

# **Causality: Explanation versus Prediction**

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- 1 Brief Review of Last Week
- 2 Causality

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2 Causality

**What did we learn  
about last week?**

# Continuing that theme...

By the end of today you should be able to:

- Identify what makes for a causal relationship
- Distinguish causation from correlation/association
- Begin to analyze research problems using counterfactual thinking

1 Brief Review of Last Week

2 Causality

**Write for 1 minute**

**What makes  
something a  
*cause*?**

# Physical causality

- Action and reaction
- Features: Observable and deterministic
- Example:
  - Picture a ball resting on top of a hill
  - What happens if I push the ball?
- Physical causality is easy to see



# Correlation I

- Correlation is the non-independence of two variables for a set of observations

# Correlation II

- *Observation*: A case or unit (e.g., person, country)
- *Variable*: A dimension that describes an observation (e.g., income)
- *Independence*: Variables are unrelated to one another
  - Independent: Height and value on a fair dice roll
  - Non-independent: Height and weight

# Correlation III

- Synonyms: correlation, covariation, relationship, association
  - “Effect” is frequently used to mean correlation
  - We’ll reserve that term for a *causal effect*
- Any correlation is a potential cause
  - X might cause Y
  - Y might cause X
  - X and Y might be caused by Z
  - X and Y might cause Z
  - There may be no causal relationship

# Mill's methods<sup>1</sup>

- Agreement
- Difference
- Agreement and Difference
- Residue
- Concomitant variations

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<sup>1</sup>Discussed in Holland

# Difference

If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance save one in common, that one occurring only in the former; the circumstance in which alone the two instances differ, is the effect, or cause, or an necessary part of the cause, of the phenomenon.

# Four (or five) principles of causality<sup>2</sup>

- 1 Correlation
- 2 Nonconfounding
- 3 Direction (“temporal precedence”)
- 4 Mechanism
- 5 (Appropriate level of analysis)

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<sup>2</sup>From Kellstedt and Whitten

# Questions?

# Counterfactual Thinking

- *Counterfactual*: relating to what has not happened or is not the case
- Causal inference involves inferring *what would have happened* in a counterfactual reality *where the potential cause took on a different value*



# “A Christmas Carol”

- 1843 novel by Charles Dickens
- Ebenezer Scrooge is shown his own future by the “Ghost of Christmas Yet to Come”
- Has the choice to either:
  - stay on current path (one counterfactual), or
  - change his ways (take a different counterfactual)

# Causation

- *Causal effect*: The difference between two “potential outcomes”
  - The outcome that occurs if  $X = x_1$
  - The outcome that occurs if  $X = x_2$
- The causal effect of Scrooge’s lifestyle is seen in the differences between two potential futures

# Fundamental problem of causal inference

We can only observe any given unit in one reality!

# Two solutions!<sup>3</sup>

## 1 Scientific Solution

- All units are identical
- Each can provide a perfect counterfactual
- Common in, e.g., agriculture, biology

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## 1 Scientific Solution

- All units are identical
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## 2 Statistical Solution

- Units are not identical
- Random exposure to a potential cause
- Effects measured on average across units
- Known as the “Experimental ideal”

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<sup>3</sup>From Holland

# In Political Science

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# In Political Science

- Causal inference is about searching for appropriate counterfactuals
  - *Causal effect*: Difference in an outcome variable between two counterfactuals
  - *Causal inference*: A belief that an event or variable exerts a causal effect on an outcome
- Where can we look for counterfactuals?

# An Example

- For example, if we think smoking might cause lung cancer, how would we know?
- How would we know if smoking caused lung cancer for an individual who smoked?
  - What's the relevant counterfactual?
- How would we know if smoking causes lung cancer on average across many individuals?
  - What's the relevant counterfactual?



# Mill's Methods

# Agreement

If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree, is the cause (or effect) of the given phenomenon.

# Difference

If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance save one in common, that one occurring only in the former; the circumstance in which alone the two instances differ, is the effect, or cause, or an necessary part of the cause, of the phenomenon.

# Agreement and Difference

If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance; the circumstance in which alone the two sets of instances differ, is the effect, or cause, or a necessary part of the cause, of the phenomenon.

# Residue

Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents.



# Concomitant variations

Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation.