Philosophy of Science

Lecture 7: Explanation
Special Topic: Reductionism

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The Covering Law Model

The covering law model

- **Origin:** Logical Empiricists

- CLM takes explanations to be:

  - Arguments
  - With particular and general claims (laws) as premises.
  - By and large, rational reconstructions.
  - Symmetrical with predictions

- The model encompasses two complementary accounts:

  (1) The Deductive-Nomological (DN) account
  (2) The Inductive-Statistical (IS) account

The Deductive-Nomological Account

The deductive-nomological account

- On this account, good explanations are arguments that satisfy the following four conditions:

  (a) Deductive validity
  (b) True premises
  (c) Empirical content
  (d) At least one deterministic law of nature

  NB: The premises are assumed to be non-redundant.

- **Prominent proponents**: Hempel, Oppenheim & Nagel.

The deductive-nomological account: The schema

1. $C_1, C_2, \ldots, C_n$
2. $L_1, L_2, \ldots, L_m$

$\therefore E_1$

(1–2) *Explanans / Explicans*

(E_1) *Explananandum / Explicandum*

C_1 - C_n stand for descriptions of particular facts
L_1 - L_m for descriptions of laws and
E_1 for a description of that which is explained

Example: Free falling objects

- Suppose we want to find out why two objects reach the ground at the same time.

1. All freely falling bodies fall with constant acceleration.
2. *X* and *Y* are free falling bodies.
3. *X* and *Y* are released from height *x* simultaneously.

∴ *X* and *Y* reach the ground simultaneously.

red: law
green: initial conditions

Explaining laws and theories

- This model also provides explanations of generalisations.
- Hempel: "...the question, 'Why do Galileo's and Kepler's laws hold?' is answered by showing that these laws are but special consequences of the Newtonian laws of motion and of gravitation; and these, in turn, may be explained by subsumption under the more comprehensive general theory of relativity"([1962] 1998, pp. 686-7).

Einstein's Theory of Relativity

Newton's laws

Galileo's laws + Kepler's laws

↓

Explaining laws and theories (2)

- Such explanations lead to an increase in "the breadth and the depth of our scientific understanding" (p. 687).

- **Breadth**: A broader range of phenomena is covered.

  Example: Newtonian laws explain (over and above the laws of Galileo & Kepler) motions of comets, satellites and tides.

- **Depth**: The phenomena are more accurately described.

  Example: Newtonian laws explain (contra Kepler's first law) that orbits are not perfect ellipses.

List the four conditions required by the D-N account.

The Inductive Statistical Account

The inductive-statistical account

- On this account, good explanations are arguments that satisfy the following five conditions:

  (a) Inductive strength
  (b) True premises
  (c) Empirical content
  (d) At least one probabilistic law of nature
  (e) Maximal specificity

  NB: The premises are assumed to be non-redundant.

- **Prominent proponents**: Hempel (1965).

The inductive-statistical account: The schema

1. $C_1, C_2, \ldots, C_n$
2. $P_1, P_2, \ldots, P_m$ [x%]

$\therefore E_1$

(1–2:) *Explanans / Explicans*

($\therefore E_1$:) *Explananandum / Explicandum*

C_1 - C_n stand for descriptions of particular facts
L_1 - L_m stand for descriptions of probabilistic laws and
E_1 for a description of that which is explained

x denotes the strength of the support; this strength must be very high (i.e. the premises make E_1 highly probable).

NB: The strength of the support can be expressed either quantitatively or qualitatively.

IS account: An example

- Suppose we want to find out why person *A* has COVID-19.
- The following would be a good IS explanation.

1. Person *A* has been in close physical contact with person *B.*
2. Person *B* has COVID-19.
3. The vast majority of people who come into close physical contact with those infected with COVID-19 contract it.

——————————————————— [very probably] ——

∴ Person *A* has COVID-19.

List the five conditions required by the I-S account.

"the same as the DS account except instead of requiring a deductive explanation it requires a probabilistic explanation!"

"Empirical content At least 1 Prob law of nature True premises Strongly inductive Maximal specificity"

"Inductive strength - true premises - empirical content - at least one probabilistic last of nature - maximal specificity"

"- also implicitly non redundant"

"Inductive strength, true premises, empirical content, at least 1 probabilistic law of nature, maximal specificity"

"inductive strength, true premises, empirical content, at least one probabilistic law of nature, maximal specificity, ALSO premises are assumed to be non-redundant"

"Inductive strength, true premises, empirical content, at least one probabilistic law of nature, maximal

Explanation and Prediction

The symmetry thesis

- According to the CLM, explanations and predictions are symmetrical. That is, the following thesis is meant to hold:

  DN symmetry thesis: An adequate DN explanation can be used as a deterministic prediction and vice-versa.

  Example: We *can predict* that the two objects will reach the ground simultaneously but we *can explain* it too!

  IS symmetry thesis: An adequate IS explanation can be used as a highly probable prediction and vice-versa.

  Example: We *can predict* that person *A* will contract COVID-19 but we *can explain* it too!

Objections

Against sufficiency: A recipe for objections

- **The DN model recipe**:

  The DN claim: If it is a DN explanation, it is a good deterministic explanation.

  Objection against sufficiency: DN explanations which are not good deterministic explanations.

- **The IS model recipe**:

  The IS claim: If it is an IS explanation, it is a good probabilistic explanation.

  Objection against sufficiency: IS explanations which are not good probabilistic explanations.

Against necessity: A recipe for objections

- **The DN model recipe**:

  The DN claim: If it is a good deterministic explanation, it is a DN explanation.

  Objection against necessity: Good deterministic explanations which are not DN explanations.

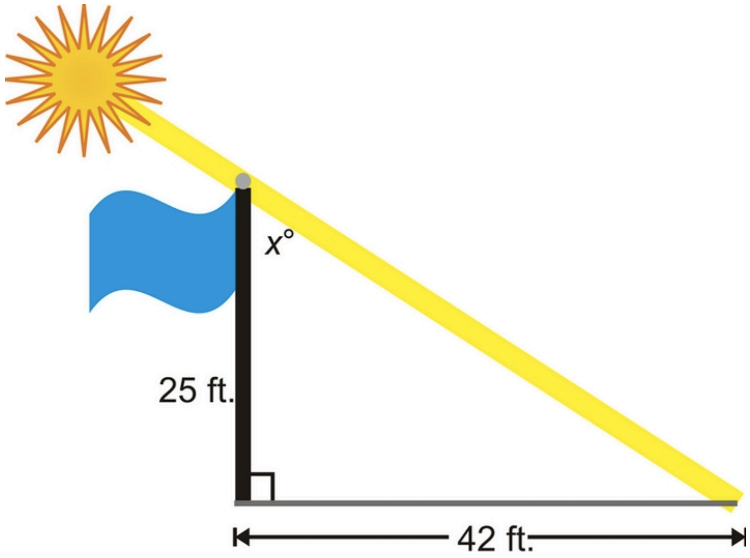
- **The IS model recipe**:

  The IS claim: If it is a good probabilistic explanation, it is an IS explanation.

  Objection against necessity: Good probabilistic explanations which are not IS explanations.

Against the sufficiency of DN

- Not all DN explanations are good deterministic explanations.
- **Flagpole example** (Bromberger 1966).

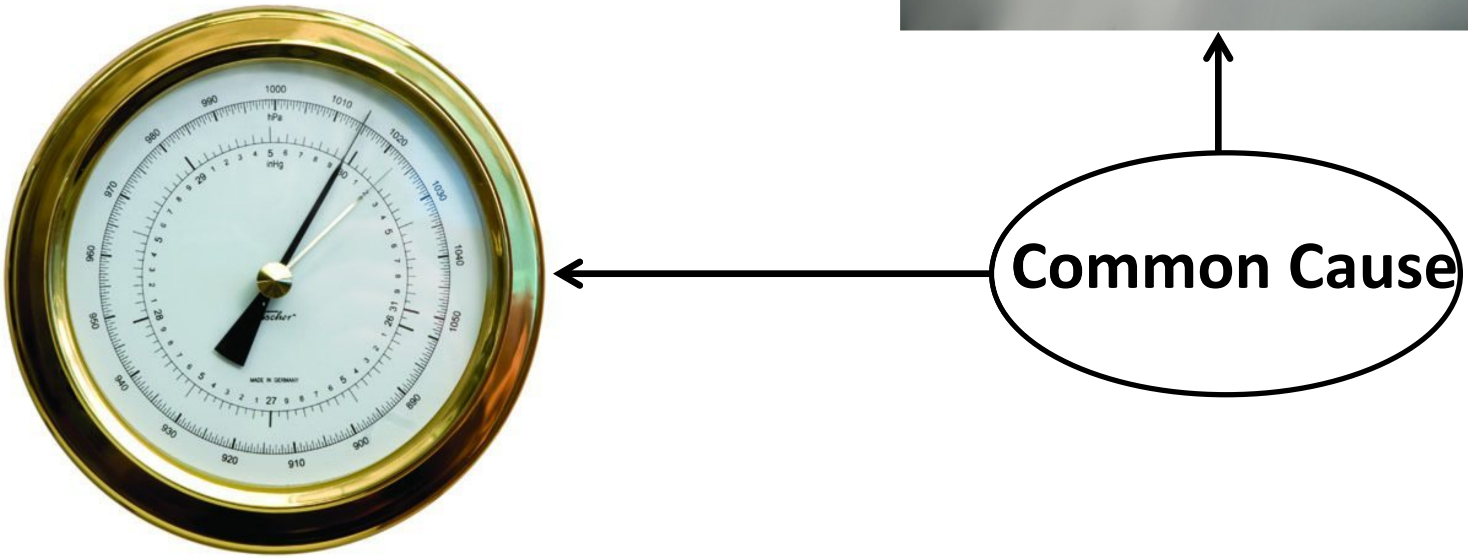


- We can derive the height of the flagpole from the given premises but it doesn't seem like a good explanation.

  NB: The symmetry thesis is violated here! The reason seems to be the asymmetry of causal relations.

Against the sufficiency of DN (2)

- **Barometer example**:
  We can derive the coming of the storm from the drop in barometric pressure but we cannot explain it thus.



NB: As above regarding the symmetry thesis and causality!

Against the necessity of DN

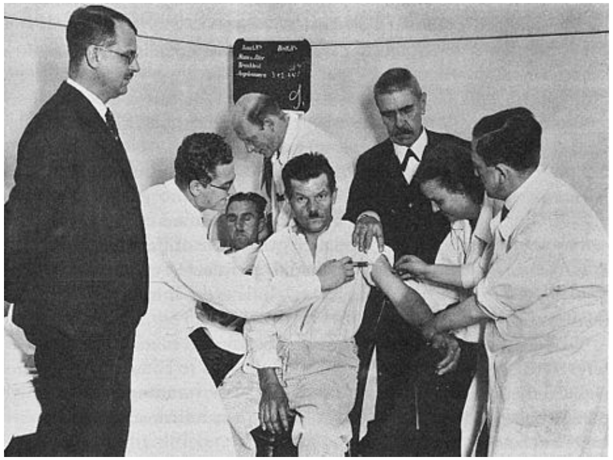
- Not all good deterministic explanations are DN ones.

- **Ink-bottle example** (Scriven 1959/1962)

"If you reach for a cigarette and in doing so knock over an ink bottle which then spills onto the floor, you are in an excellent position explain to your wife how that stain appeared on the carpet, i.e., why the carpet is stained... This is the explanation of the state of affairs and there is no nonsense about it being in doubt because you cannot quote the laws that are involved..." (p. 198).

Against the necessity of IS

- IS cannot explain events that are highly unlikely yet happen. That is, the high probability requirement is too strict.
- Suppose we want to explain why a patient has paresis.
- Very few (around 25%) who have untreated syphilis contract paresis.
- Yet it seems like a good explanation to say that they have paresis because they have untreated syphilis.



- Indeed, only those who have syphilis contract paresis.

A general problem for CLM

- Historical explanations are often concerned with one-off, i.e. unique, events.

  Examples: The trial of Anne Boleyn in 1536, the battle of Waterloo in 1815, the fall of the Berlin wall in 1989.

- Such explanations thus seem to rarely, if ever, appeal to laws, deterministic or probabilistic.

- More generally, explanations in social science and the humanities do not seem to appeal to laws.

  NB: Not least because they have few, if any, laws.

Replies

Tackling the counterexamples

- Contrast the following two *explananda*:

  Q1: Why is the flagpole so high?
  A: It's so high <u>because</u> it was designed by *X* to be that way.

  Q2: How high is the flagpole?
  A: It's *y*-meters high <u>as shown by</u> the length of its shadow.

- DN advocates can easily reply:

  The premises cited earlier provide an answer to Q2.

  Other premises (i.e. factory design) provide an answer to Q1.

Elliptical explanations

- Drawing on an analogy w/mathematics, Hempel asserts:

  "When a mathematician proves a theorem, he will often omit mention of certain propositions which he presupposes... he then simply assumes that his readers or listeners will be able to supply the missing items... Similarly, explanations put forward in everyday discourse and also in scientific contexts are often *elliptically formulated*" (p. 691) [original emphasis].

  NB: Why opt for elliptical formulations? Expedience!

- Returning to the ink-bottle case, DN advocates hold that the non-elliptical version would have to cite laws of nature.

Causation

- The DN model is meant to capture all kinds of explanations, including causal ones.

  Hempel: "... the given causal explanation implicitly claims that there are general laws... by virtue of which the occurrence of the causal antecedents mentioned in C_1, C_2, ..., C_k is a sufficient condition for the occurrence of the event to be explained. Thus, the relation between causal factors and effect is reflected in the [DN] schema... The converse does not hold: there are deductive-nomological explanations which would not normally be counted as causal... [For example] the subsumption of laws..." (p. 687).

Explanation in the social sciences and humanities

- One might argue that the social sciences and the humanities are less well developed.

- They thus cannot be expected at present to have well-confirmed laws and thus to give *complete* explanations.

- In short, it is not the CLM that's at fault but rather the kinds of explanations currently on offer in these disciplines.

Special Topic: Reductionism

The classical conception of reduction

- This view goes back to Nagel (1961).

  A theory *T* reduces to a theory T' if, and only if, the following two conditions are met:

  (i) connectability: for every term *F* in *T*, there is a term *G* constructible in T' such that for any object α, $F\alpha$ IFF $G\alpha$.

  and

  (ii) derivability: *T* is derivable from T' (potentially via bridge laws *B* and/or restrictive conditions *A*).

Homogeneous reductions

- Nagel identified two types of reduction, viz. homogenous and inhomogeneous.

  NB: The latter are also known as ‘heterogeneous’.

- **Homogeneous:** The reduced theory’s vocabulary is included in, or can be defined in terms of, the reducing theory’s.

  Example: Galileo’s law of free fall to Newtonian physics.

Homogeneous and heterogeneous reductions

- **Heterogeneous:** Bridge laws are required to connect the vocabulary of the reduced and reducing theories.

  NB: The bridge laws act as translation rules.

  Example: Boyle-Charles law to statistical mechanics.

$$pV = \frac{2n}{3}\langle E_{\mathrm{kin}}\rangle \qquad T = \frac{2n}{3k}\langle E_{\mathrm{kin}}\rangle \qquad p\,V = k\,T$$

The End