# Correlation vs. Causation

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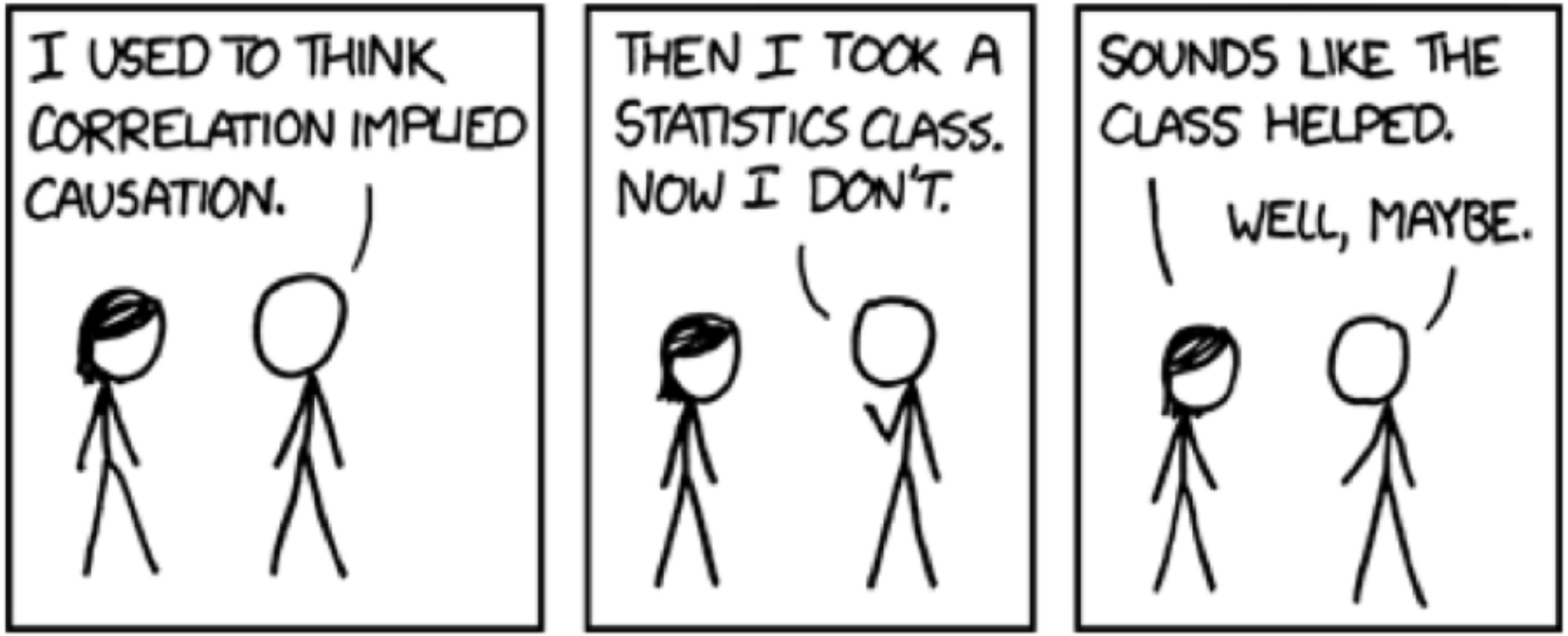
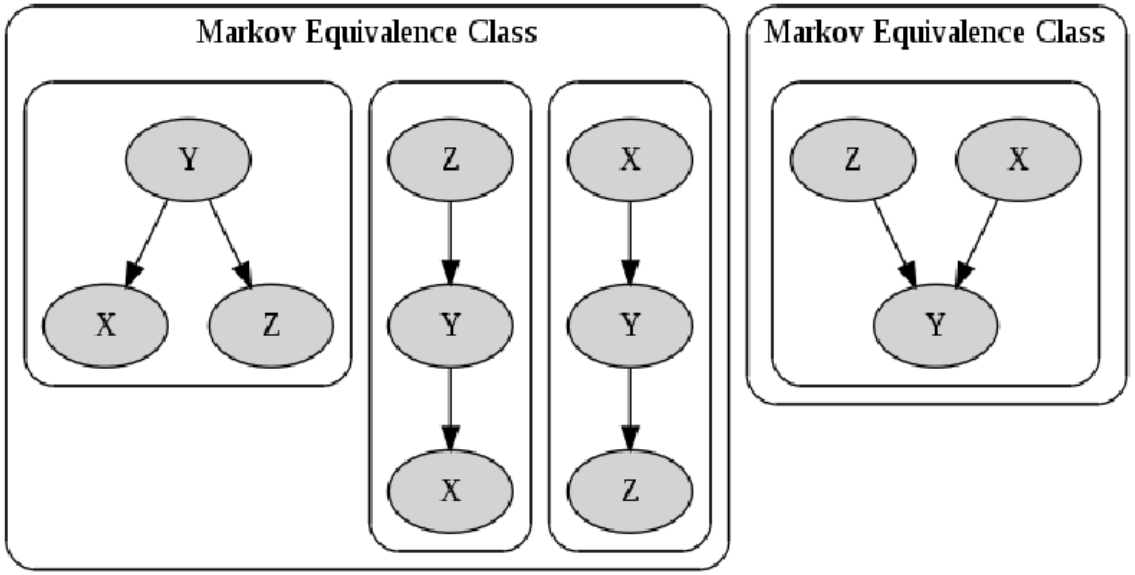
# Correlation does NOT imply Causation



# Reichenbach Principle

- If two events are correlated, it is either because:
  i. the is a causal connection between the two, or
  ii. there is a third event that brings about the correlation.

- Markov Equivalent Classes:
  - $X$ correlated with $Z$.




Distributionally Equivalent

# A general mathematical language for causality

- Interventions (actions) vs. observation – the $do$-operator (Pearl 2000)

$$p(y \mid \boldsymbol{do}(\boldsymbol{T} = \boldsymbol{t}), X = x) = p(y \mid \boldsymbol{T} = \boldsymbol{t}, X = x)$$

- Causation vs. Correlation
  - Randomized Controlled trials (RCTs) can help identify causal relationships and effects by careful design!

What happens when you can't intervene – or don't know what to intervene on, e.g., economics?

# Causal Inference and Discovery

- Causal Inference
  - When you can’t intervene, can you identify effects?
- Causal Discovery
  - When you don’t fully understand the system, can you discover causal relationships from observational/partially-observational?

# Applications

- Neuroscience: Effective connectivity
- Healthcare: Automated diagnoses
- Fairness: Decision making with sensitive attributes
- Science: Flexibility with experiments
- Artificial Intelligence: A more general understanding of the world

# Interested? Here are some starting points.

- Potential Outcomes (Rubin) vs. Graphical (Pearl) Framework
- Potential Outcome
  - Ignorability, Conditioning
- Graphical Framework
  - $do$-calculus
  - Back-door criterion, Blocking

# Thanks!

Questions?