Notes on Scientific Explanation

Three accounts:

1. Deductive-Nomological (DN) account
2. Unificationist account
3. Causal account

1. Deductive-Nomological (DN) Account

Hempel & Oppenheim (1948) "Studies in the Logic of Explanation"

DN explanation = an account of the observation to be explained that indicates how it follows deductively from a law of nature ("covering-law" account).

Key characteristics are given by:

Conditions of Adequacy

1. Must be a valid-deductive argument with premises the conclusion stating the observation to be explained.
2. Premises must contain a law.
3. Premises must have empirical content.
4. Premises must be true.

The conditions of adequacy define what a DN explanation is. In other words, *an explanation is a DN explanation if and only if it satisfies conditions 1-4.*

General form of DN explanations

premises	$L_1, L_2, \ldots$	*law(s)*
	$C_1, C_2, \ldots$	*conditions underwhich laws are applicable*
conclusion	$O_1, O_2, \ldots$	*observed phenomena*

General Characteristics

(a) *Argument Thesis*: DN explanations are *arguments*.

(b) *Nomic Expectability Thesis*: DN explanations demonstrate how the observation to be explained is *nomically expected*; *i.e.*, how it follows necessarily from a law.

(c) *Explanation/Prediction Symmetry Thesis*: Any DN explanation of a *particular fact* could have been used to *predict* the fact if the premises had been available prior to the fact's occurrance. So:

(i) Every DN explanation is a potential prediction.

(ii) Every prediction is a potential DN explanation.

Ex1: Why do skaters spin faster as they bring their arms in towards their bodies?

DN explanation:

1. Angular momentum is conserved. } *law*
2. Skater doesn't interact with external objects.
3. Skater has non-zero initial angular momentum. } *conditions*
4. Skater brings arms in towards body (reducing rotational intertia).

∴ Skater spins faster. *observed phenomena*

Subsumption of particular fact (skater spinning faster) under a law (conservation of angular momentum).

ASIDE: *Ex1* satisfies the 4 conditions of adequacy. In particular, it is a *valid-deductive argument*--If the premises are all true, then the conclusion must be true. To see this concretely, note that the argument can be formulated mathematically in the following manner (where the *angular momentum* L of a spinning object is defined as $L = I\omega$, where I is the object's *moment of inertia* (it's *rotational inertia*, which is roughly a measure of the object's tendancy to continue spinning in the absernce of external forces), and ω is its *rotational velocity* (which measures how fast it is rotating)):

(i) $L_i = L_f$

(ii) $L_i = I_i\omega_i$ and $L_f = I_f\omega_f$ ⟸ Nothing contributes to L other than the skater's I and ω.

(iii) $L_i = 0$

(iv) $I_f < I_i$

∴ $\omega_f > \omega_i$ ⟸ To preserve the equation $I_i\omega_i = I_f\omega_f$ when I_f is less than I_i, the quantity ω_f must be greater than ω_i.

Ex2: Why did Jan's bracelet melt when it was heated to 1063° C?

DN explanation:

(i) Gold melts at 1063° C. *law*

(ii) Jan's bracelet is made of gold. *condition*

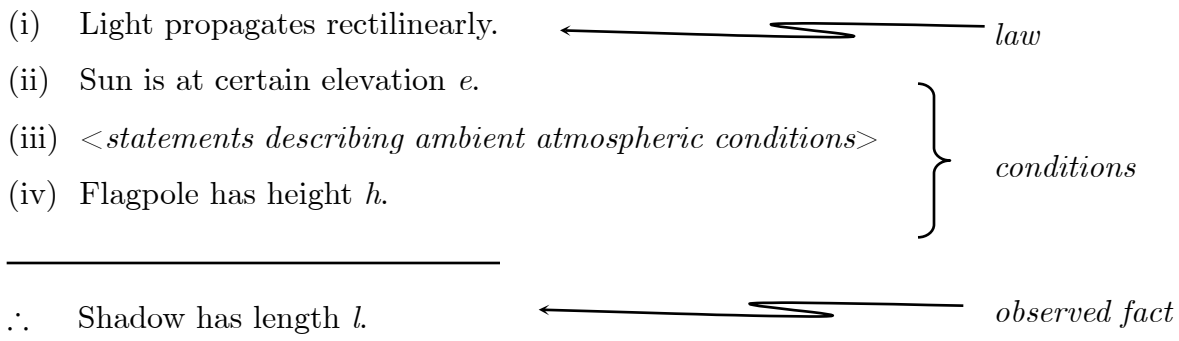
∴ Jan's bracelet melted at 1063° C. *observation*

Problems with DN account:

(1) *What is a "law of nature"?*

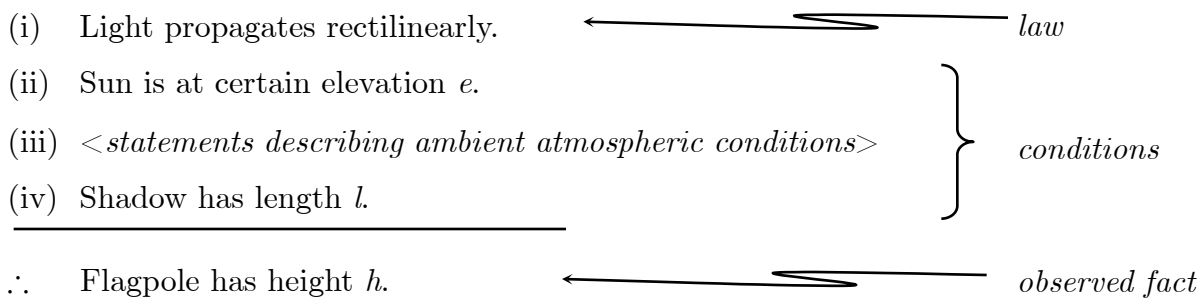
(2) *Counterexamples: Flagpole and Shadow*

Consider the following DN explanation of the length of the shadow of a flagpole:



- Explains the length l of the flagpole's shadow by showing how l follows from a law and the conditions that make the law applicable. Satisfies Adequacy Conditions 1-4, so it's DN.

<u>*But*</u>: We can also construct the following DN explanation that *also* satsifies Conditions 1-4:



- Explains the height h of the flagpole by showing how h follows from a law and the conditions that make the law applicable. Satisfies Conditions 1-4, so it's a DN explanation.

<u>*But*</u>: Is it a *legitimate* explanation? It explains a *cause* (the *height* h of the flagpole) by means of its *effect* (the length l of the shadow). Effects are normally explained in terms of their causes, and not *vice-versa*.

<u>*ASIDE*</u>: Explaining why a flagpole has a certain height by refering to the length of its shadow is analogous to explaining why you approached an automatic sliding door (in a grocery store, say) by refering to the door sliding open. Your approach to the door caused it to slide open; it's sliding open is the effect of your approaching it. You *don't* normally say "Why did I approach the door? Because it slid open." You *do* normally say "Why did the door slide open? Because I approached it."

<u>*Moral*</u>: The DN model does not account for *causal factors* in explanations.

2. Unificationist Account

Friedman (1974) "Explanation and Scientific Understanding"
Kitcher (1981) "Explanatory Unification"

A scientific explanation of a fact (particular or general) is a *demonstration* of how the fact can be *derived* from a *unifying set of argument patterns.*

Set of argument patterns = *basic principles* (axioms, theorems, *etc*) that (may) underlie a *theory.*

Unifying power: a set of argument patterns T is *unifying* if it scores high on the following properties:

1. *Scope*: The greater the *scope* of T, the greater the *number of conclusions* that can be drawn from T.
2. *Simplicity*: The greater the *simplicity* of T, the smaller the *number of argument patterns* in T.
3. *Stringency*: The greater the *stringency* of T, the smaller the *range of applicability* of T.

> Ex. *General relativity* can be thought of as a *unifying set of argument patterns* that can be used to describe a certain class of phenomena. Arguably, the set has great *scope*, great *simplicity*, and great *stringency* (it only applies to certain phenomena; namely, phenomena that experience the gravitational force; and it prescribes the behavior of such phenomenon in very restricted ways). *Astrology*, on the other hand, is not stringent: you can apply its descriptions to almost any phenomenon you experience. (Any event you experience in the course of a day is bound to have been "predicted" by your daily horoscope, given a flexible enough interpretation.)

General Idea: To scientifically explain a fact, you have to demonstrate how it can be embedded in a unifying theory. This explains the fact by showing how it is related to other facts.

Four Characteristics:

(1) *Unificationist explanations are derivations.*

> A *derivation* = A sequence of justified steps; each step being explicitly shown to follow from the preceding ones.
>
> *Note*: Contrast with DN-type explanations, which are *arguments* (recall, arguments are sets of setences with one being a claim and the others reasons given for the claim).
>
> In an *argument*, you don't have to explicitly show how each sentence follows directly from the last. This allows *irrelevant premises* to crop up; in a *derivation*, there can be *no* step which is not relevant to the other steps.

(2) *The unificationist account is committed to an Expectibility Thesis*: A unifying explanation must show how the *explanandum* is to be *expected* from the *explanans*.

Note: This is not necessarily *nomic expectibility*, as with DN. In comparison to DN, one might say that unification replaces "law" with "unifying systematization" (*i.e.*, "theory"). But note the other main difference with DN given in Characteristic 1.

(3) *Unificationist explanations are not necessarily reductionistic*. One might think that to provide a unificationist explanation of a fact is to show how that fact can be *reduced* to the fundamental facts that underlie the ultimate grand-unifying theory of everything. In particular, to provide a unifying explanation of a biological fact, you have to show how it can be reduced to facts in chemistry, say, or physics.

But: The unificationist account *is* compatible with the possibility that biology, say, ultimately can never be reduced to physics. If this is so, you can still construct unifying explanations of biological facts; they'll just refer to unifying theories in biology and make no reference to physics.

(4) *The unificationist account is global*: A unifying explanation embeds a *local* fact in a larger, *global* theory.

Problems with the Unificationist Account

(1) *Problem of subjective standards*: How are we to judge which explanations are more unifying than others?

(2) *Problem of probabilistic explanations:* Some legitimate explanations give a low probability to the observation to be explained, hence it is *not expected*. Since the unification account is commited to an *Expectability Thesis*, it faces this problem.

(i) 25% of all victims of untreated latent syphilis develop paresis.
(i) The only way to get paresis is if you had untreated latent syphilis.
(iii) Smith had untreated latent syphilis.
[.25]
∴ Smith developed paresis.

This seems to be a legitimate scientific explanation of why Smith developed paresis.

But: It's not a *strong inductive argument*: The premises give a very *low* probability to the conclusion.

3. Causal Account

Salmon (1984) *Scientific Explanation and the Causal Structure of the World*
Lewis (1986) "Causal Explanation"

To explain an event is to provide information about what caused it.

Two Characteristics

(1) *The causal account is local.*

(2) *Basic causal account claim: Causal structure underlies laws and theories.* This is what gives them explanatory power. So all DN-type and unification explanations are causal explanations, but not all causal explanations can be viewed as DN-type or unification explanations.

Problems with the Causal Account

(1) *Problem of the nature of causality*: How are legitimate causal explanations distinguished from illegitimate explanations based on mere statistical correlations?

(2) *Problem of purely theoretical explanations*: Some theoretical explanations do not explicitly refer to causes.

Ex: Why can't you fit a left-handed glove on your right hand?

Theoretical explanation: Due to the topological properties of the left-handed glove and the right hand.
Causal explanation: Due to the resistance of the inner surface of the left-handed glove with your right hand.

Claim: Purely theoretical explanations count as legitimate scientific explanations. So the causal account cannot be a complete account of scientific explanation.

(3) *Problem of irreducible probabilistic explanations:* What caused the Yanomami to attack village *A*? What caused an electron to tunnel through a potential barrier? To provide causal explanations of irreducibly probabilistic events, we need a theory of probabilistic causation (and a theory of simple causation is hard to come by).