

17. Sci Explanation: Unification and Causal Accounts

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.

- A *systematization* Σ of a set of claims is a subset of those claims from which the rest can be derived (like a theory).
- Σ is *unifying* if it 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 .

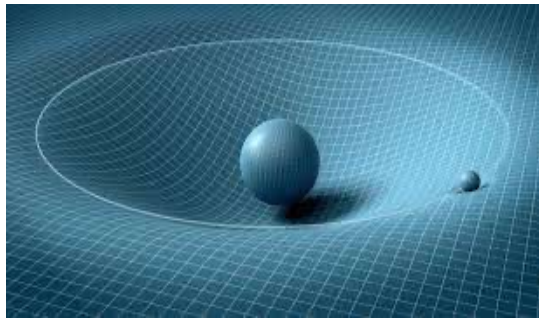
- Intuition: Unifying power is a characteristic of a scientific theory.

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:

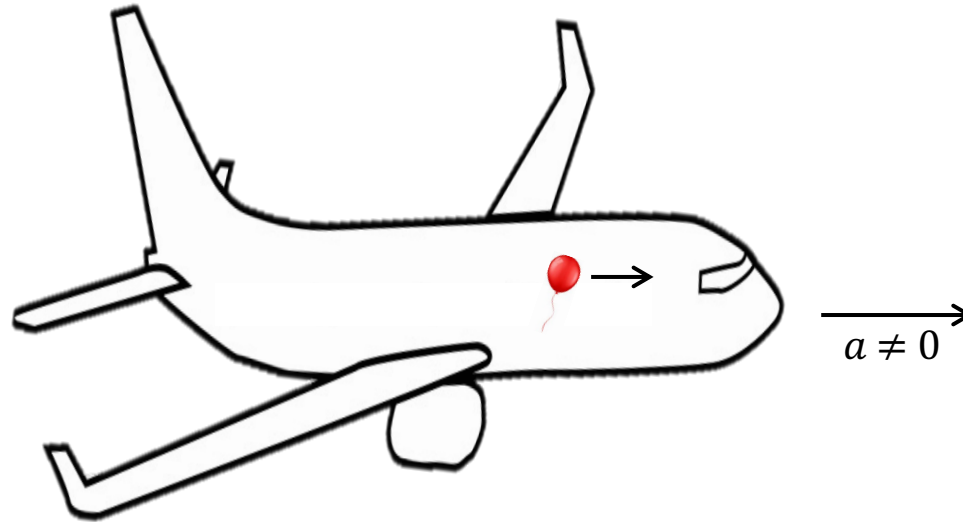
- A systematization of claims about human behavior based on the large scale structure of space, time and matter.
- Not all that stringent (your horoscope is typically flexible enough to account for any event you might experience in a given day).



- 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.

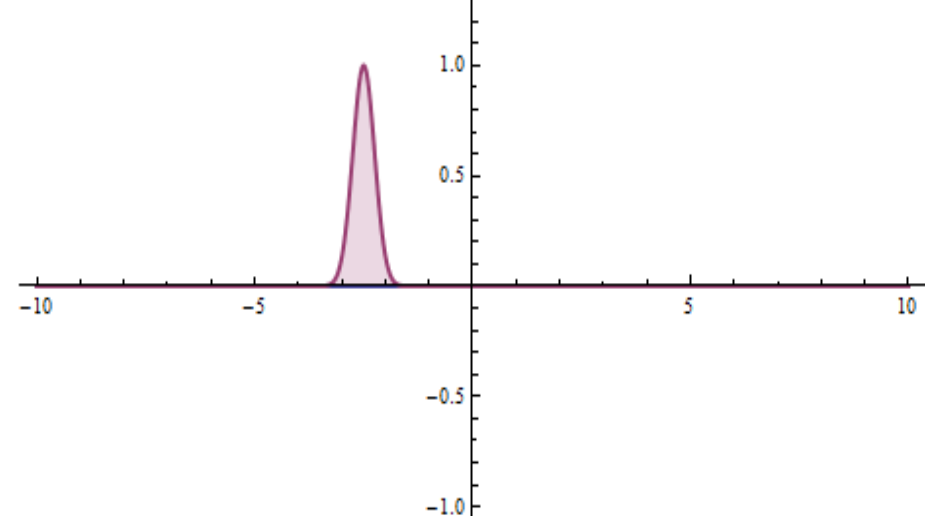


Claim (Deductive Chauvinism): All probabilistic explanations are reducible.

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!*

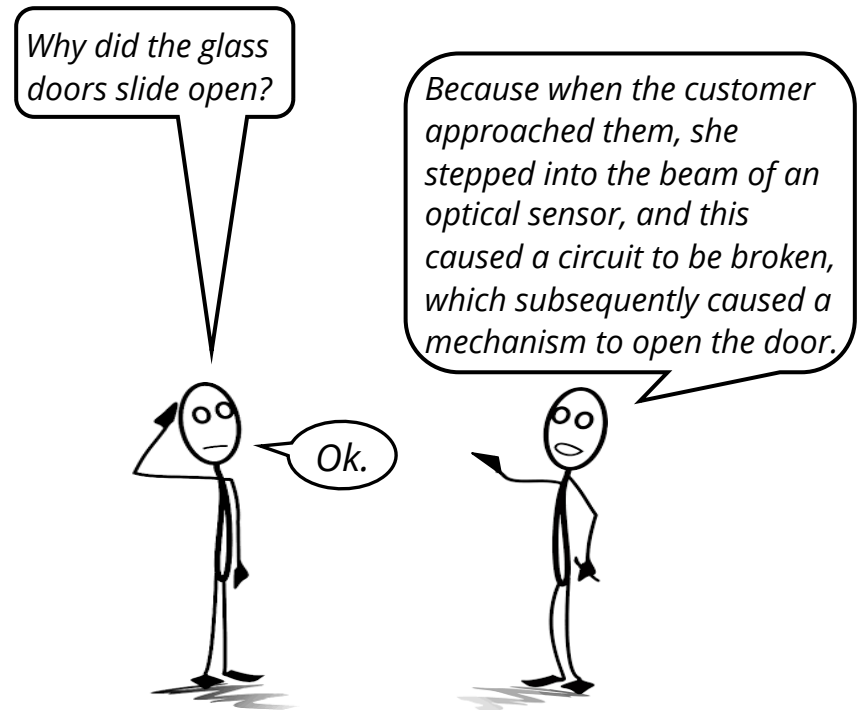
But surely an anthropologist will seek some form of explanation...

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

2. Causal Account

- *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.



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?

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

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

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

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!"