IRT SAINT EXUPÉRY

Data Exploration

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“Torture the data, and it will confess to anything”.
Ronald Coase

What is Machine Learning ?

Definition of Machine Learning:

A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E.

TOM MITCHELL

What is Machine Learning ?

Exemples of Machine Learning (T. Mitchell)

Use case	Chess	Handwriting recognition	Financial trading
Task T	Playing chess	Recognizing and classiying handwritten words within images	Predict stock prices
Performance measure P	Percent of games won against opponents	Percent of words correctly classified	Average absolute error between predicted and real prices
Training experience E	Playing practice games against itself	A database of handwritten words with given classification labels	Historical stock prices and market states

- The machine learns how to perform tasks without being explicitly programmed.
- Instead, it learns from the **<u>data</u>** to build rules and knowledge.

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WE NEED DATA !!

- The machine learns how to perform tasks without being explicitly programmed.
- Instead, it learns from the **data** to build rules and knowledge.

What is « Data »?

Definitions of data:

[…] result of an observation made on a population or a sample.

Dodge (2007)

- Data are a collection of […] values that convey information, describing quantity, quality, fact, statistics, other basic units of meaning.

Wikipedia

What is « Data »?

More concretly

- Data can be a number or a symbol that inform on an individual, an object or an observation.

Example

- 5000 is a number (not interesting by itself)
- « My salary is 5000€ » is data (information on M. Dupont)

Variable

- A variable is a mathematical object related to a given concept (e.g. salary)
- It can take different values coming from different observations/individuals/objects
  - Example 1: X_i salary of an person i in France (1500€, 4000€, 500000€, …)
  - Example 2: $X_{k,t}$ salary evolution of a person k with time t (3500€, 4000€, 4500€, 5000€, …)

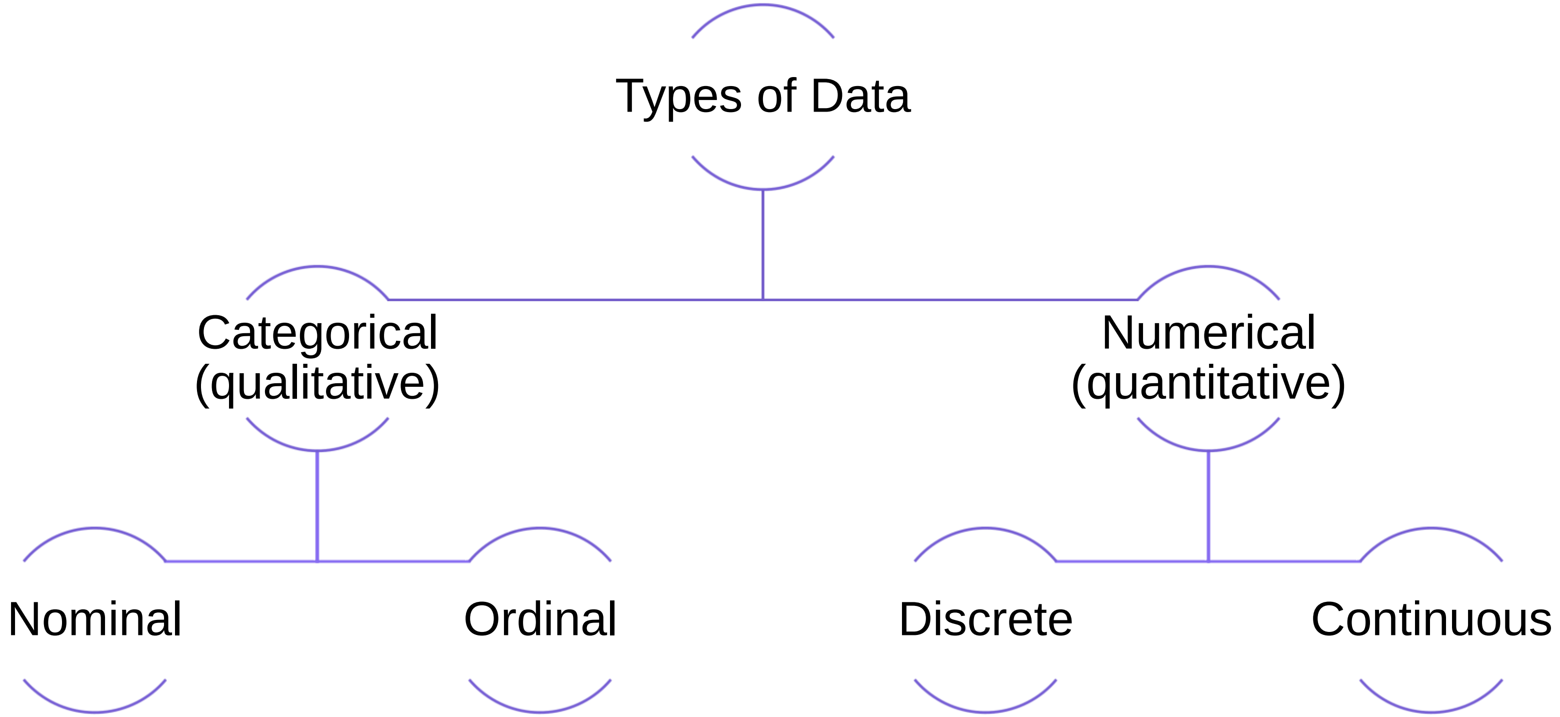
FRENCH INSTITUTES OF TECHNOLOGY

Origin of « Data »

- Every day, we create roughly 2.5 quintillion bytes of data
- Data come from anything observable through **surveys**, **sensors**, **logs**, etc…

- **Private** data: e.g., emails and pictures
- **Public** data: open data, open APIs, web (scraping)
- Data **operations**: modeling, storage, access and processing
  - Different formats: audio, video, time series, tabular, text …
  - Data centers, data lakes, data hubs …

Types of Data



Types of Data

Categorical (qualitative)

Numerical (quantitative)

Nominal

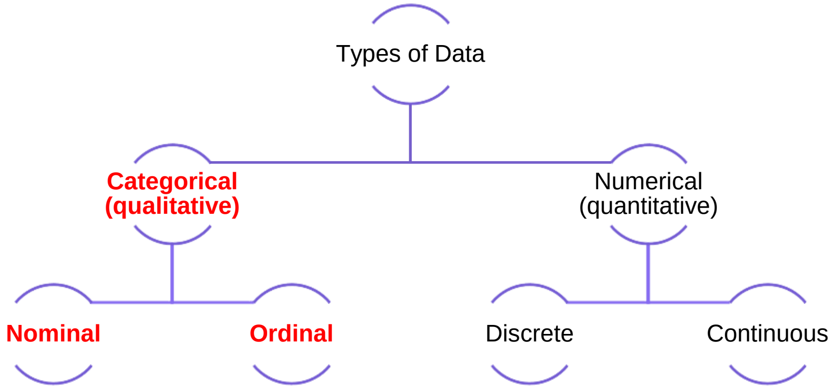
Ordinal

Discrete

Continuous

Categorical Data

- Describe qualitative characteristics (e.g., gender)
- Do not provide any quantitative value
- Do not support arithmetical operations



Nominal Data

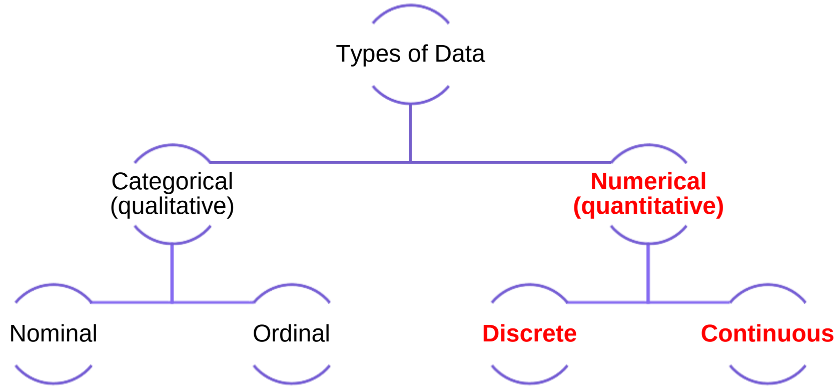
- No intrinsic ordering: can not be compared
- Examples: gender, marital status, color

Ordinal Data

- Have a logical sequential order
- Examples: clothes size (S, M, L, XL…), satisfaction (low, medium, high), opinion (strongly disagree, disagree, agree, strongly agree)

Numerical Data

- Expressed in numerical values (price, height …)
- Support arithmetical operations and statistical analysis



Discrete Data

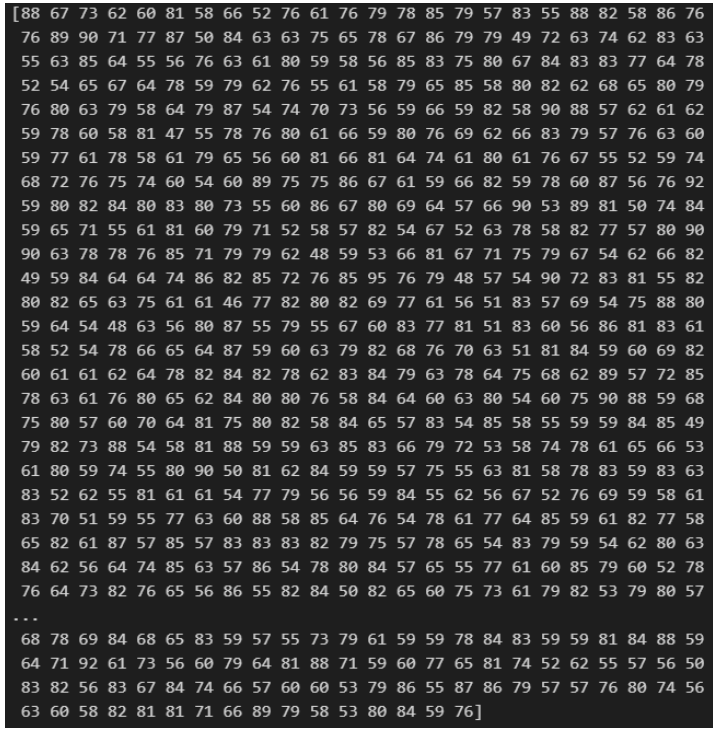
- Can have only finite (or countable) values (integer numbering)
- Examples: number of children, number of rooms in a house

Continuous Data

- Can take infinite number of values (real values)
- Examples: weight, temperature, unemployment rate

Statistics

- Consider the weights of a group of 1000 persons.
- Hard to describe the data by just looking at the numbers ☹ !



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 59 78 60 58 81 47 55 78 76 80 61 66 59 80 76 69 62 66 83 79 57 76 63 60
 59 77 61 78 58 61 79 65 56 60 81 66 81 64 74 61 80 61 76 67 55 52 59 74
 68 72 76 75 74 60 54 60 89 75 75 86 67 61 59 66 82 59 78 60 87 56 76 92
 59 80 82 84 80 83 80 73 55 60 86 67 80 69 64 57 66 90 53 89 81 50 74 84
 59 65 71 55 61 81 60 79 71 52 58 57 82 54 67 52 63 78 58 82 77 57 80 90
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 63 60 58 82 81 81 71 66 89 79 58 53 80 84 59 76]
```

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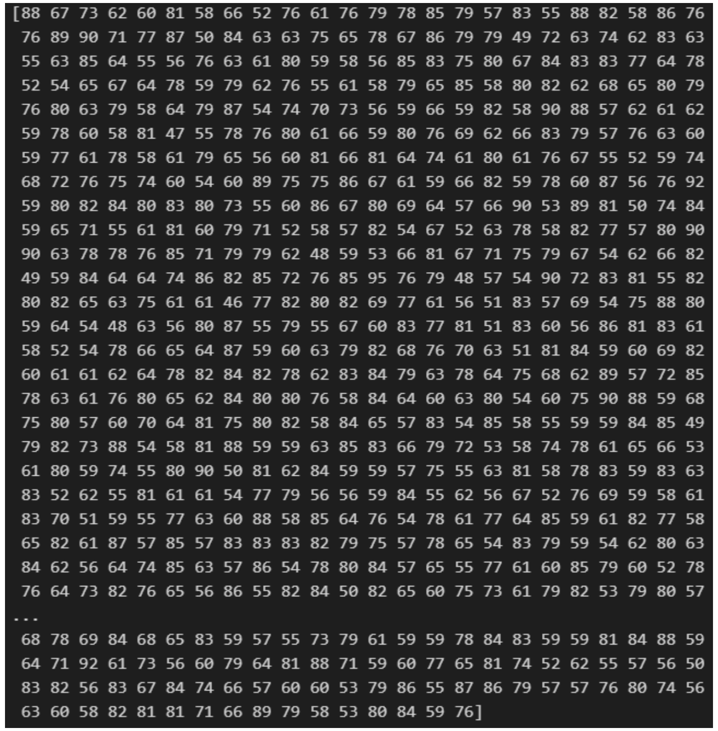

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 63 60 58 82 81 81 71 66 89 79 58 53 80 84 59 76]
```

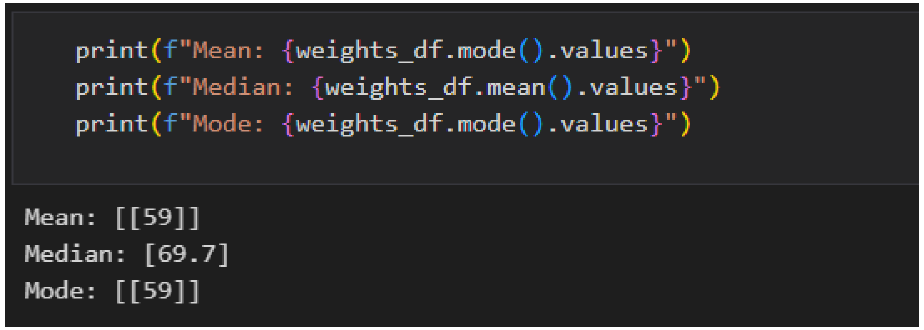
Descriptive statistics

- Summarizes or describes the characteristics of a data set.

- Consists of three basic categories of measures:
  - **Central tendency**: describes the center of the data set (mean, median, mode)
  - **Variability (or spread)**: describes the dispersion of the data set (variance, standard deviation)
  - **Frequency distribution**: describes the occurrence of data within the data set (count)

Statistics

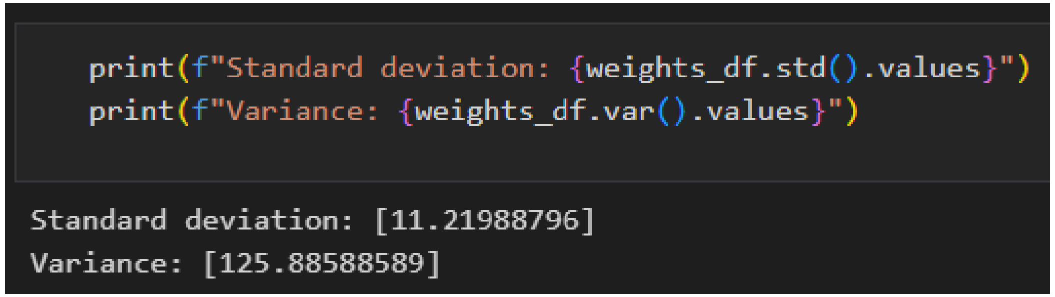
Central tendencies



```
print(f"Mean: {weights_df.mode().values}")
print(f"Median: {weights_df.mean().values}")
print(f"Mode: {weights_df.mode().values}")
```

```
Mean: [[59]]
Median: [69.7]
Mode: [[59]]
```

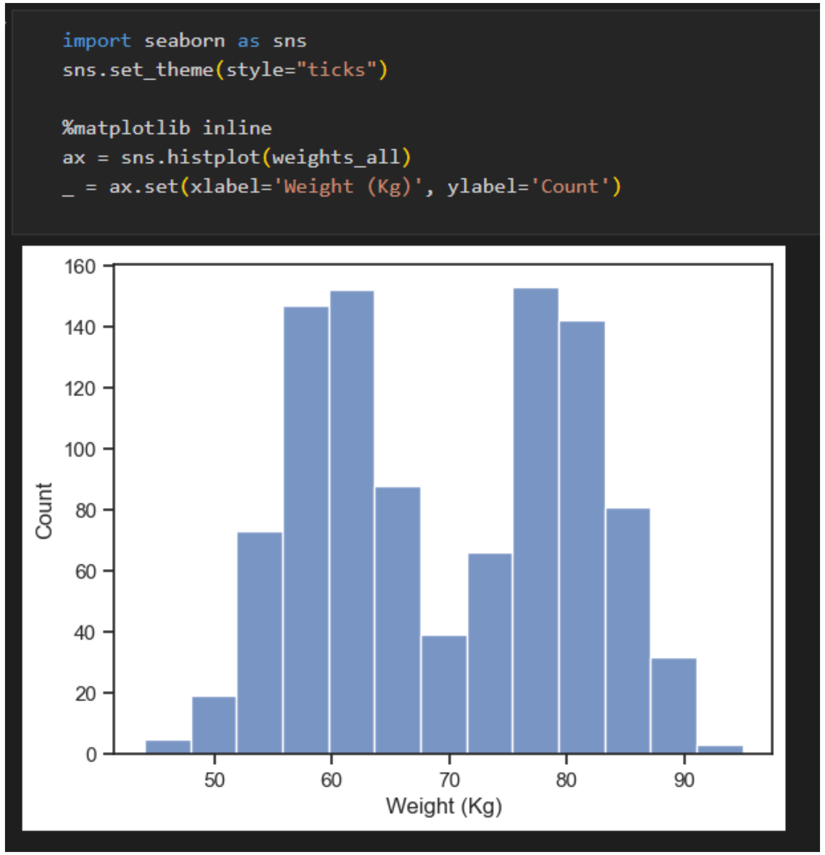
Variability



```
print(f"Standard deviation: {weights_df.std().values}")
print(f"Variance: {weights_df.var().values}")
```

```
Standard deviation: [11.21988796]
Variance: [125.88588589]
```

Frequency Distribution



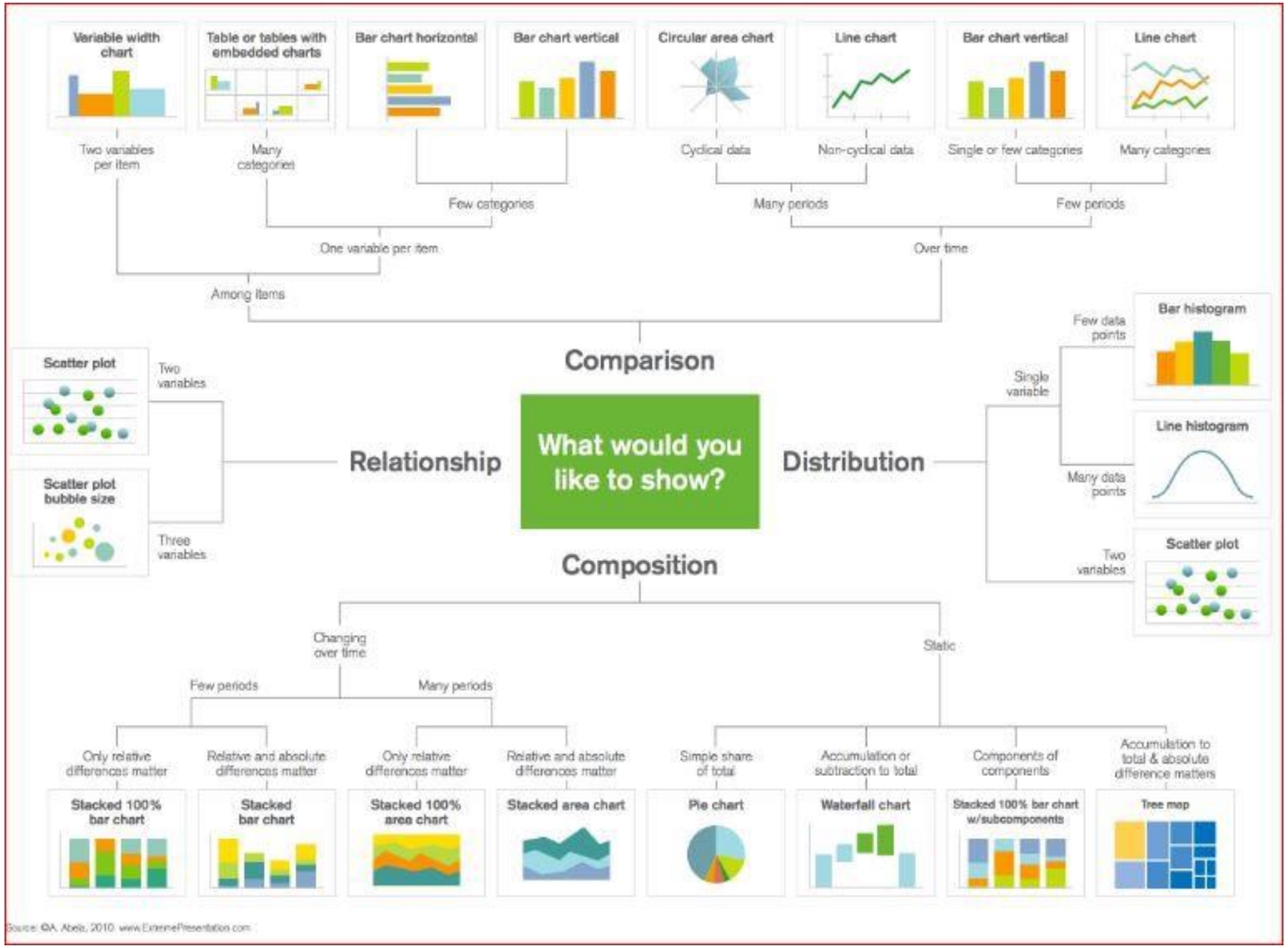
```
import seaborn as sns
sns.set_theme(style="ticks")

%matplotlib inline
ax = sns.histplot(weights_all)
_ = ax.set(xlabel='Weight (Kg)', ylabel='Count')
```

Data Visualization

- Translates information into a visual context, such as a map or graph.

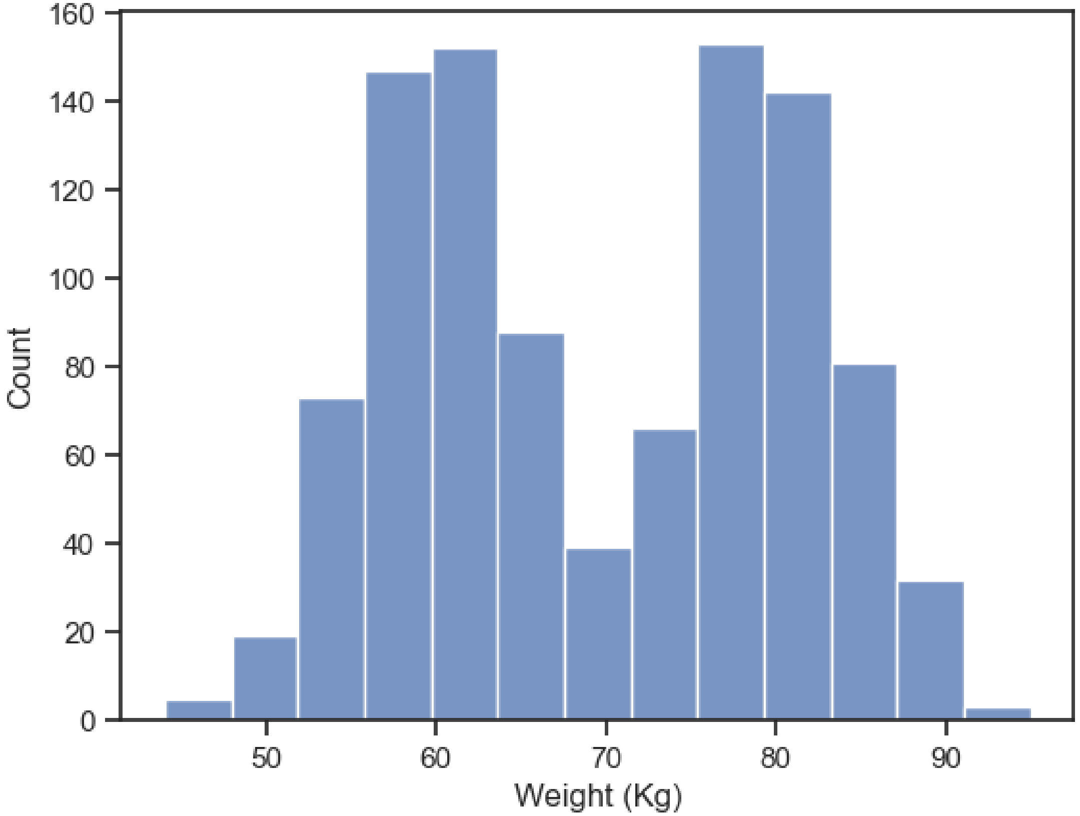
- Makes data easier for the human brain to understand and pull insights from.



[Source: www.kdnuggets.com]

Patterns

- Bimodal distribution (two peaks).
  - Why ?



Patterns

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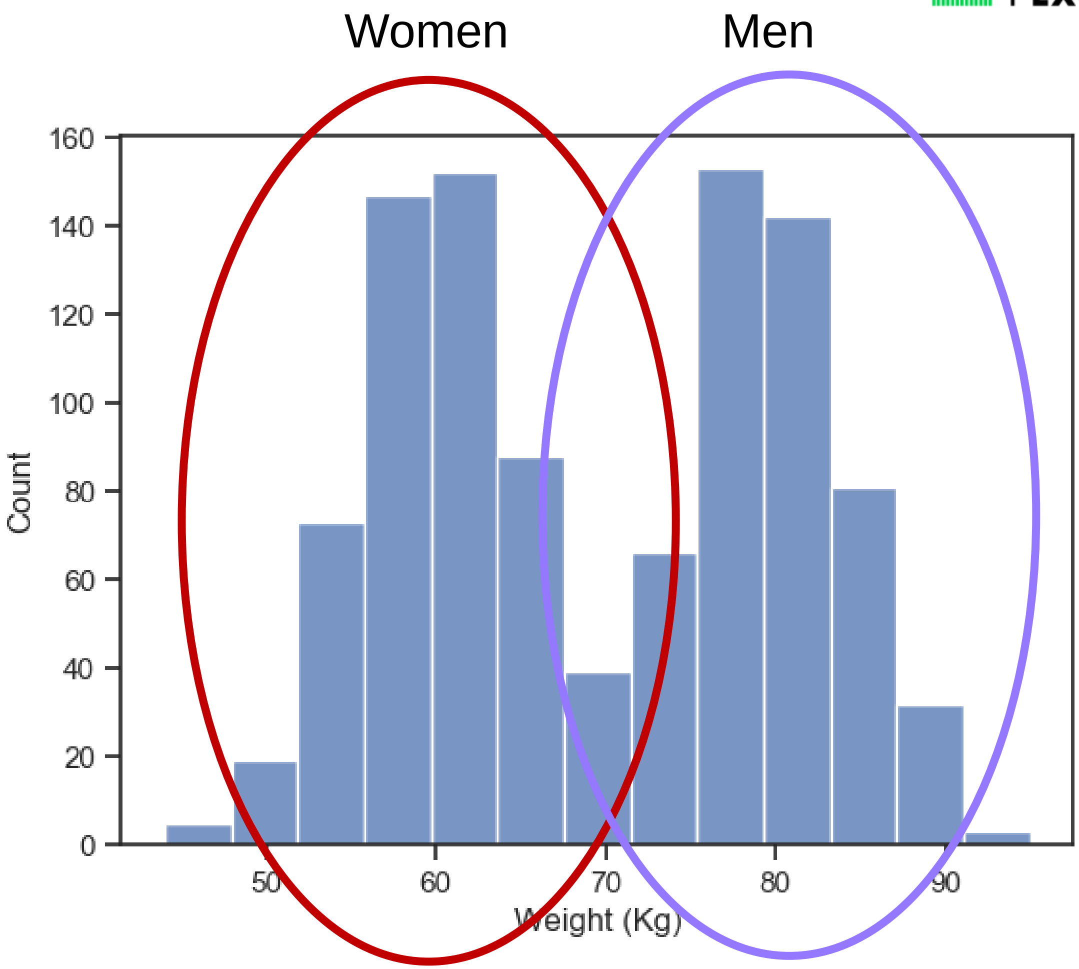
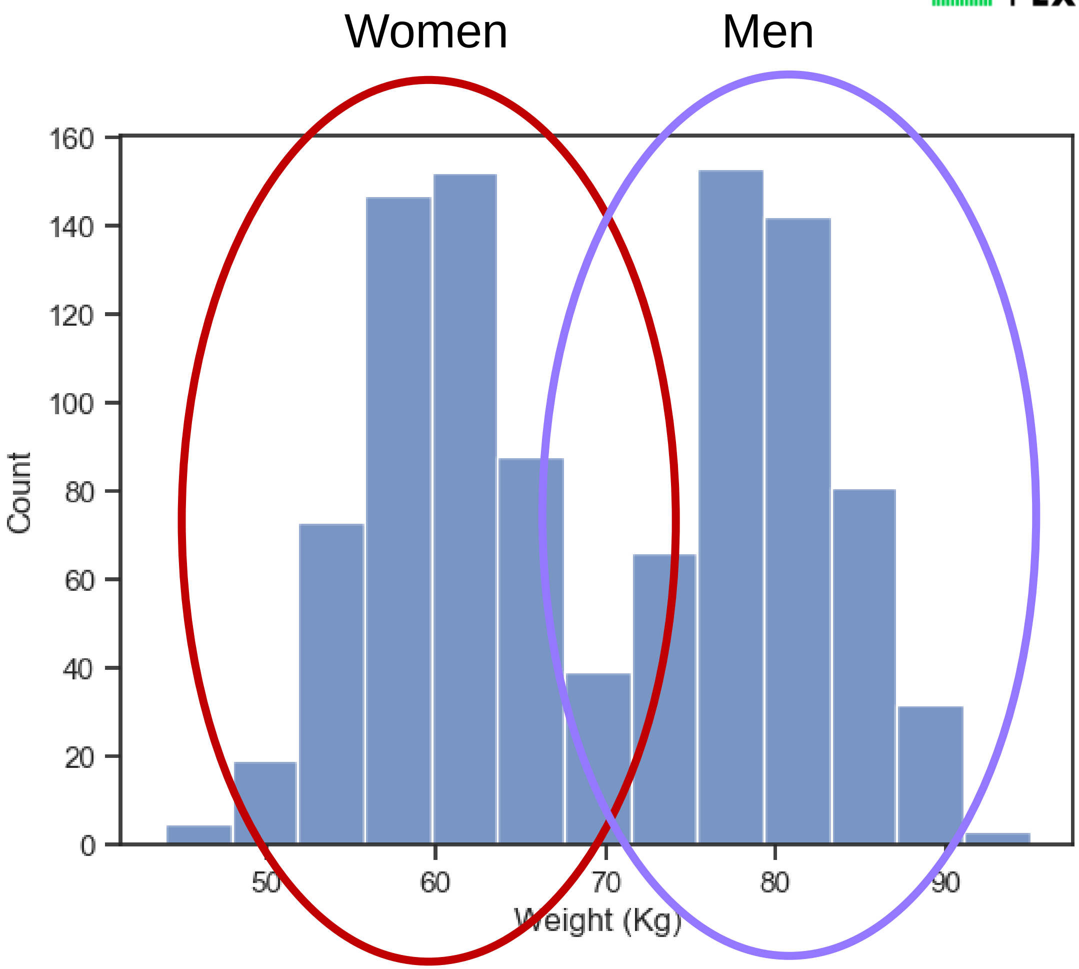
- It’s a Gaussian mixture:
  - Subpopulations of men and women



Patterns

- Bimodal distribution (two peaks)
  - Why ?
- It’s a Gaussian mixture:
  - Subpopulations of men and women
- Gender and weight are linked
- Consider a new person whose weight is unknown
  - What’s a straighforward predictor of his/her weight ?



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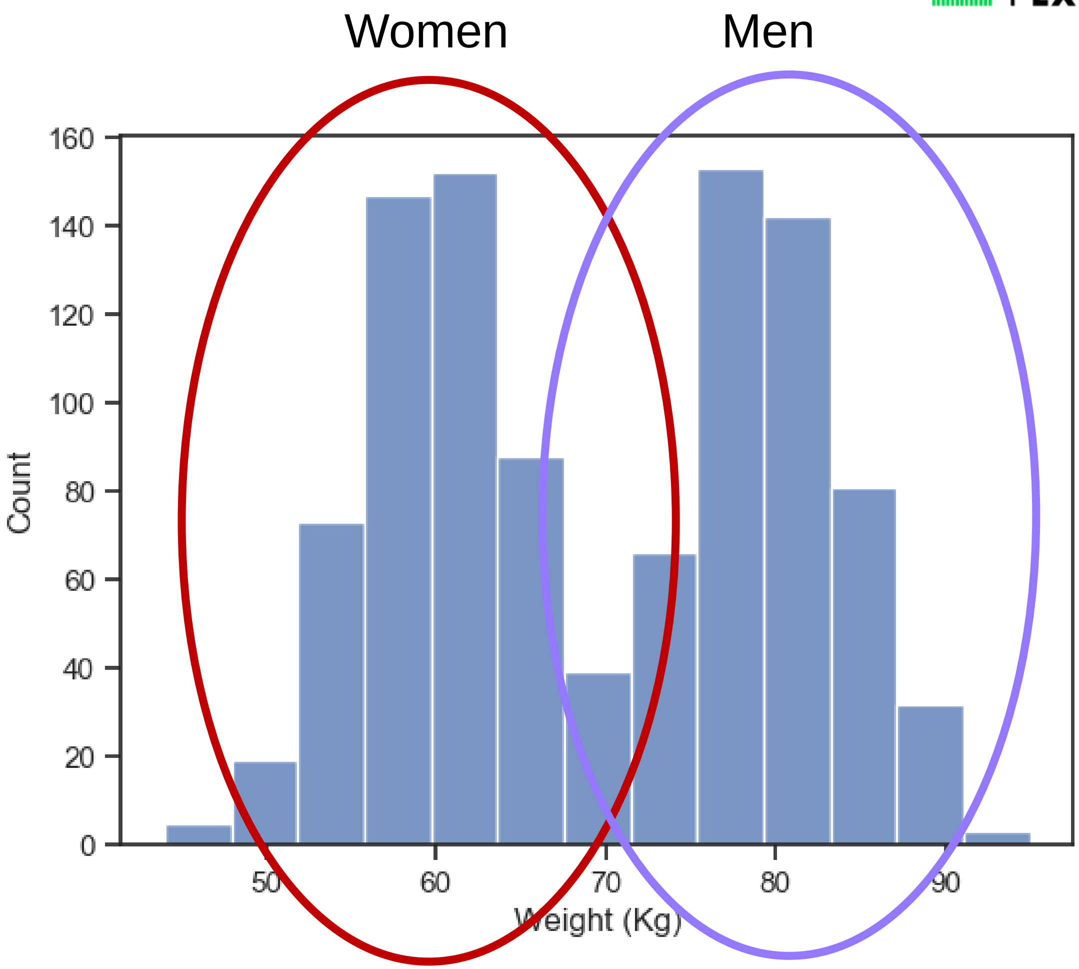
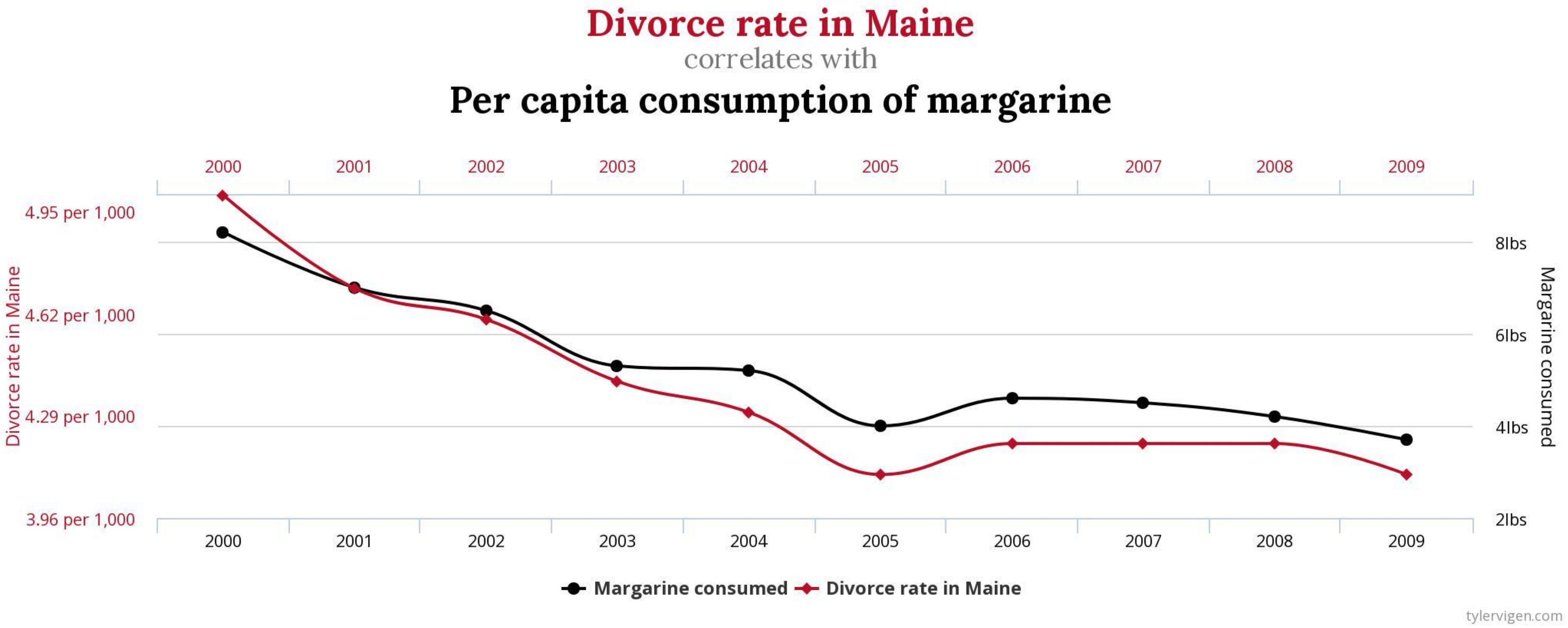


Inferential statistics allows you to make predictions (“inferences”) from that data by leveraging the underlying patterns in a sample and generalizing them to a larger population.

Patterns, but …



[Source: www.tylervigen.com]

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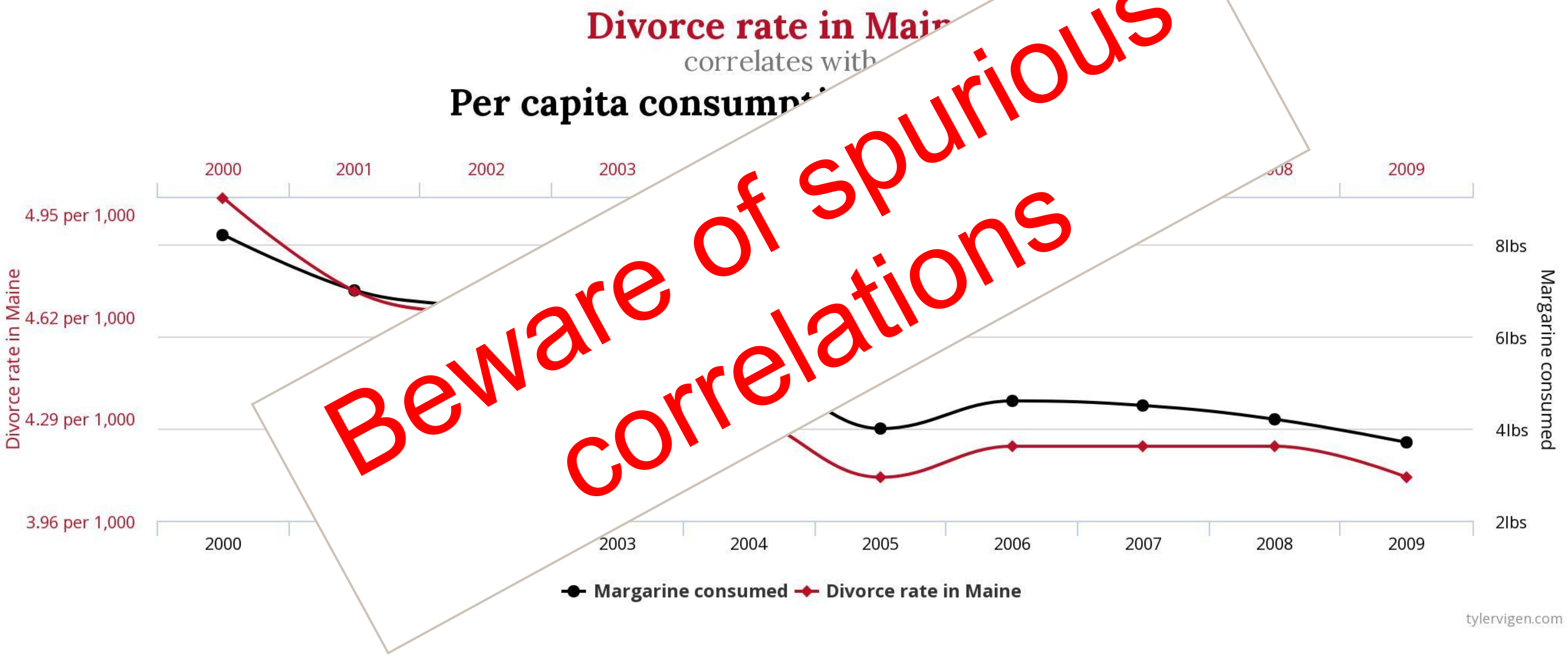
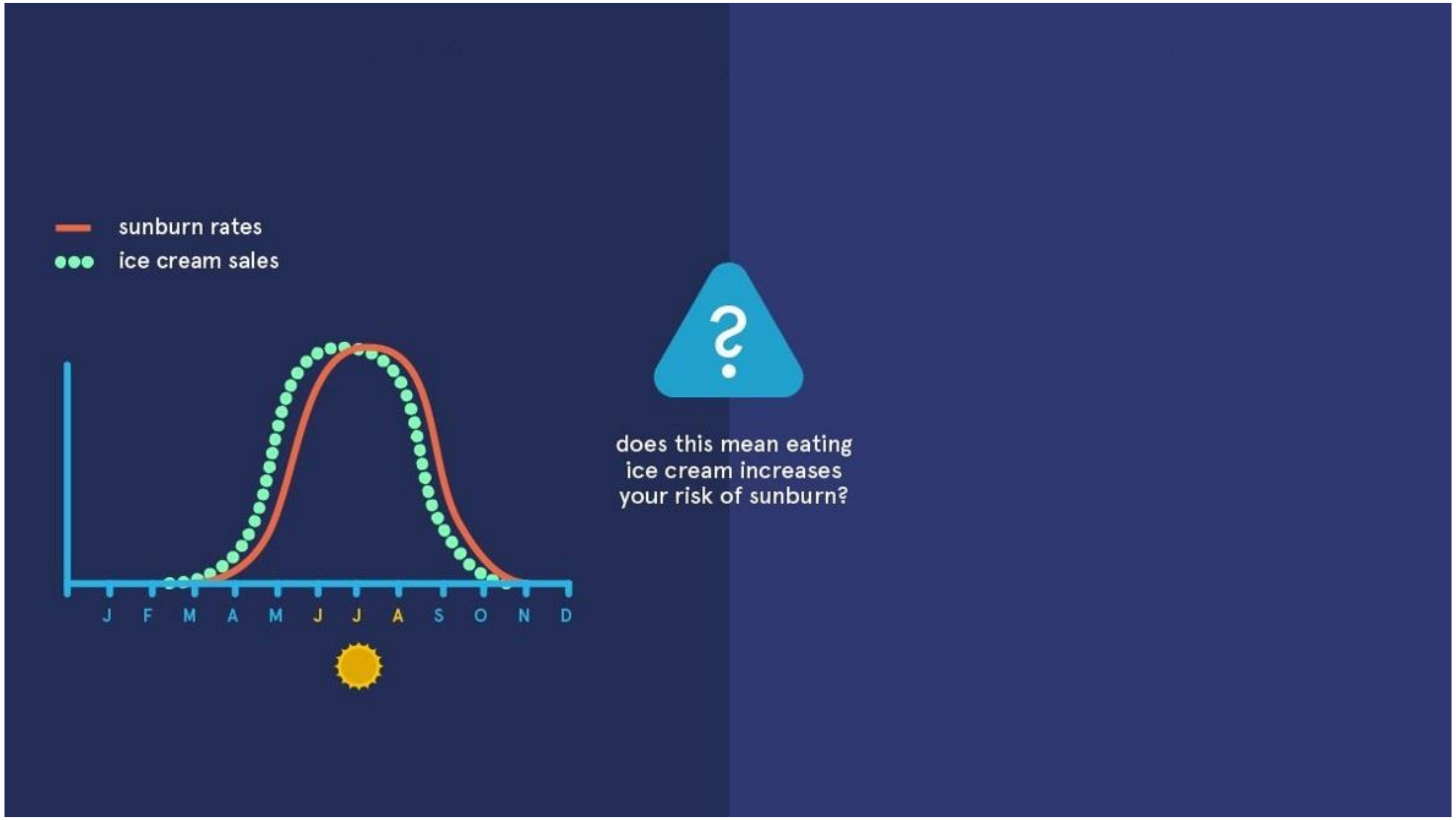


Beware of spurious correlations

[Source: www.tylervigen.com]

Patterns, but …

- You collect data on **sunburns** and **ice cream consumption**.
- You find that higher ice cream consumption is associated with a higher probability of sunburn. Does that mean ice cream consumption causes sunburn?



[Source: European Food Information Council]

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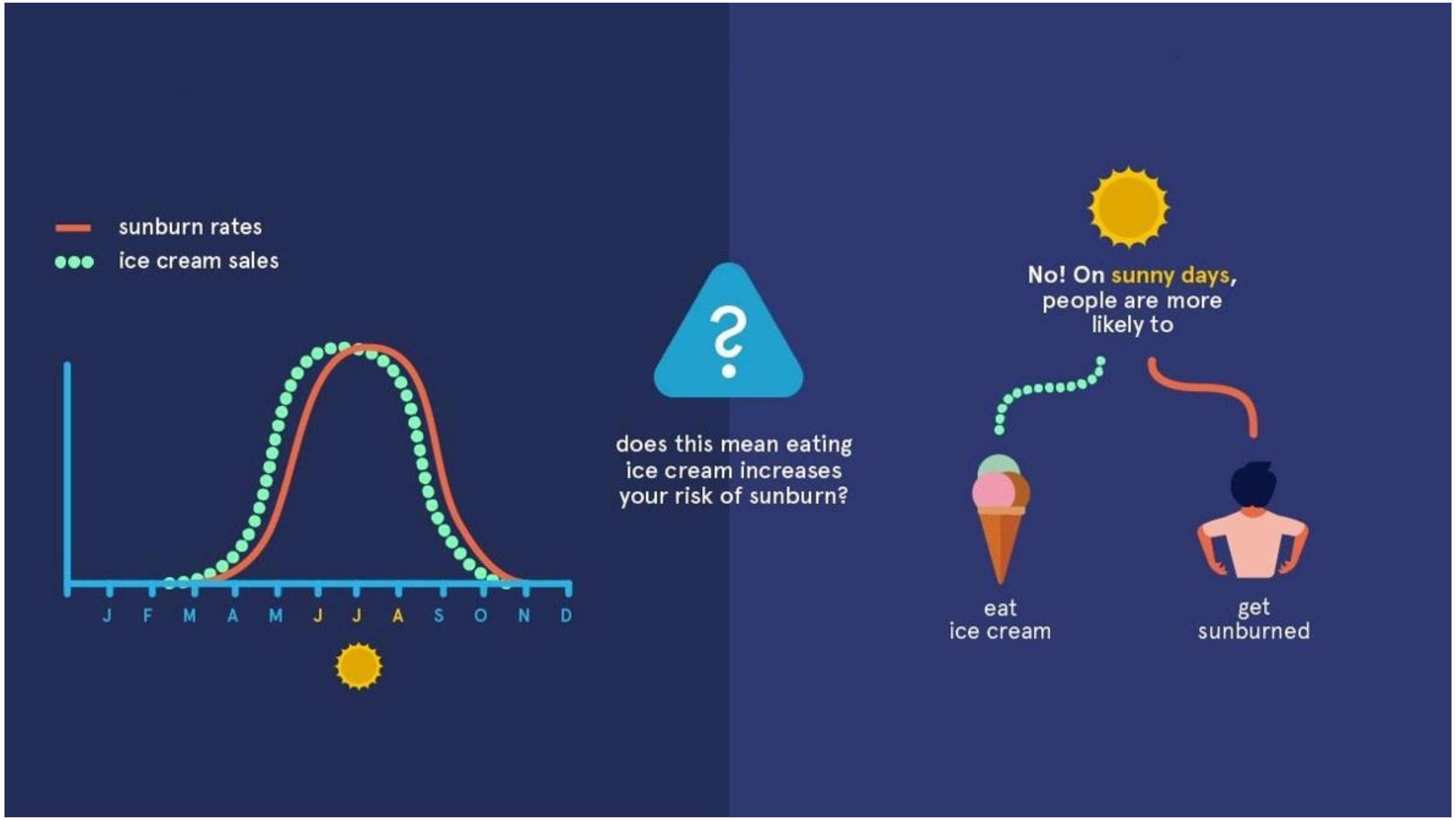
sunburn rates
ice cream sales
J F M A M J J A S O N D
does this mean eating ice cream increases your risk of sunburn?
No! On sunny days, people are more likely to
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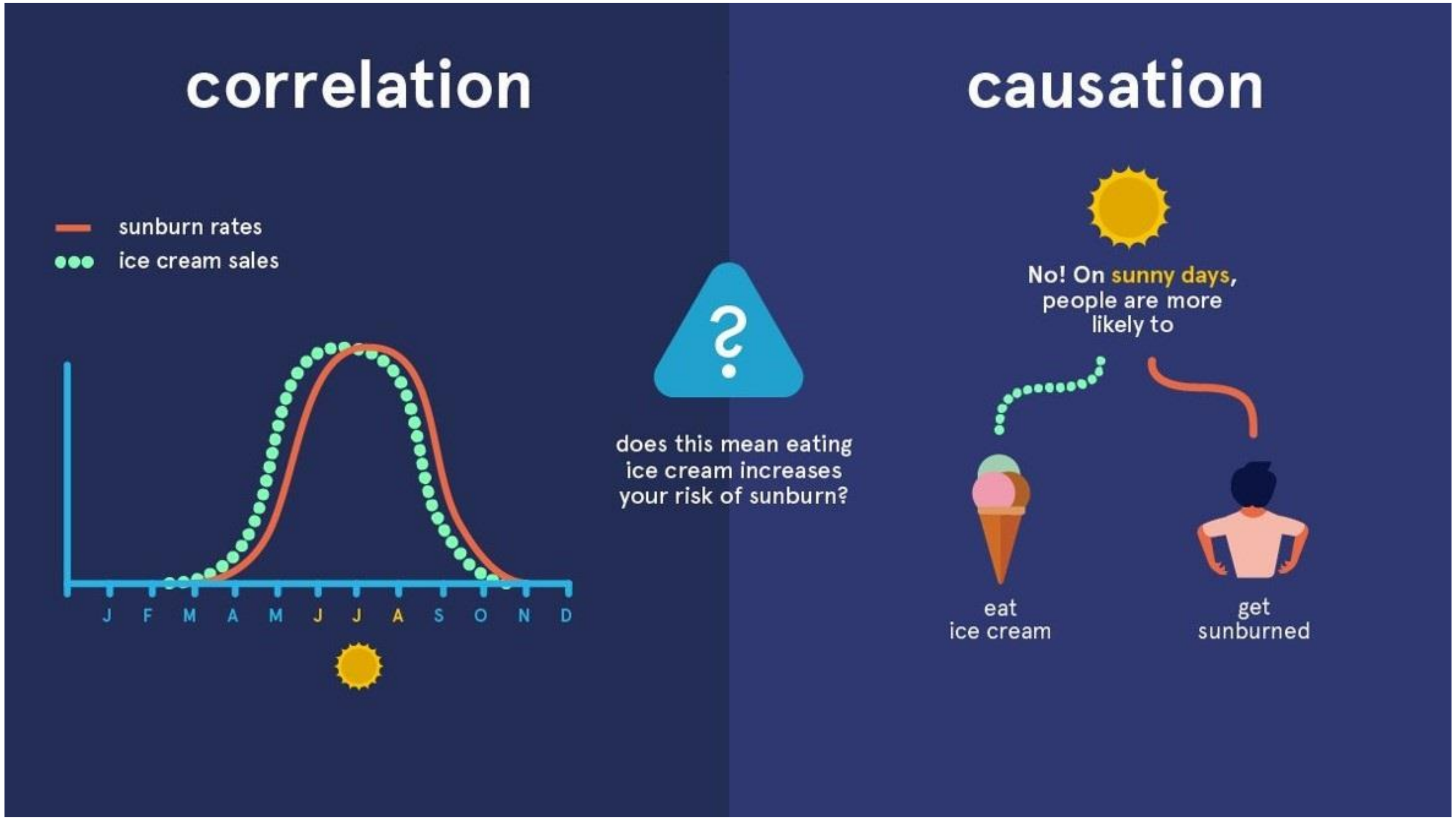
correlation
sunburn rates
ice cream sales
J F M A M J J A S O N D
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causation
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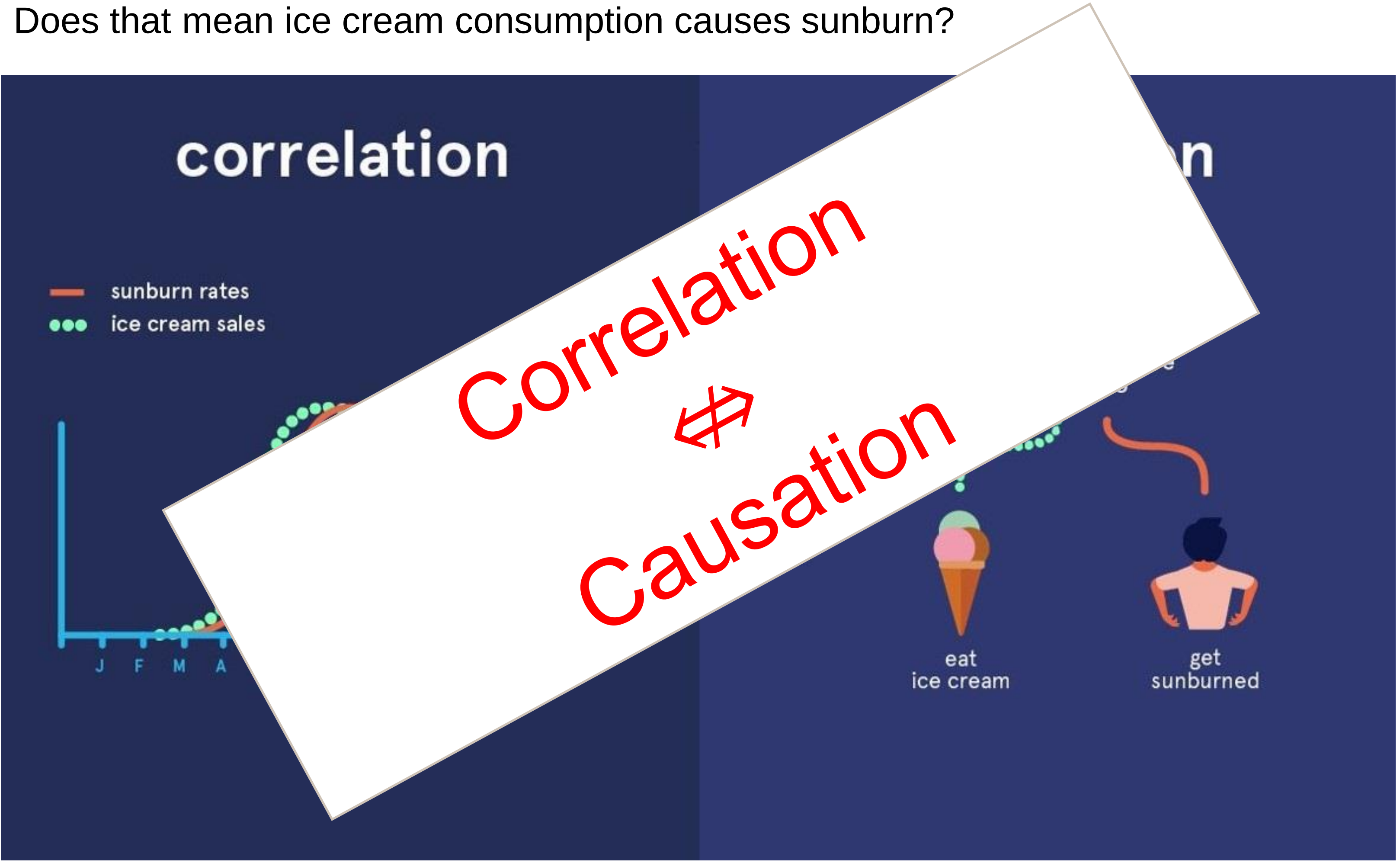


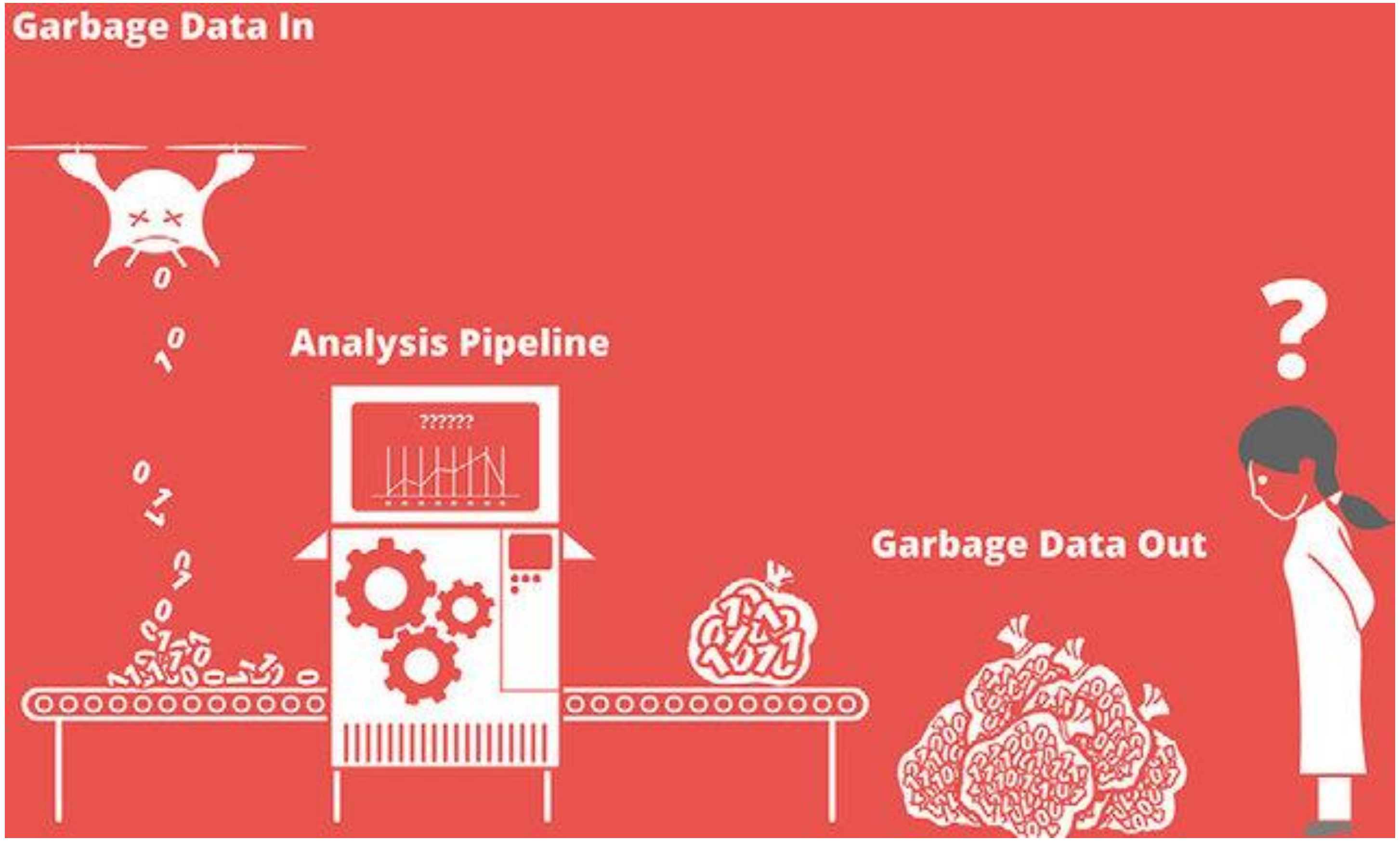
Correlation ⇎ Causation

[Source: European Food Information Council]

Data Quality

Examples:

- Incomplete data
- Inconsistent data
- Incorrect data



[Source: The Plant Phenome Journal]

Data Preprocessing

Preprocessing prepares the data for machine learning algorithms

Data cleaning

Missing values

Noisy samples

Outliers

…

Data transformation

Categorical data encoding

Feature scaling

Attribute selection

…

Data reduction

Dimension reduction

🎖 Time to practice ! 🎖