Philosophy of Science

Lecture 9: Laws of Nature

Special Topic: Ceteris Paribus Clauses

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Introduction

Patterns

- Our experiences seem to be organised in certain ways. That is, they exhibit certain patterns.

- We successfully employ these patterns to make predictions and to give explanations of the world around us.

Example:

Seasonal changes in sunlight and temperature allowed the ancients to predict when to plant crops.

What is a law of nature?

- Typically, not all patterns get called ‘laws of nature’.

- Why call some patterns laws but not others? A number of reasons have been given including:

  * laws *govern* the universe
  * laws are *fundamental*
  * laws relate *natural kind properties*

- Our aim in this lecture is to look at theories that attempt to distinguish between laws of nature and other patterns.

- That is, we seek to answer the metaphysical question ‘What is a law of nature?’ by coming up with a set of criteria.

The Regularity Account and its Objections

The account

- Laws are just (observational) regularities, i.e. a law is simply the regular occurrence of its (observable) instances.

- Such regularities are expressed in terms of *true universal generalisations* (UGs) with the logical form: $(\forall x)\ (Fx \rightarrow Gx)$

- Thus, the regularity account holds:

  It is a law that *F*s are *G*s if, and only if, all *F*s are *G*s.

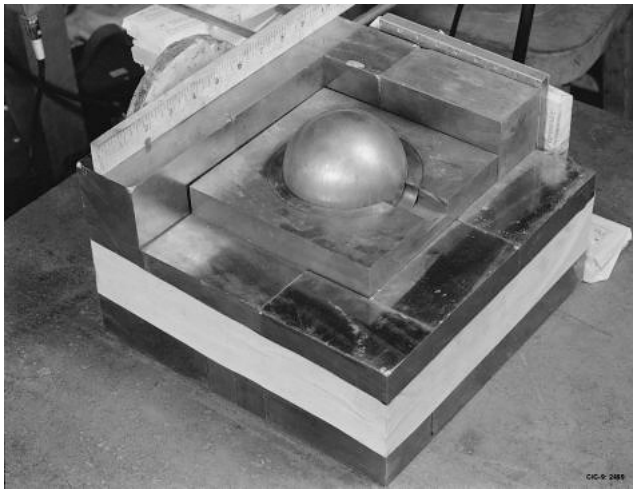
  NB: An unmistakably empiricist take, as observations are all that matter, i.e. metaphysical categories are ignored.

  Advocates: Hume, Ayer, Braithwaite, Hempel and Nagel.

Objection 1: Accidental regularities

- Some regularities, however perfect, seem to be merely accidental, not laws.

  Compare:
  (a) All lumps of pure gold-195 have a mass < 1000kg.
  (b) All lumps of pure uranium-235 have a mass < 1000kg.



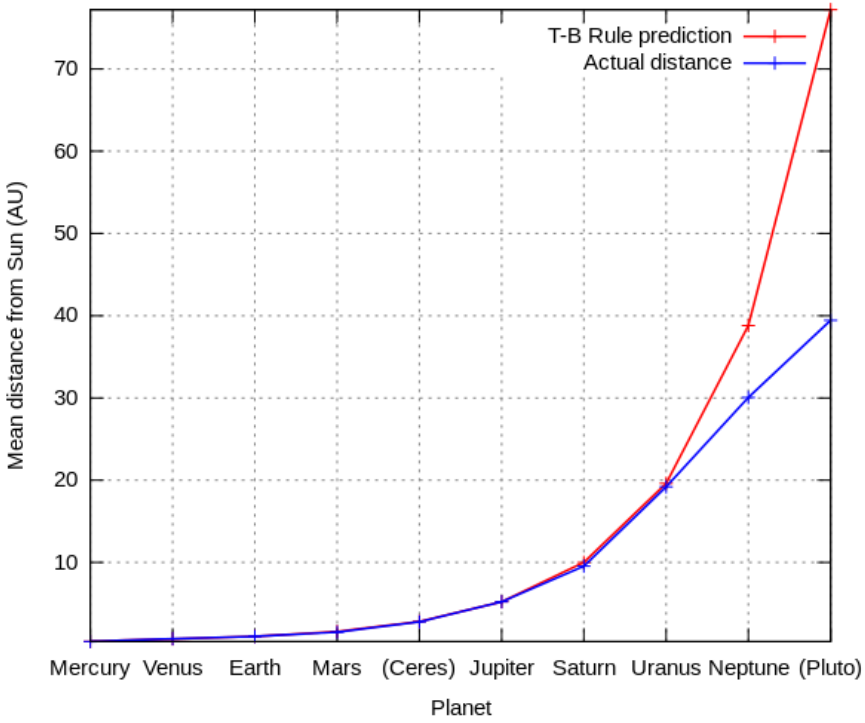
NB: Something about the structure of uranium-235 makes it impossible, not just accidentally so, for such lumps to persist.

Objection 1: Accidental regularities (historical cases)

- It may be objected that such cases are contrived. But there are also historical cases of (imperfect) accidental regularities.

Example: Titius-Bode law
The semi-major axis is a function of the inward-to-outward order of the planet.

$\alpha = 0.4 + 0.3 \times 2^n$ where α is the semi-major axis; n is the inward-to-outward order taking values: $-\infty$, 0, 1, 2,...



Objection 2: Singly-instantiated regularities

- Some true UGs, e.g. singly-instantiated ones, are not laws of nature.

  Example:
  Suppose the earth is the only planet in the universe with intelligent life forms (i.e. capable of written language, etc.).

  Now consider the generalisation:
  'All planets with intelligent life forms have only one moon'.

Objection 3: Vacuous laws

- Some laws have non-satisfiable antecedents. Regularists cannot distinguish between them and fictional statements.

- *Compare*:

  All identical goods traded freely and without friction sell for the same price throughout the world.

  Vs.

  All unicorns have wings.

Objection 4: Co-extensionality

- Not all true UGs derived by substituting co-extensional predicates are laws.

  Example:
  Fx: *x* is a diamond
  Gx: *x* has a refractive index of 2.419
  Kx: *x* is mined in kimberlite

  (1) $(\forall x)\ (Fx \rightarrow Gx)$ (law of nature)
  (2) $(\forall x)\ (Fx \leftrightarrow Kx)$ (definitional law)

  From 1 and 2 we can derive:
  (3) $(\forall x)\ (Kx \rightarrow Gx)$

  But surely statements like 3 are not laws of nature.

The ‘extra constraints’ option

- Suppose laws are not mere regularities. What are they then?
- Most attempts to answer this question hold that statements of law imply true UGs but not vice-versa. Thus, we know that:

  Law = regularity + _____
- There are different ways of filling in the blank. We come back to these ‘sophisticated’ regularity theories.
- For now we turn our attention to the regularity theory’s main competitor: the necessitarian account.

The Necessitarian Account

The account

- The necessitarian account holds that the properties in laws are held together by a necessary connection.

  It is a law that *F*s are *G*s if, and only if, N (*F*, *G*)

  where N (*F*, *G*) is read as 'the presence of *F*-ness necessitates the presence of *G*-ness'.

- Properties are typically understood as *universals*, i.e. an abstract mind-independent category that individuals share.

  Examples: Redness, fatherhood, roundness, etc.

- **Prominent advocates**: Armstrong, Dretske and Tooley.

Understanding the necessary connection

- As a first approximation, one can appeal to a metaphor:

  A necessary connection is the ‘metaphysical glue’ that binds two universal properties.

- Less metaphorically, it is “a relation of non-logical or contingent necessitation” (Armstrong 1983, p. 85).

- Why non-logical? Because viewing laws of nature as involving logical necessity leads to absurdities:

  “... the strange conclusion that the laws of nature can... be established independently of experience: for if they are purely logical truths, they must be discoverable by reason alone” (Ayer [1956]1998, p. 810).

The singular statement view

- Laws as linguistic items are *singular* statements that express a *modal* relationship between universal properties.

  NB: The regularity view sees them as *universal* statements expressing a relation between the extension of properties.

- Only the former are capable of supporting counterfactual statements. True UGs cannot entail counterfactual claims.

  Example:
  "To be told that all dogs born at sea have been and will be cocker spaniels is not to be told that we would get cocker spaniel pups (or no pups at all) if we arranged to breed dachshunds at sea" (Dretske [1977] 1998: 832).

Advantages

- Necessitarians presumably avoid the Regularists' problems.
- To be precise:

  * Accidentally true UGs are not even close to being laws.

  * Singly instantiated, non-instantiated or co-extensionally acquired true UGs may still come out as something like laws.

- That's because to be a law statement requires reference to universals that are modally connected.

Objection: The identification problem

- Not enough to say that the necessitation relation is not logical. We need a specification of this lawmaking relation.

  NB: Van Fraassen calls this 'the identification problem'.

- Lewis critique: "... *N* deserves the name of 'necessitation' only if, somehow, it really can enter into the requisite necessary connections. It can't enter into them just by bearing a name, any more than one can have mighty biceps just by being called 'Armstrong' " (1983, p. 366).

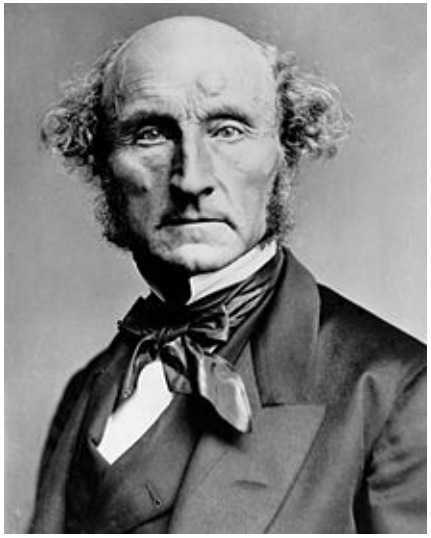
- Armstrong's reply: "... the [i]dentification problem has been solved. The required relation is the causal relation... now hypothesized to relate types not tokens" (1993, p. 422).

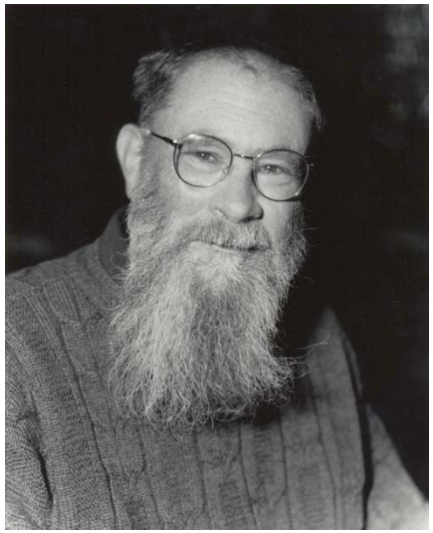
The System(s) View

Introduction

- The most influential *revision* of the regularity account is the so-called ‘system(s)’ or ‘best system(s)’ view or analysis.

  Prominent proponents: Mill, Ramsey and Lewis.





- It thus has also been branded the MRL account.

Some quotations

- "... the question, What are laws of nature? may be stated thus: What are the **fewest** and **simplest** assumptions, which being granted, the whole existing order of nature would result?... What are the fewest general propositions from which all the uniformities which exist in the universe might be **deductively inferred**?" (J. S. Mill 1904: 230).

  "[laws are] consequences of those propositions we should take as **axioms** if we knew everything and organized it as **simply** as possible into a **deductive system**" (F. P. Ramsey [1931] 1978: 138).

The systems view: Summarised

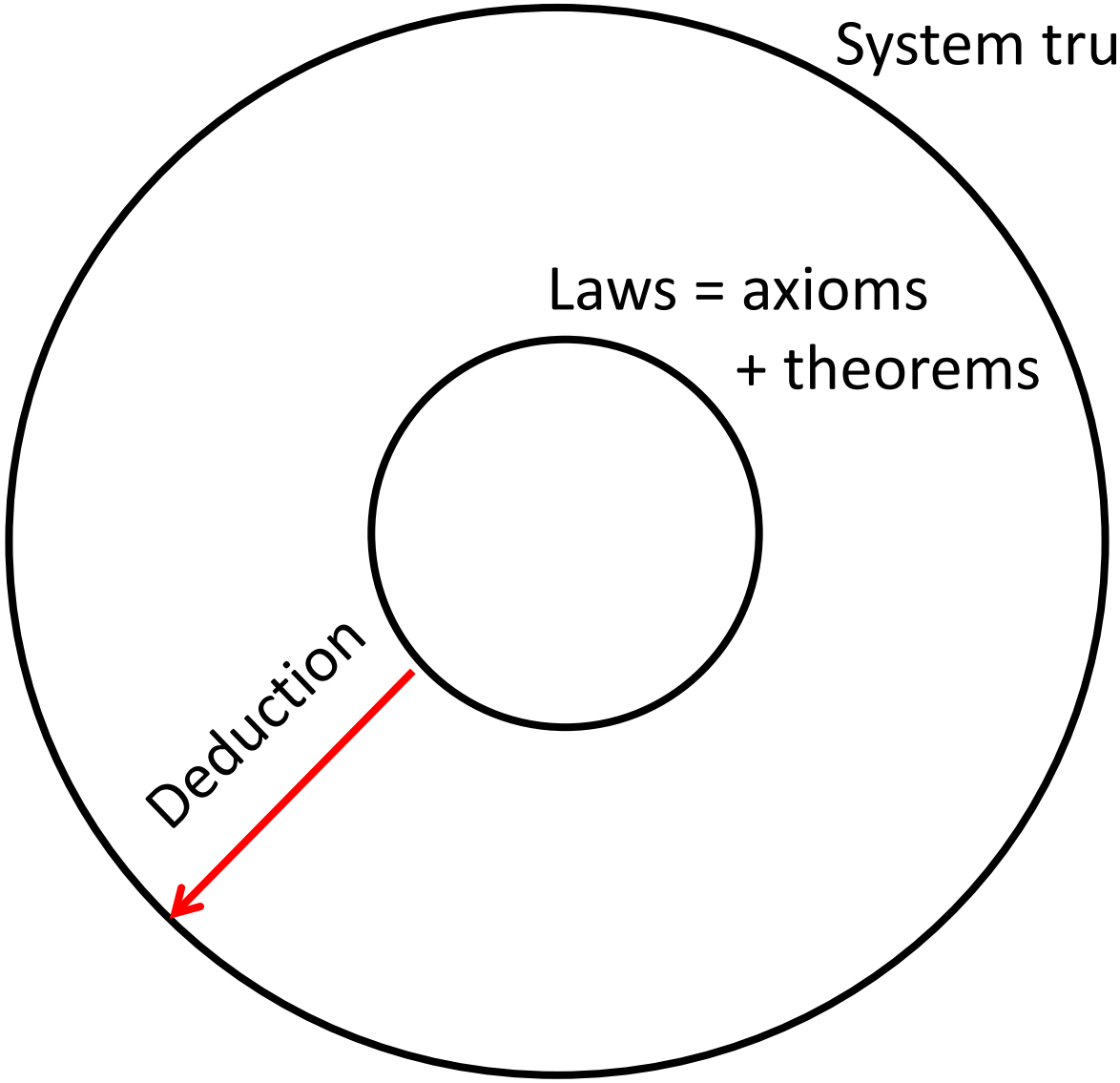
- The mature version is due to Lewis (1973):

  "... a contingent generalization is a law of nature if and only if it appears as a **theorem** (or **axiom**) in each of the **true deductive systems** that achieves a **best combination** of **simplicity** and **strength**" (p. 73).

- Why true deductive system? Because it is meant to be:

  * made up of a set of true statements
  * that is deductively closed
  * and axiomatised (or at least axiomatisable)

Truths and laws



Strength and simplicity

- Strength is here understood as the capacity of a set of statements to express a lot of information about the world.

- Simplicity, in this context, is the economy of the expression of that information, e.g. a smaller set of axioms.

- Why should these two be traded off? Because even though they need not be, they are often at odds.

  Compare:
  There is only one kind of sub-atomic particle.
  There are three kinds of sub-atomic particles and four forces.

- When that happens, the MRL account aims to find balance.

Advantages: Accidental regularities

- Not all regularities count as laws as they have to fit snugly in a system with the aforementioned constraints.

  Compare these two again:

  (1) All lumps of pure gold-195 have a mass < 1000kg.
  (2) All lumps of pure uranium-235 have a mass < 1000kg.

- Presumably 2 could be a law but not 1 because only 2 would come out as a theorem in a best system.

- Why? Because it systematises a lot more information about the world – to be precise, information about critical mass.

Advantages: Singly- or non-instantiated regularities

- Singly instantiated or non-instantiated regularities can be included so long as they 'produce work' in such a system.

  The following do not seem to systematise our knowledge:

  * All talking ants have psychological problems.
  * All planets in the solar system whose surface is covered by 71% water, support life.

  But the following presumably do:

  * All bodies that are inertial, do not accelerate.
  * All CP-violation universes, exhibit baryon asymmetry.

Advantages: Co-extensionality

- What about regularities that are co-extensionally acquired from laws?

- So long as these are logically equivalent and hence express the same content as the originals then they are laws.

  NB: This point holds with respect to strength but not necessarily with respect to simplicity.

- Thus, instead of throwing away such regularities we jettison the intuitions that they are not laws.

  NB: Some will see this as a weakness of the approach.

Problems: Measuring simplicity and strength

- Notions of simplicity and strength are notoriously difficult to pin down and measure.

- Take strength. How do we best measure the strength or informational content of a system?

- Moreover, how do compare the strength of systems when these formulated in different languages?

  "... if strength is a matter of how much can be deduced from the axioms, we lack a way to compare the relative strength of systems that differ in their expressive resources or basic predicates (kinds)" (Cohen and Callender 2009: 6).

  NB: Similar remarks apply to simplicity.

Special Topic:
Ceteris Paribus Laws

Introduction

- Laws in physics and in chemistry are often formulated as (something like) true universal statements.
- The same cannot be easily said about laws in the special sciences, e.g. biology, economics and psychology.
- Such laws, or at least our current conception of them, are taken to have exceptions.
- That is, they seem to work only in a range of circumstances.
- Whenever the exact range is unknown, we speak of laws with *ceteris paribus*, i.e. 'other things being equal', clauses.

Examples

- Other things being equal (OTE), if demand for a certain product outstrips supply, the price of that product will rise.

  Exception: State-controlled pricing

- OTE, taking hydrocortisone reduces skin inflammation and irritation.

  Exception: Allergic reactions

- OTE, birds fly!

  Exception: Penguins

The meaning of ceteris paribus clauses

- **Comparative cp-laws**: "... require that factors not mentioned in the antecedent or the consequent [of] the law remain unchanged" (Reutlinger et al. 2015).

  NB: This is closest to the literal meaning of 'ceteris paribus'.

  Example: OTE (i.e. normal conditions), alcohol increase in the blood leads to increased sensory-motor impairment.

- **Exclusive cp-laws**: "... assert the connection between antecedent and consequent only under the condition that certain factors are excluded" (ibid.).

  Example: OTE (e.g. the absence of other planets), a planet will follow an elliptical orbit.

Dilemma: Between Falsity and Triviality

- This dilemma can be found in Lange (1993), who in turn acknowledges Hempel (1988).

  "*First horn*: if exclusive cp-laws are reconstructed as some sort of strict law, then they will tend to be false: typically it will not be the case that all *A*s satisfying a completer condition *C* are *B*s, since the range of potentially disturbing factors is typically indefinable..."

Dilemma: Between Falsity and Triviality (2)

- "*Second horn*: If we instead suppose that an indefinite exclusive *ceteris paribus* clause is attached to the law so that it means 'All *A*s are *B*s, *if nothing interferes*', then the cp-law in question is in danger of lacking empirical content. It lacks empirical content because it seems to say nothing more than 'All *A*s are *B*s or not-(All *A*s are *B*s)'. If this is true, then exclusive cp-laws are analytically true sentences and, therefore, trivially true" (Reutlinger et al. 2015).

The End