**🔗 Correlation**

**Definition**: Correlation measures the **strength and direction** of a linear relationship between two variables.

* Represented by the **correlation coefficient** rrr, which ranges from **-1 to 1**.
  + r=1r = 1r=1: perfect positive correlation
  + r=−1r = -1r=−1: perfect negative correlation
  + r=0r = 0r=0: no linear correlation

**Key Points**:

* Correlation does **not** imply that one variable causes the other.
* Example: Ice cream sales and drowning deaths are correlated, but eating ice cream doesn’t cause drowning — both are related to summer weather.

**Mathematical Tools**:

* **Pearson’s correlation coefficient** (for linear relationships)
* **Spearman’s rank correlation** (for monotonic relationships)

**🎯 Causation (Causal Relationship)**

**Definition**: Causation means that **one variable directly affects another** — a change in variable A **causes** a change in variable B.

**Key Points**:

* Requires more than statistical association; often established through:
  + **Controlled experiments**
  + **Longitudinal studies**
  + **Causal inference methods** (e.g., using directed acyclic graphs or structural equation modeling)
* Causation **implies** correlation, but correlation **does not imply** causation.

**Example**:

* Smoking causes lung cancer. This has been shown through years of experimental, observational, and statistical evidence — not just a correlation.

**📊 Summary Table**

| **Feature** | **Correlation** | **Causation** |
| --- | --- | --- |
| Relationship | Association | Cause and effect |
| Directionality | No direction implied | Directional (cause → effect) |
| Proof Method | Statistical analysis | Experimental or advanced statistical design |
| Implies | Possible connection | Definite effect |
| Example | Coffee consumption ↔ productivity | Virus infection → fever |