

Week 4

Part A

Scientific Understanding

Hans Halvorson

May 19, 2025

Table of Contents

1. Introduction
2. What drives science?
3. Philosophy of science background
4. Theories of scientific explanation
5. Resurrecting “understanding”

Table of Contents

1. Introduction
2. What drives science?
3. Philosophy of science background
4. Theories of scientific explanation
5. Resurrecting “understanding”

De Regt and Dieks on Quantum Non-Locality

- Henk de Regt (Nijmegen) and Dennis Dieks (Utrecht) are philosophers of science from the Netherlands. They have made central contributions to discussions about the foundations of quantum mechanics.
- De Regt and Dieks have wrestled with the apparent unintelligibility of quantum non-locality.
 - Some interpretations of QM try to make non-locality intelligible by appeal to superluminal causation.



Henk de Regt



Dennis Dieks

- De Regt and Dieks offer us a “theory” of what scientific understanding is — or, at least, what its characteristic signs are
- Their account of understanding is a successor to several competing accounts of scientific explanation that were offered between 1960 and 2000
- Their account is intended to show that understanding is **epistemically relevant**

Table of Contents

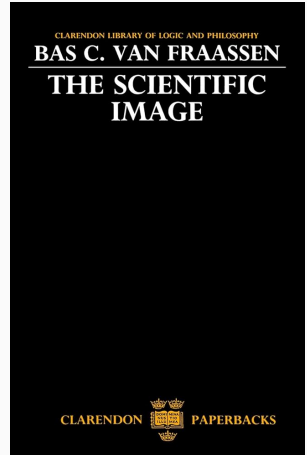
1. Introduction
2. What drives science?
3. Philosophy of science background
4. Theories of scientific explanation
5. Resurrecting “understanding”

What Drives Science?

Empiricism: The goal of science is to predict the results of experiments.

"According to empiricists such as Hempel and van Fraassen, the epistemic aim of science is (roughly stated) the production of factual knowledge about natural phenomena." (p. 141)

- 1870–1950: Ernst Mach, Logical Positivism
- 1960– : Carl Hempel, Bas van Fraassen, Brad Wray



Bas van Fraassen,
The Scientific Image (1980)

What drives science?

- **Scientific Realism:** Science aims to **explain** phenomena.
 - The realist reaction to logical positivism has been dominant among philosophers in the anglo-american tradition since the 1960s

- Empiricists see the aim of science as knowing **that** while realists see the aim of science as knowing **why**
- Is understanding needed?

What drives science?

- De Regt and Dieks: “We will argue that achieving understanding is among the general (macro-level) aims of science” (p 140)
- “Understanding is an inextricable element of the aims of science” (p 142)

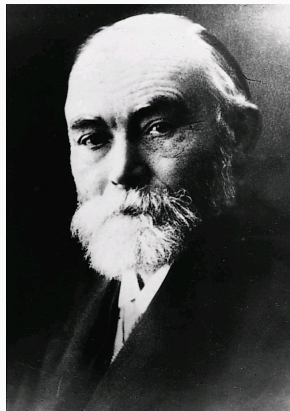
Table of Contents

1. Introduction
2. What drives science?
3. Philosophy of science background
4. Theories of scientific explanation
5. Resurrecting “understanding”

Origins of logical positivism

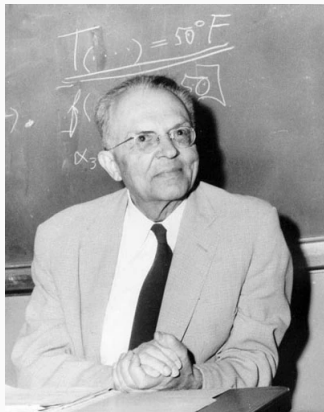
Gottlob Frege (1848–1925) was a German mathematician who argued for a strict separation of the (objective) logical from the (subjective) psychological

- He was a key player in formalizing the logical foundations of mathematics
- The validity of a “inference” is an objective fact, independent of any person who is thinking about it



Origins of logical positivism

- Rudolf Carnap (1891–1970) was a student of Frege, also trained in physics and philosophy
- Carnap's idea: apply Fregean logical rigor to the empirical sciences — **logic of science program**



A scientific theory of science?

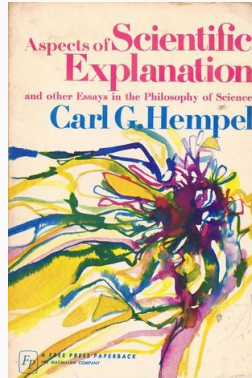
- Carnap was concerned with talking *about* science in a scientifically rigorous fashion
- Mathematical rigor: definable in some well-understood formal system
- At first, Carnap thought that not even “truth” qualified as a scientifically legitimate concept
- He never recognized “explains” as a scientifically legitimate concept

“To explain the phenomena in the world of our experience, to answer the question ‘why?’ rather than only the question ‘what?’, is one of the foremost objectives of all rational inquiry; and especially, scientific research in its various branches strives to go beyond a mere description of its subject matter by providing an explanation of the phenomena it investigates.” (Hempel and Oppenheim 1948)

- Carl Hempel (1905–1997) was a member of the Berlin Circle, and immigrated to the US in 1937
- Hempel: “explains” is a worldly relation that holds between facts, quite independent of the person (or group) of people considering them
- The goal of science is to find the (objective) explanation for the phenomena



“Such expressions as ‘realm of understanding’ and ‘comprehensible’ do not belong to the vocabulary of logic, for they refer to the psychological and pragmatic aspects of explanation.”
(Carl Hempel)



“Carl Hempel . . . argued that ‘understanding’ is subjective and merely a psychological by-product of scientific activity and is, therefore, not relevant for the philosophy of science.” (Krenn et al., p 762)

Table of Contents

1. Introduction
2. What drives science?
3. Philosophy of science background
4. Theories of scientific explanation
5. Resurrecting “understanding”

Major Accounts of Scientific Explanation (Historical Overview)

- **Hempel (1940s–60s):** Deductive-Nomological Model
 - Explanation = logical deduction from laws + initial conditions
 - Criticized for overgenerating (irrelevance) and symmetry
- **Salmon (1970s–80s):** Causal Models
 - Statistical relevance \Rightarrow causal relevance
 - Explanation = tracing causal/mechanical processes
- **Friedman & Kitcher (1970s–80s):** Unificationist Accounts
 - Explanation = increased understanding via unification
 - Fewer independent assumptions; general argument patterns

Deductive nomological account

Nomos = law

Hempel proposed a general schema according to which a fact E (the explanandum) is explained by being deduced logically from a covering law L and an initial condition C (the explanans).

Initial condition

Law

Explanandum (to be explained)

DN both over- and undergenerates

- DN undergenerates: There are legitimate scientific explanations that do not match the strict, DN format
- Hempel nuanced the DN account to include statistical explanations
- DN overgenerates: There are pseudo-explanations that match the strict DN format
 - Asymmetry: Flagpole
 - Relevance: Birth control pills

Flagpole and Shadow: A Problem for Hempel

D-N Explanation (Hempel):

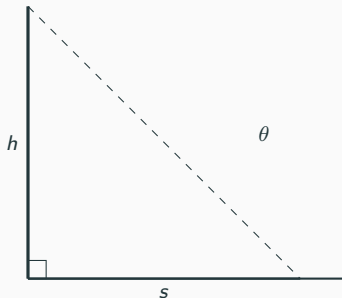
- Given: flagpole height h , sun angle θ
- Law: $\tan(\theta) = \frac{h}{s}$
- Deduce: shadow length s

But also:

- Given s and θ , deduce h

What's wrong?

- Both directions are deductive...
- ...but only one feels explanatory.



Hempel's D-N Model Overgenerates

Premises (Laws + Initial Conditions):

- (L) All males who take birth control pills regularly fail to get pregnant.
- (C) John Jones is a male who has been taking birth control pills regularly.

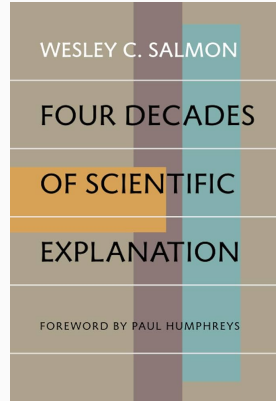
Conclusion (E):

- (E) John Jones fails to get pregnant.

Problem:

- The derivation is logically valid under the D-N model.
- But it fails to identify a genuine *explanatory* relation.
- Taking birth control pills is irrelevant to John's failure to become pregnant.

- For more than forty years, philosophers debated about the “right” account of scientific explanation.
- “Newton-Smith (2000) observes that fifty years of discussion have not led to consensus, but, on the contrary, to many rival models of explanation.”



- A natural addendum to the DN account of explanation would be to require that the explanans is **causally relevant** to the explanandum.
- Wesley Salmon developed the idea that a scientific explanation is a description of the causal mechanism that results in the production of the phenomenon.

- The causal-mechanical account taps into the old tradition of mechanistic explanation (and visualizability)

“Science advances our understanding of nature by showing us how to derive descriptions of many phenomena, using the same patterns of derivation again and again, and, in demonstrating this, it teaches us how to reduce the number of types of facts we have to accept as ultimate (or brute).” (Philip Kitcher)

- Proved beyond difficult to isolate the core idea of **explanation** that holds throughout all the different sciences
- The methodology of “whatever examples I can remember from when I was a physics student” was recognized as unacceptable

Table of Contents

1. Introduction
2. What drives science?
3. Philosophy of science background
4. Theories of scientific explanation
5. Resurrecting “understanding”







- “The present paper argues, *pace* Newton-Smith, that understanding can play the desired unifying role.” (p 137)
- “Should we rely on the view of practicing scientists...?” (p 138)

- De Regt and Dieks argue that understanding is an **epistemically relevant** concept.
“We will argue that understanding ... is epistemically relevant” (p 138)
- De Regt and Dieks argue that understanding transcends individual psychology
“We will argue that understanding ... transcends the domain of individual psychology.” (p. 138)

Understanding is contextual

- HH: A phenomenon can be contextual and yet be second-order objective
- For example, it is second-order objective that “Oslo is less than 500km from us”
- HH: de Regt and Dieks have not yet shown the sense in which understanding or intelligibility is second-order objective

Selected References i

-  De Regt, Henk W. **Understanding Scientific Understanding**. Oxford University Press, 2017.
-  Hempel, Carl G. **Aspects of Scientific Explanation and Other Essays in the Philosophy of Science**. New York: Free Press, 1965.
-  Lawler, Insa. **“Scientific Understanding”**. In: *The Routledge Handbook of Philosophy of Scientific Modeling*. New York: Routledge, 2023, pp. 298–311.
-  Salmon, Wesley C. **Four Decades of Scientific Explanation**. Minneapolis: University of Minnesota Press, 1989.
-  —. **Scientific Explanation and the Causal Structure of the World**. Princeton: Princeton University Press, 1984.
-  Strevens, Michael. **“No understanding without explanation”**. In: *Studies in history and philosophy of science Part A* 44.3 (2013), pp. 510–515.



Woodward, James. **“Explanation”**. In: *The Blackwell Guide to the Philosophy of Science*. Ed. by Peter Machamer and Michael Silberstein. Oxford: Blackwell, 2002, pp. 122–137.