CAUSALITY

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Important distinction between the **actual** causal processes that shape the world and the **inferences** we make about them.

Philosophers (eg Hume) point to unobservability of the former and suggest ways of making the latter.

Causal inference is “in the head” but it is strange to believe that causality itself is.

“Reality is that which, when you stop believing in it, doesn’t go away.”

Philip K. Dick

Inferences about causality normally exploit variation in the explanatory factor of interest.

Key question to ask: how was the variation generated?

By the observer: random allocation to treatment and control

By “nature”: the observed outcome of a social process

Did “nature” provide us with exogenous variation?
For example the US draft lottery.

Does nature’s variation only depend on observables?

Does nature’s variation also depend on unobservables?

Missing variables?

Expected outcomes?

What you can infer about causation (ie what meaning the numbers you estimate will sustain) depends crucially on the answers to these questions.

Broad views of causality

- Focus on the **effects of causes**
  - Typically interest is in saying something about the magnitude of the causal impact or effect of one variable on an outcome variable with all other influences "held equal".
    - New drug on five year survival rate
    - Training program for unemployed on probability of getting a job
    - Staying in school for an extra year on adult earnings
    - Going to a religious rather than a secular school on exam success
  - Other factors (observed and unobserved) are nuisance factors to be controlled for.
  - Intense spotlight on the impact of just one variable – no attempt to provide a "complete" explanation or evaluate the relative "importance" of many competing explanatory variables.

Broad Views of Causality

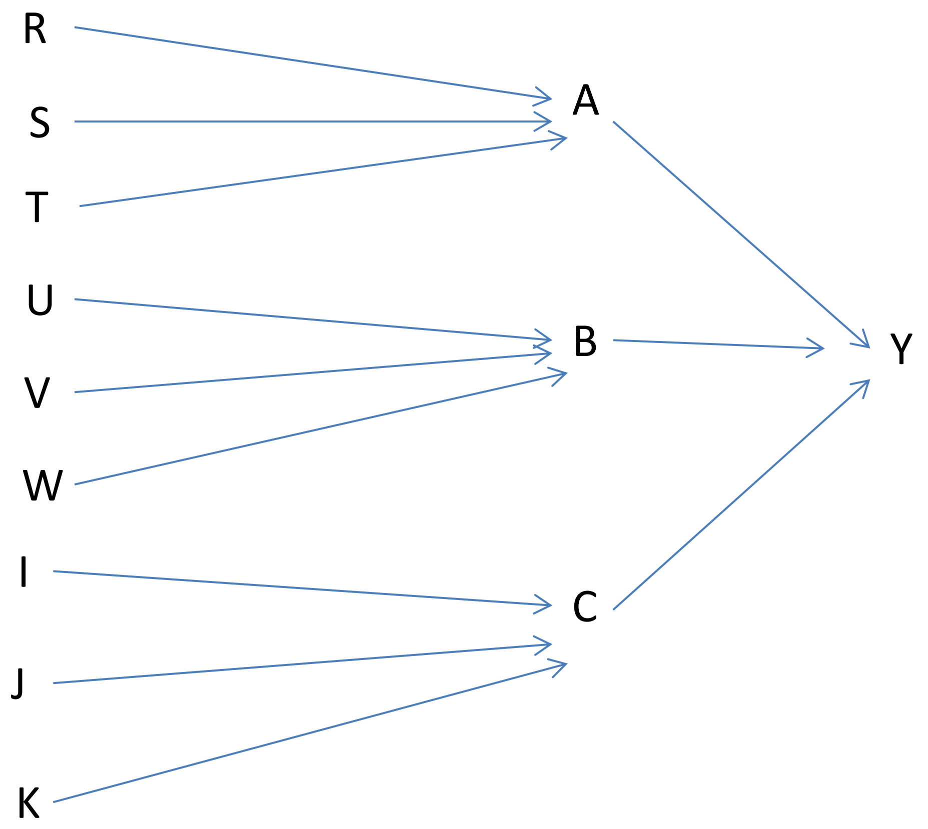
- Important to understand how variation in causal factor generated.
  - Simplest case is randomization to treatment & control by the investigator
  - Causality as consequential manipulation (CACM)
  - Classic randomized controlled trial

- Questions
  - Does “nature” ever mimic this? Occasionally.
  - What kinds of things can be usefully be regarded as treatments?

Broad Views of Causality

- **Causes of effects**
  - What are the causes of wars, gender discrimination, ethnic conflict, educational achievement………

Causes of Effects



Randomisation

- Key to sound experimental inference
- Subjects are allocated by lottery to the different experimental conditions
  - In within-subject designs subjects are exposed to the different conditions in random order
- Usually there is a “control” condition where nothing happens to the subjects (or something that is known to be irrelevant for the phenomena under investigation)
- Sometimes the randomisation is such that neither experimenter nor subject know (at the time) what condition the subject is in (double-blind trials)
- Randomisation has nothing to do with random sampling in the social survey sense
  - Inference is over the hypothetical population of random allocations of subjects to conditions

Before-After Two-Group Design I

R	Y_1	X	Y_2
R	Y_3		Y_4

H_0: $(\overline{Y}_2 - \overline{Y}_1) - (\overline{Y}_4 - \overline{Y}_3) = 0$

Internal Validity

- Internally valid designs are resistant to rival explanations in terms of factor(s) other than the applied treatment is (are) the **cause(s)** of any observed effect
- Good experimental design seeks to maximize internal validity against a number of particular threats, in other words weaknesses of design that call into doubt the unique attribution of changes in values of the response to the experimental manipulation.
- (In an observational context this kind of idea is usually discussed in terms of having an "identification strategy"

The Potential Outcomes Framework

Define potential outcome random variables Y^1 and Y^0

Where Y^1 is the PO in the treatment condition and Y^0 is the PO in the control condition

Realised values are y_i^1 and y_i^0 for individual i

The **individual-level** causal effect of the treatment is then: $\delta_i = y_i^1 - y_i^0$

Define a "causal exposure variable" D.

D = 1 for those i exposed to the treatment state and D = 0 for those i exposed to the control state

The observable outcome variable is defined as

$$Y = Y^1 \ \text{if}\ D = 1$$

$$Y = Y^0 \ \text{if}\ D = 0$$

The fundamental problem of causal inference

Group	Y^1	Y^0
Treatment group (D=1)	Observable as Y	Counterfactual
Control group (D=0)	Counterfactual	Observable as Y

Average Treatment Effect

$$E[\delta] = E[Y^1 - Y^0]$$

$$= E[Y^1] - E[Y^0]$$

Treatment assignment 1

Consider a randomized experiment

Subject i is allocated either to D=1 or to D=0 by a lottery like process.

For instance imagine we use a random number generator to create for each subject i a value in the 1-100 interval of a variable we'll call R.

I	R	D
1	23	0
2	31	0
3	56	1
4	4	0
.	.	.

Treatment assignment 2

Subjects are allocated to treatments according to a rule:

If R <= 50 D=0; if R > 50 D=1.

By definition R cannot influence Y because R is just a random number.

Whatever relationship R may appear to have with Y must be because R controls allocation to D.

R → D → Y

Treatment assignment 4

Another important situation in which the treatment assignment mechanism is ignorable is when assignment to D depends **only on observed variables** S

In this case we say that the potential outcomes are independent of D **conditional on S**

Ignorability through randomization under investigator's control leads to experiments, RCTs etc

Ignorability through randomization via a suitable "instrument" leads to "natural experiments", instrumental variable estimation with observational data etc

Ignorability through conditioning on variables that select units into treatment conditions leads to observational data analyses with matching, propensity score analysis, selection models (for unobservables) or rigorous conditioning

Bottom line: to make sense of a causal claim you need to know (or make assumptions about) how units are assigned to treatments. Human subjects make choices….

Stable Unit Treatment Value Assumption (SUTVA)

SUTVA is the assumption that the value of Y for individual i exposed to treatment d does not depend on the way the individuals are assigned to treatments

Table 2.2: A Hypothetical Example in Which SUTVA is Violated

Treatment assignment patterns	Potential outcomes	
$\begin{bmatrix} d_1 = 1 \\ d_2 = 0 \\ d_3 = 0 \end{bmatrix}$ or $\begin{bmatrix} d_1 = 0 \\ d_2 = 1 \\ d_3 = 0 \end{bmatrix}$ or $\begin{bmatrix} d_1 = 0 \\ d_2 = 0 \\ d_3 = 1 \end{bmatrix}$	$y_1^1 = 3$ $y_2^1 = 3$ $y_3^1 = 3$	$y_1^0 = 1$ $y_2^0 = 1$ $y_3^0 = 1$
$\begin{bmatrix} d_1 = 1 \\ d_2 = 1 \\ d_3 = 0 \end{bmatrix}$ or $\begin{bmatrix} d_1 = 0 \\ d_2 = 1 \\ d_3 = 1 \end{bmatrix}$ or $\begin{bmatrix} d_1 = 1 \\ d_2 = 0 \\ d_3 = 1 \end{bmatrix}$	$y_1^1 = 2$ $y_2^1 = 2$ $y_3^1 = 2$	$y_1^0 = 1$ $y_2^0 = 1$ $y_3^0 = 1$