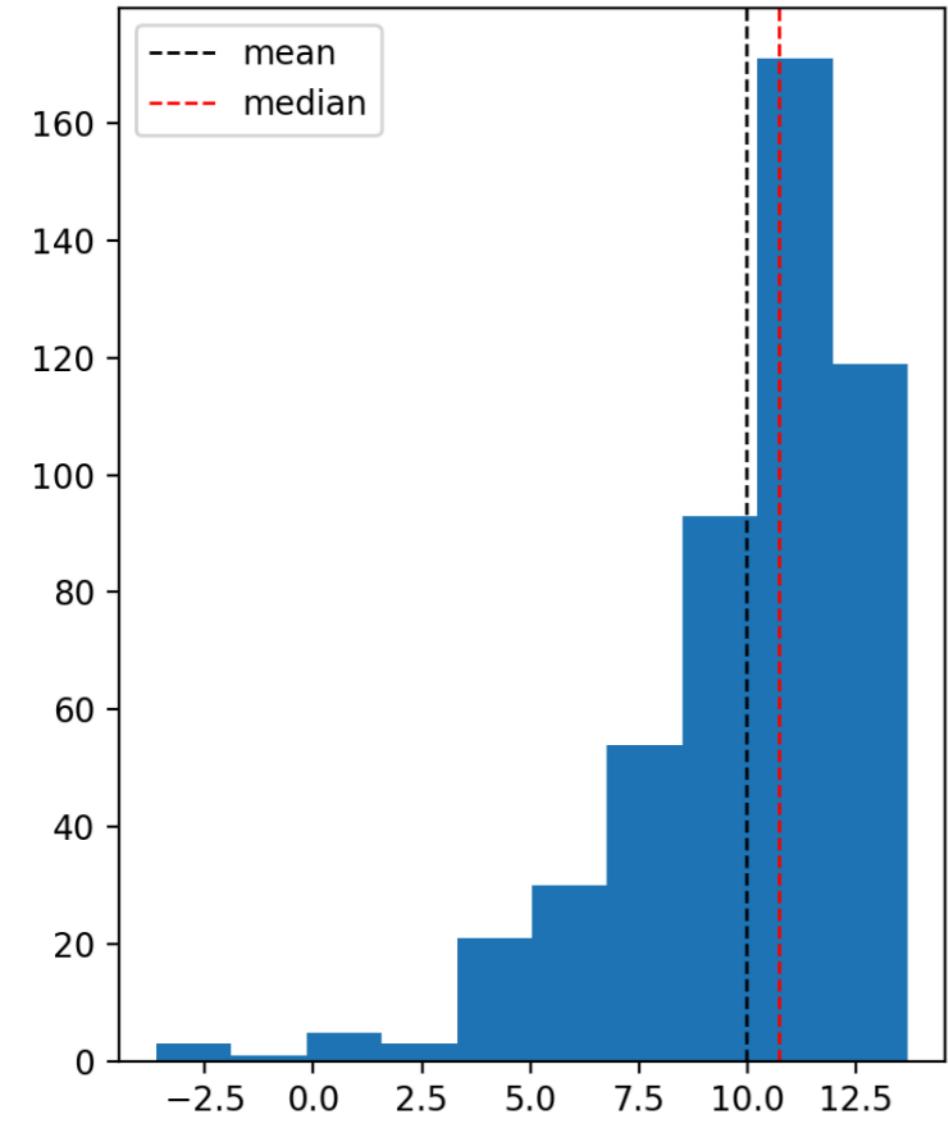
# Histogram of values
data['values'].hist()

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

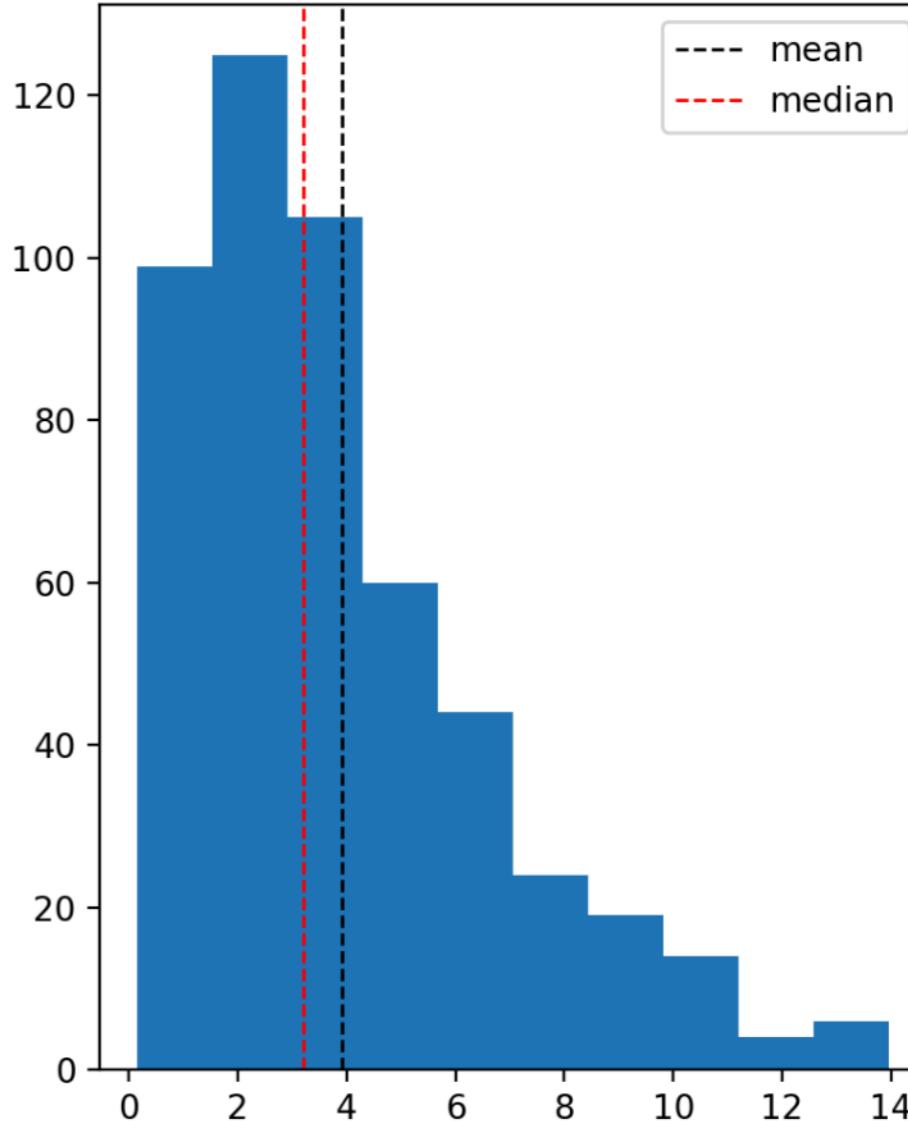


Skew

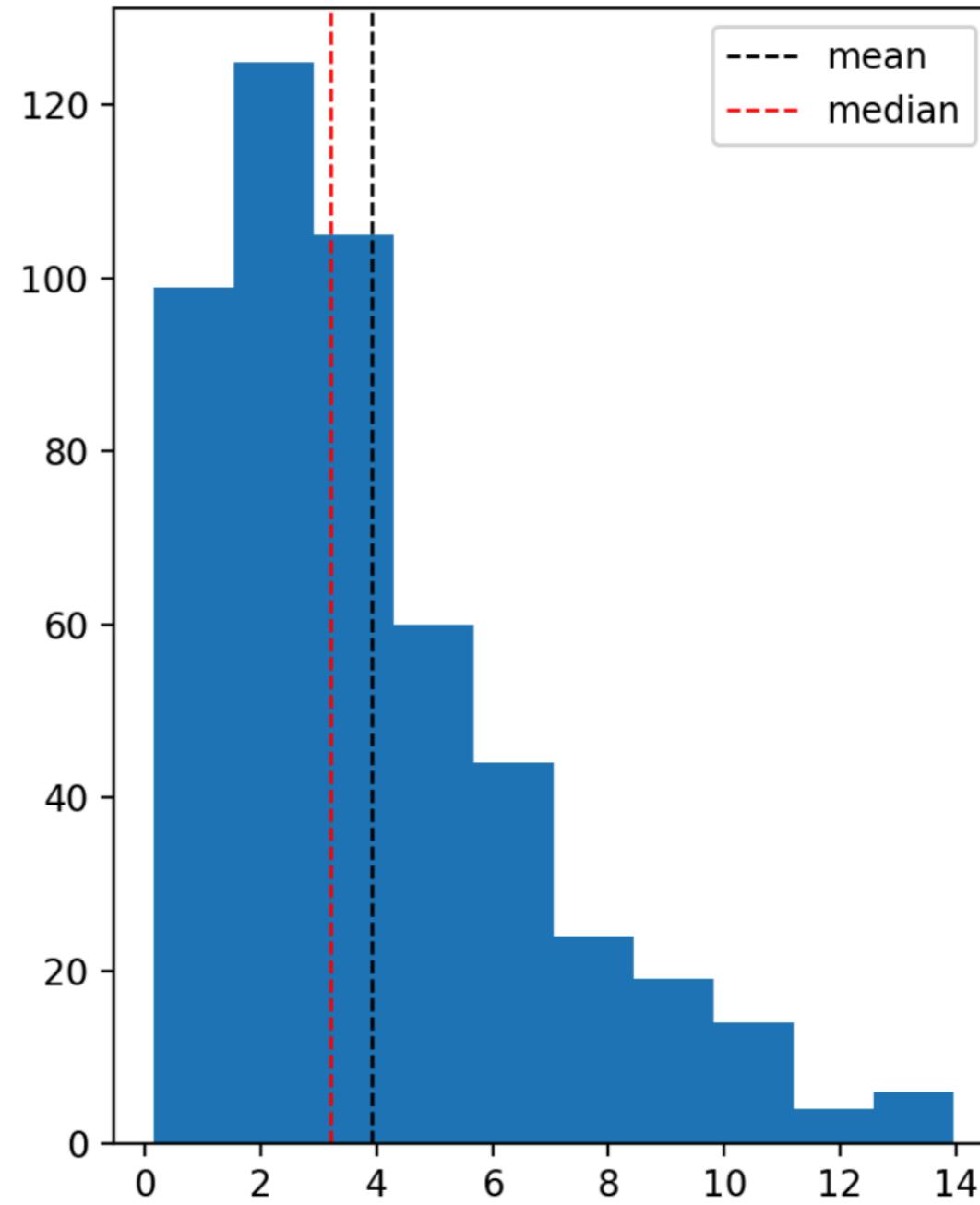
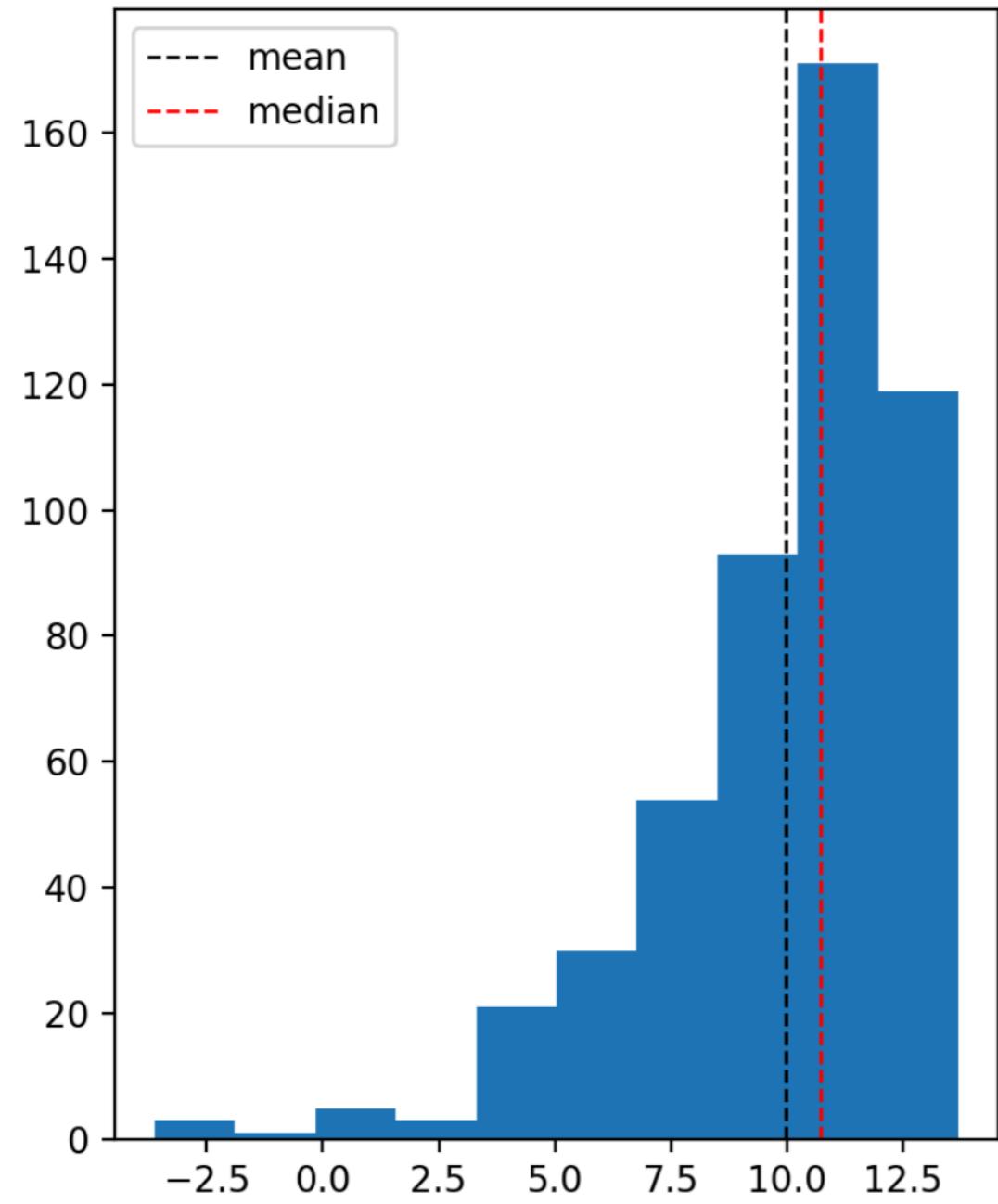
Left-skewed



Right-skewed



Which measure to use?



Let's practice!

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Measures of spread

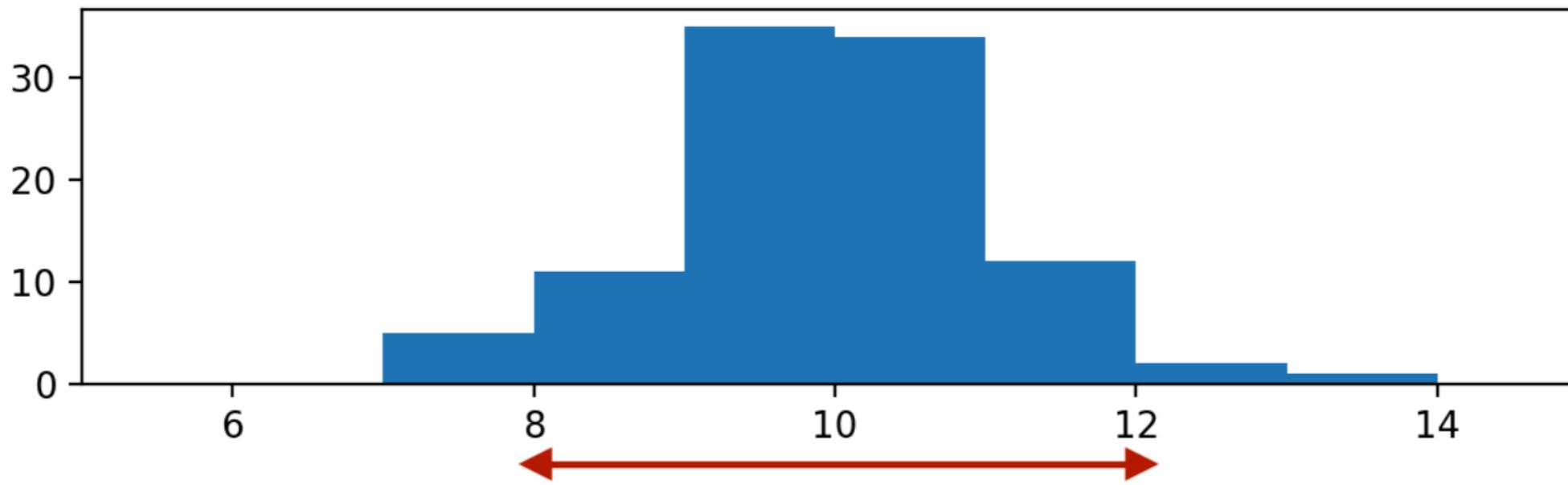
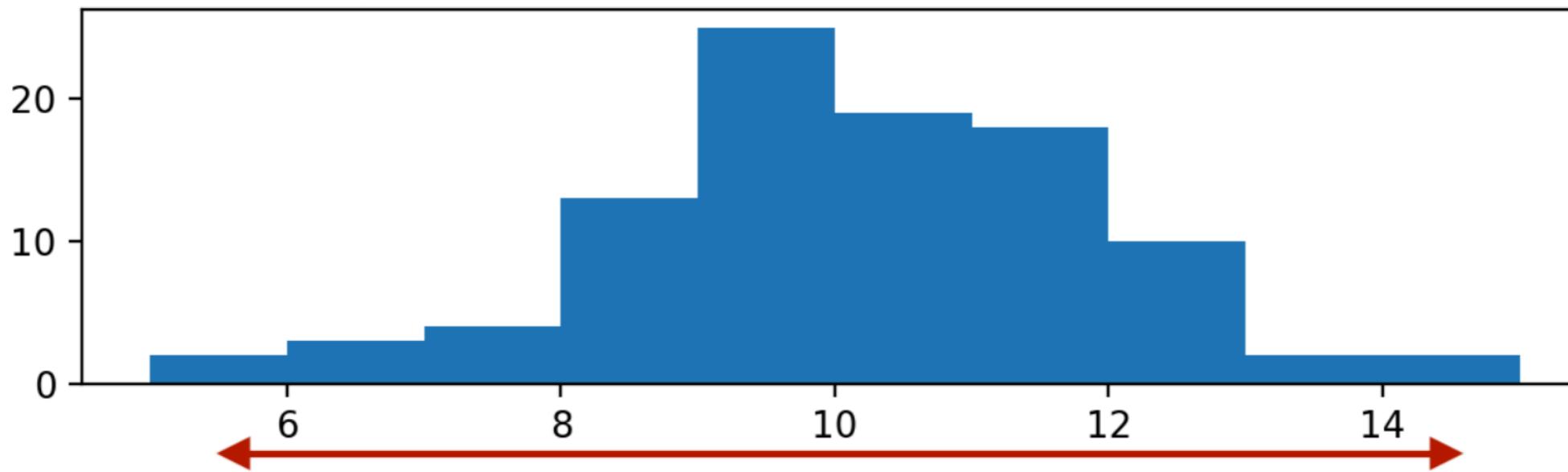
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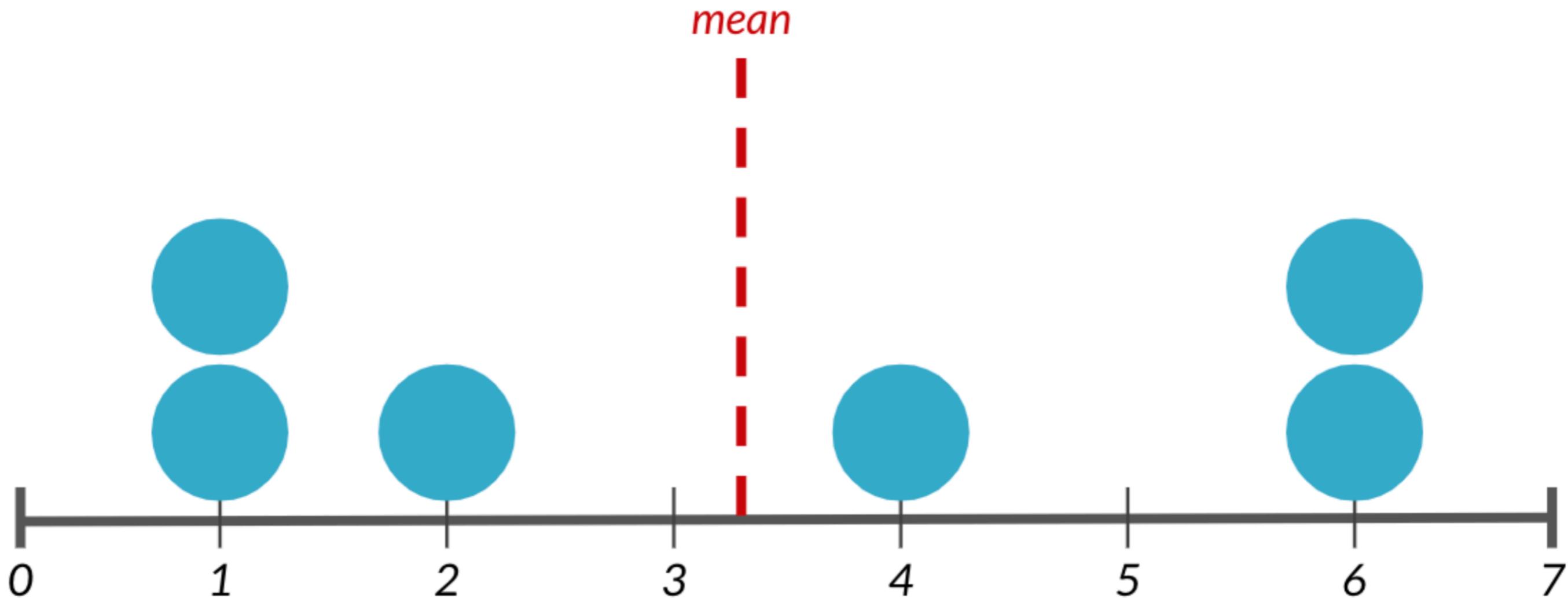
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What is spread?



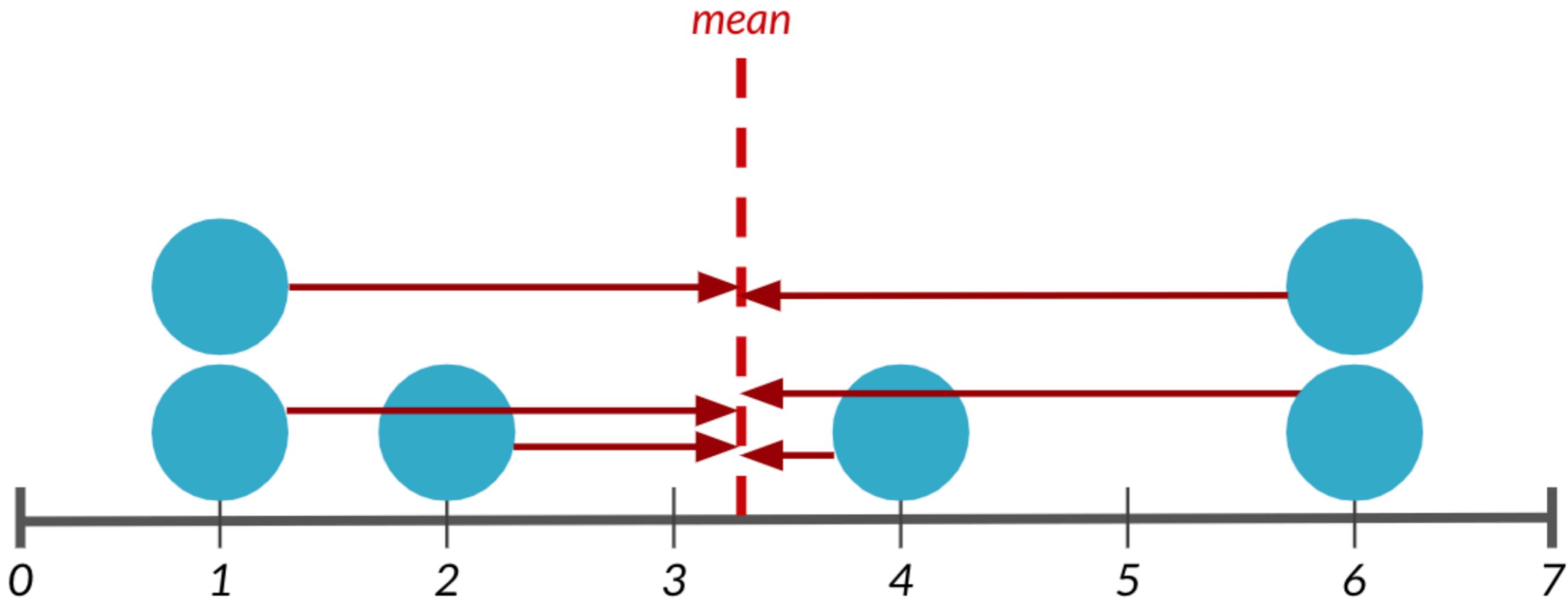
Variance

Average distance from each data point to the data's 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  
...  
...
```

Calculating variance

3. Sum squared distances

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

1624.065542

Use `np.var()`

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

19.805677

4. Divide by number of data points - 1

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

19.805677

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

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

19.567055

Standard deviation

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

4.450357

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

4.450357

Mean absolute deviation

```
dists = msleep['sleep_total'] - 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

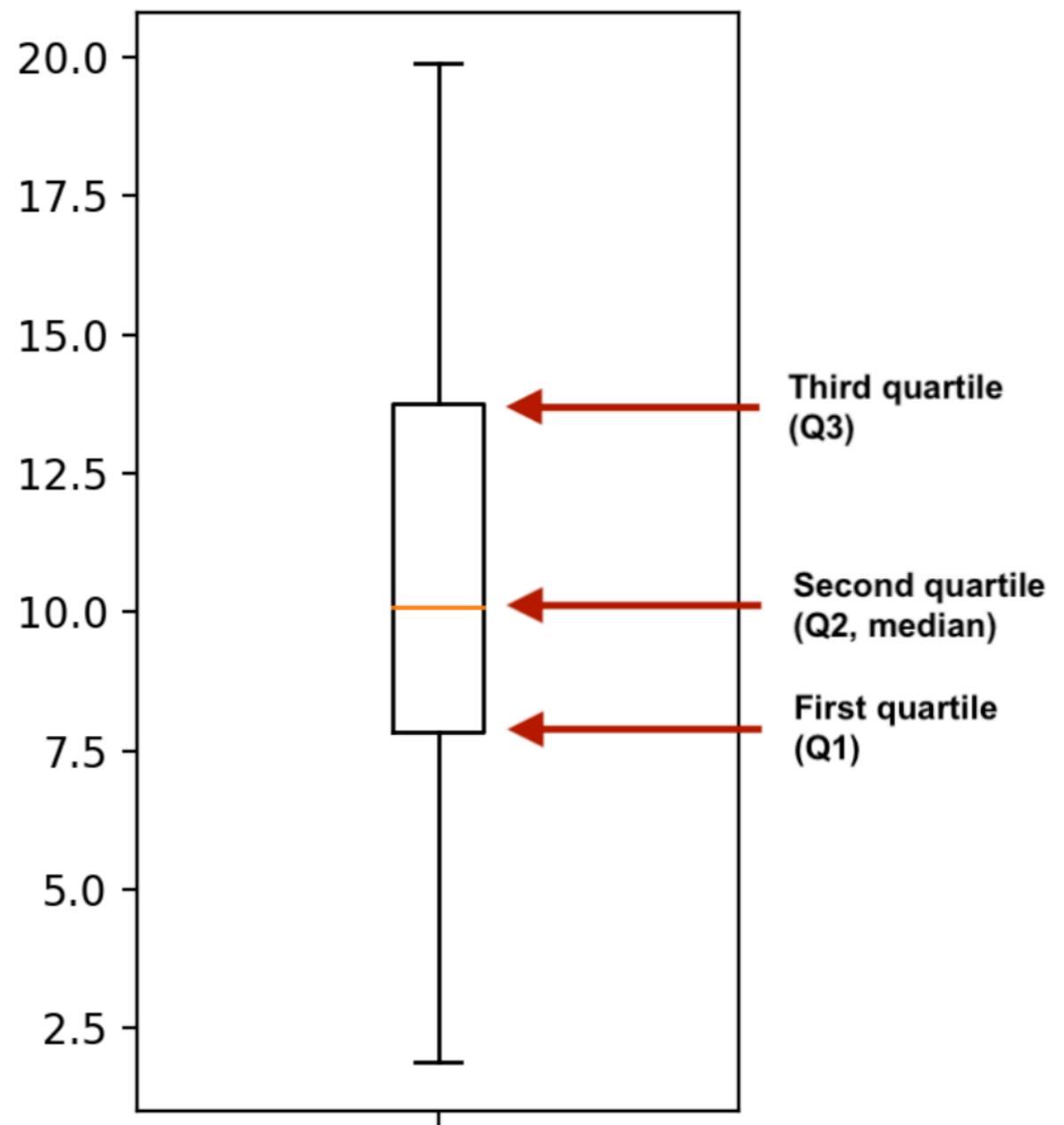
Quartiles:

```
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:

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

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
```

Let's practice!

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