

17. Sci Explanation: Unification and Causal Accounts

1. Unification Account
2. Causal Account

1. Unification Account

Friedman, M. (1974) "Explanation and Scientific Understanding"
Kitcher, P. (1981) "Explanatory Unification"

- Intuition: To explain is to connect a diverse set of facts by subsuming them under a set of basic claims.

Unification Account: To explain something is to demonstrate how it belongs to the most *unifying systematization* of the set of claims currently endorsed by the scientific community.

- Some definitions:
 - A *systematization* Σ of a set of claims is a subset of those claims from which the rest can be derived (like a theory).
 - A *unifying systematization* is a systematization that maximizes scope, simplicity and stringency.
 - *Scope* measures the number of conclusions that can be drawn from Σ .
 - *Simplicity* measures the size of Σ .
 - *Stringency* measures the range of applicability of Σ .

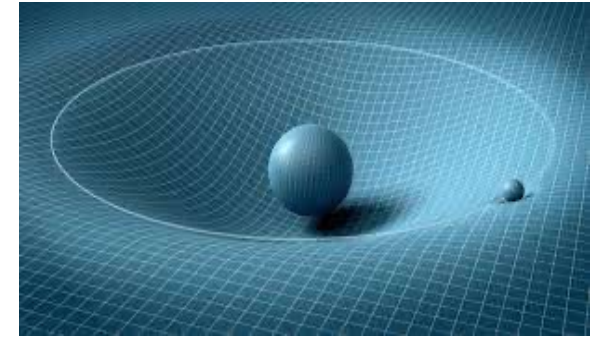
- Intuition: Unifying power is a characteristic of a scientific theory.

General relativity:

- A unifying systematization of claims about the large scale structure of space, time and matter.
- Has great scope, great simplicity, and great stringency (it only applies to phenomena that experience gravity, and it prescribes the behavior of such phenomena in very restricted ways).

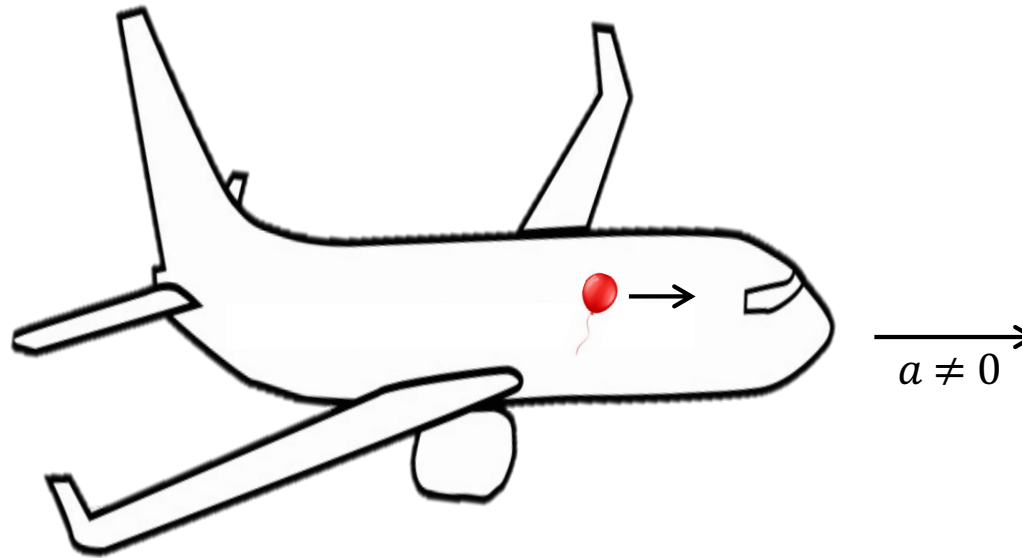
Astrology:

- A systematization of claims about human behavior based on the large scale structure of space, time and matter.
- Not all that stringent (your horoscope is typically flexible enough to account for any event you might experience in a given day).



- General Idea: To scientifically explain a fact, you have to demonstrate how it can be embedded in a unifying theory.
 - *Maxwell's theory of electromagnetism provides unifying explanations of electric and magnetic phenomena.*
 - *The Standard Model provides unifying explanations of phenomena that experience the electromagnetic, strong, and weak forces.*

Ex: Why does a helium balloon float towards the front of an accelerating airplane as it takes off?



Unifying explanation: According to the Principle of Equivalence from General Relativity, a uniformly accelerating frame is indistinguishable from a frame at rest in a homogeneous gravitational field directed in the opposite direction. So the accelerating plane is indistinguishable from a plane at rest in a gravitational field directed towards its rear. And a helium balloon floats upward, away from the gravitational source in such a frame; in this case, toward the front of the cabin.

Three Characteristics of the Unification Account

(a) Expectability thesis

- A unifying explanation shows how the *explanandum* is to be expected from the *explanans*.
 - But: Not necessarily *nomic* (i.e., lawlike) expectability.
 - Idea: The unification account replaces the "law" in the covering law account with a "unifying systematization" (i.e., theory).

(b) Not necessarily reductionistic

- A unifying explanation does not need to refer to a fundamental "grand unified theory".
 - *A unifying explanation of a biological fact doesn't necessarily have to show that it can be reduced to chemistry and physics.*

(c) Global

- A unifying explanation embeds a *local* fact in a larger, *global* theory or framework.

Advantages

- Recall the flagpole and its shadow:
 - The covering law account allows the flagpole's height to be explained by the length of its shadow (which seems wrong).
 - The unification account avoids this!

Claim: An explanation of a flagpole's height in terms of its shadow is not a unifying explanation:

- *It requires a larger (less simple) systematization (i.e., "theory") of objects and shadows than an explanation of the shadow's length in terms of the flagpole's height.*

Intuition: A systematization/theory (set of claims) is more constrained than a single claim (law).

- Thus: Explanations based on systematizations can be more constrained than explanations based on laws.

Two Problems for the Unification Account

(i) Problem of subjective standards

- How are we to judge which explanations are more unifying than others?
 - *How do we identify the systematization (theory) that maximizes scope, simplicity, and stringency?*

(ii) Problem of probabilistic explanations

- Some legitimate explanations give a low probability to their *explananda*; hence their *explananda* are not expected from their *explanans*.
 - *Any account that adopts the expectability thesis faces this problem: recall the syphilis and paresis counterexample for the covering law account.*

One response: Deductive Chauvinism...

Two types of probabilistic explanation

- (a) *Reducible*: Given enough information, the *explanandum* can be logically deduced from the *explanans*.
- (b) *Irreducible*: The *explanandum* cannot be logically deduced from the *explanans*, regardless of how much further information is provided.



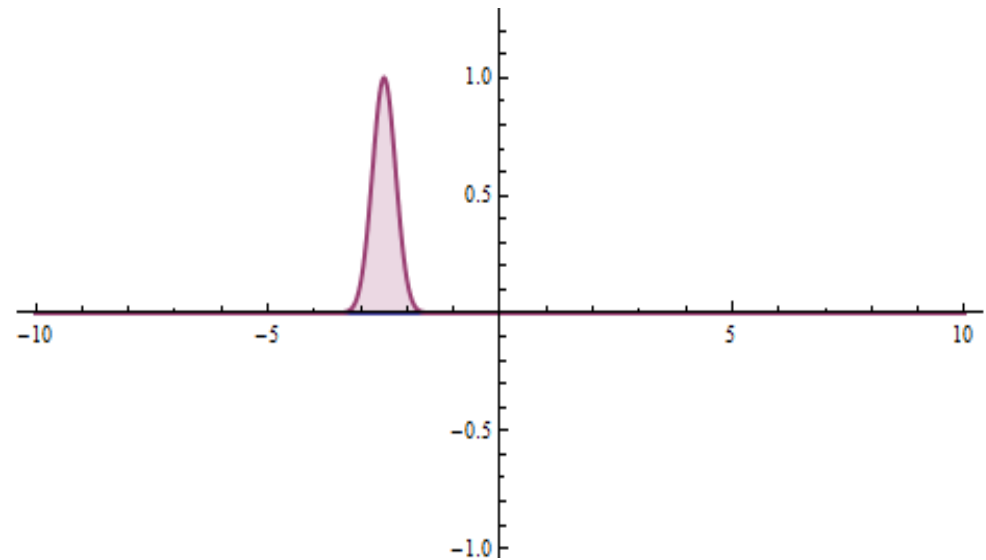
Claim (Deductive Chauvinism): All probabilistic explanations are reducible.

Implication: While there may be inherently probabilistic processes, these cannot be explained.

Ex. 1. An electron beam impinging on a potential barrier.

- Suppose: Electron e_1 tunnels through.

Why did e_1 tunnel through?



- No derivation with the conclusion " e_1 tunneled through the barrier".
 - *The Schrodinger equation just predicts the probability that e_1 will tunnel through.*
- So: We cannot construct a unifying explanation of why e_1 tunneled through.
- A deductive chauvinist says: "This is fine, since there are no explanations of inherently probabilistic processes, like electron tunneling."

Maybe ok for strange things like electrons, but...

Ex. 2. Warfare among the Yanomami.*

- Suppose: An anthropologist studying Yanomami people of Brazil seeks an explanation of why the Yanomami attacked Village A.
- Factors correlated with attacks:
 - *Scarce resources.*
 - *Increased military advantage.*
 - *Decreased social influence.*
- Importantly: There are *no* factors that determine with certainty the event of an attack.
- So: The event of an attack is inherently probabilistic.
- Thus: A deductive chauvinist must claim there is *no explanation* for why the Yanomami attacked Village A.

← *All prevalent when Western influence is present!*



But surely an anthropologist will seek some form of explanation...

Moral: Deductive chauvinism is a high price to pay as a response to the problem of probabilistic explanations.

2. Causal Account

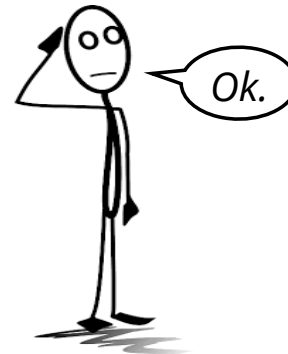
Salmon, W. (1984) *Scientific Explanation and the Causal Structure of the World*
Lewis, D. (1986) "Causal Explanation"

- Recall: A flagpole *causes* its shadow, and thus can explain it. Its shadow does not *cause* the flagpole, and thus cannot explain it.

Causal Account: To explain something is to describe what caused it.



Why did the glass doors slide open?



Ok.

Because when the customer approached them, she stepped into the beam of an optical sensor, and this caused a circuit to be broken, which subsequently caused a mechanism to open the door.



Two Characteristics of the Causal Account

(a) Local

- A causal explanation explains by identifying a *local* cause, as opposed to a *global* theoretical framework, or a law that's supposed to hold everywhere.

(b) Ontological Claim: Causal structure underlies laws and theories

- Implication: All covering law and unifying explanations are causal explanations; but not all causal explanations can be viewed as covering law or unifying explanations.

Three Problems for the Causal Account

(i) Problem of the nature of causality

- What distinguishes causal relations from mere statistical correlations?

90% of smokers got lung cancer.

$\therefore$ Smoking causes lung cancer.



- What role do causes play in fundamental theories?

$$F(t) = ma(t) = m \frac{d^2 x(t)}{dt^2}$$

$$\vec{\nabla} \cdot \vec{E}(x, t) = 4\pi\rho \quad \vec{\nabla} \times \vec{E}(x, t) = \frac{1}{c} \frac{\partial \vec{B}(x, t)}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B}(x, t) = 0 \quad \vec{\nabla} \times \vec{B}(x, t) = \frac{1}{c} \frac{\partial \vec{E}(x, t)}{\partial t} + \frac{4\pi\vec{J}(x, t)}{c}$$

*No parameter for
"causation" in
equations of motion of
fundamental theories
in physics...*

(ii) 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?



Causal explanation: The friction between the inside surface of the glove and your hand causes your hand to stop short of sliding all the way into the glove.

Theoretical explanation: A left-handed glove and your right-hand are topologically inequivalent in 3-dim Euclidean space: one cannot be mapped onto the other by a series of 3-dim rigid motions



Isn't this a scientific explanation?

(iii) Problem of irreducibly probabilistic explanations

- What caused the Yanomami to attack Village A?
- What caused electron e_1 to tunnel?
- To provide causal explanations of irreducibly probabilistic events, we need a theory of probabilistic causation.
 - *Even more difficulty than a theory of simple causation!*

Recap: What does the Explaining in a Scientific Explanation?

Covering Law Account: "*Laws* explain!"

Unification Account: "*Theories* explain!"

Causal Account: "*Causes* explain!"