

Notes on Scientific Change

Topics:

1. Received View
2. Historicist View
3. Social Constructivism
4. Practical Science View

1. Received View

(Hacking *Scientific Revolutions*)

(a) Realism: Science yields objective knowledge of the world.

Weak version: The world exists *independently* of the scientist, who's role is to discover its properties.
(Compare with Kant)

Strong version (anti-nominalism):

The world has a given structure that science aims to uncover. Science cuts Nature at its joints.

ASIDE: *Nominalism* is the claim that there are no essences; no natural kinds. There are only individuals. A natural kind is like a species, but more permanent. A realist (strong version) may claim that electrons, for instance, form a natural kind. There are electrons as individuals, and there is the natural kind to which all electrons belong. A nominalist thinks there are no such permanent groupings in Nature; there are only individual objects.)

(b) Demarcation: Clear distinction between science and non-science.

Ex: Popper's criterion - falsifiability *psychoanalysis,*
Marxism vs. *general relativity*

(c) Cumulative Nature of Progress: Science progresses by building on previous developments.

(d) Observation/Theory Distinction: 3 levels:

<i>observable objects</i>	i. directly observable objects
	ii. indirectly observable objects
<i>theoretical objects</i>	iii. in-principle unobservable objects

(e) Foundationalism: Hierarchical view of scientific knowledge with observation and experiment at base.

(f) Deductive nature of theories:

- theories are representable in a formal language
- observational predictions can be deduced from hypotheses
- strong claim: theories in science can be axiomatized

(g) Meanings of scientific terms are precise, fixed, objective.

(h) Distinction between Discovery and Justification

For any hypothesis H , we can ask:

(a) How was H discovered?

Claim: Factors influencing discovery may be psychological, social, economic, political, etc.

Examples:

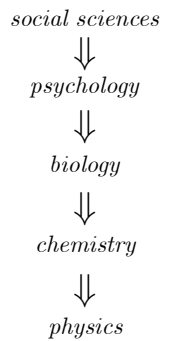
- (a) Kekule's discovery of the structure of benzene (firey snakes).
- (b) Ramanujan and the smallest integer expressible as a sum of two cubes (goddess in dream).
- (c) Newton and the apple.

(b) How is H justified?

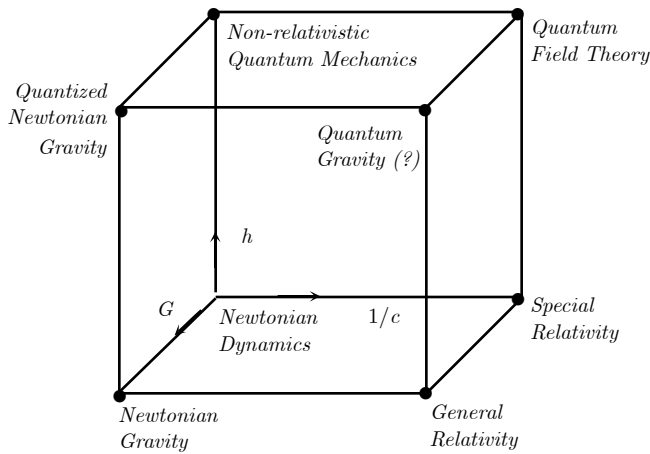
Claim: Justification, unlike discovery, is subject to a purely logical analysis. Philosophy of science should restrict its attention to the context of justification *only*.

(i) Unity of Science Thesis: 2 views

- (a) Hierarchy of fields plus reductionism
- (b) Unity of method



Motivation from physics:



Major fields in physics are related to each other *via* 3 constants of nature G, h, c .

3 fundamental constants of nature:
 G = Newtonian gravitational constant
 h = Planck's constant
 c = speed of light

Question 1: Is physics representative of *all* fields in science?

Question 2: Is View (a) compatible with strong realism?
 Is View (b) compatible with strong realism?

Question 3: Is View (a) compatible with nominalism?
 Is View (b) compatible with nominalism?

2. Historicist (Globalist) View (Kuhn, Lakatos, Laudan, Feyerabend)

Thomas Kuhn (1962) *The Structure of Scientific Revolutions*

Overview:

1. Change comes in stages:

normal science \Rightarrow *crisis* \Rightarrow *revolution* \Rightarrow *new normal science*

Ex: *classical physics* \Rightarrow *problems* \Rightarrow *quantum physics*

2. Underlying aim of science: Problem-solving

General Characteristics

(A) Normal Science vs. Revolutionary Science

(B) Paradigm: 2 senses

- (a) *World-view* associated with a particular episode of normal science.
- (b) Collection of problem-solving *techniques* that characterize a particular episode of normal science.

(C) Crisis: A buildup of anomalies (problems that the current paradigm cannot solve) that leads to a revolution.

Example: Classical physics at the turn of the century could not solve two "small" problems: (1) consistent description of black body radiation (leads to quantum theory); (2) consistent description of motion with respect to the aether (leads to relativity theory).

(D) Incommensurability Thesis: New and old paradigms are incommensurate; they are "completely different". (One sense of "completely different": non-translatable.)

Example: The term "mass" in Newtonian physics is "completely different" from (cannot be translated into) the term "mass" in relativistic physics.

Note: The incommensurability thesis presupposes *meaning holism*: the claim is that there is no neutral observation language by means of which we can compare paradigms.

(E) Noncumulative nature of change: Paradigms determine what the appropriate questions are that drive research. When you change paradigms, you change what the appropriate questions are; hence you change *fundamentally* the focus of research.

(F) Gestalt-Switch: New paradigms *completely* replace old ones. Paradigm change involves a complete switch in ways of thinking about and viewing the world.

(G) Social Character of Science: Scientific change is modeled after social change (scientific revolutions are literally revolutions (except (usually) without the guns)). The emphasis is on social, institutional, political, etc., factors.

Main Problem: How to reconcile meaning holism and incommensurability with change?

We need some common frame of reference for comparing old and new paradigms; *i.e.*, we need to be able to coherently explain how a new paradigm solves the anomalies of an old one.

But: If there is a common frame of reference, then change cannot be completely noncumulative, and paradigms cannot be completely incommensurate.

Concern: Slipping from a linguistic claim (meaning holism) to an ontological claim (scientists live in "different worlds").

One Option: View Kuhn as subscribing to a Kantian metaphysics. Kant claims the way we "construct" the phenomenal world is fixed. Kuhn claims the way we "construct" the phenomenal world is not fixed, but changes as paradigms change.

Paul Feyerabend (1978) *Against Method*

Claims:

- (1) Scientific practice is not rational (no underlying method).
- (2) Thus progress cannot be characterized by reference to an underlying method.

ASIDE: This is a criticism of Kuhn. On Kuhn's view, science is rational in the sense of possessing a method; namely, the method associated with a given paradigm. For Kuhn, progress involves the replacement of one paradigm with another.

More precisely, Feyerabend argues that:

- | | | |
|---|---|--|
| (a) There is no <i>meaning invariance</i> over theory change; | } | <i>i.e., there is incommensurability over theory change. Evidence: Historical examples (Newtonian mass vs. Relativistic mass, etc)</i> |
| (b) There is no <i>consistency</i> over theory change; | | |

But: This is good (he claims).

Claim: (a) & (b) lead to *theoretical monism*: the dominance of a single theory or method to the exclusion of all others. Theoretical monism leads to dogmatism and stagnation.

Progress (critical comparison) occurs *via theoretical pluralism*: allow as many competing conflicting theories/methods as possible.

Ex: acupuncture, creationism, astrology, *etc.*

Feyerabend's motto: "*Anything goes*".

ASIDE: Feyerabend is motivated by Popper: If you allow a free arena of competition, the strongest theories/methods will survive; *i.e.*, those that have passed severe tests.

Problem: Theoretical pluralism is itself a method; so it should go, too.

3. Social Constructivism

D. Bloor (1976) *Knowledge and Social Imagery*

B. Latour and S. Woolgar (1986) *Laboratory Life*

S. Shapin and S. Schaffer (1985) *Leviathan and the Air Pump*

A. Sokal and *Social Text* (1996)

Claim: Science is a social phenomena in 2 respects:

- (1) The *manner* in which it produces results.
- (2) The *results* themselves: scientific facts are "socially constructed".

Big Unresolved Problem: What does "socially constructed" mean?

One option: Scientific facts are socially constructed in so far as they can be explained *solely* in terms of *social parameters*.

Problem: Requires a theory of *social causation*; a causal account of how knowledge arises in which only social parameters occur. In particular, such an account must be able to distinguish social causes from mere correlations--highly problematic.

General Problem: Risk is great of running the above 2 claims together. This conflates *methodological* claims with *ontological* claims:

- (a) *Methodological claim*--Methods used by science are socially influenced (peer review, grant application process, institutional politics, *etc.*)
- (b) *Ontological claim*--Products of science (*i.e.*, facts) are social constructs.

Claim (a) is not controversial. But *evidence for Claim (a) is not evidence for Claim (b)*. To substantiate Claim (b) requires arguments based on *ontological* premises.

One option: Show that scientific facts *supervene* on social facts--for every scientific fact, there are social facts that are *necessary* and *sufficient* conditions for it.

Another option: Note that the distinction between (1) and (2) in terms of methodology and ontology is blurred if we subscribe to a Kantian notion of "fact". Kant maintains that the world of experience (the phenomenal world) is essentially, literally constructed by us. But Kant still retains the noumenal world as the unknowable objective substrate of experience. The social constructivists reject the noumenal world, but still retain the Kantian subjective description of the phenomenal world. So perhaps "socially constructed" means "constructed in a Kantian sense".

4. Practical Science View

P. Galison (1987) *How Experiments End*

D. Hull (1987) *Science as a Process*

S. Pickering (1984) *Constructing Quarks*

Emphasis on experimental science and technology.

Claim: Experimental procedures are independent of theoretical practices.

Strong Claim: Scientific change is driven by experimental practices.

Weak Claim: Scientific change must be understood both in terms of theory succession and in terms of how experimental practices change.

- Exs:
- Particle beam accelerators
 - PCR (polymerase chain reaction) technology
 - DNA chip technology

The Practical Science View sometimes overlaps the Social Constructivist view:

Pickering (1984, *Constructing Quarks*): Notions of *resistence* and *acomodation*. Nature resists experimental probing, and experimentalists accomodate (cooking the data in chem lab).

Practical Science Claim: Accomodation first occurs at the experiemental/technological level and then percolates up to the theoretical level.

Further Claim: There are many ways to accomodate resistence, and nothing inherant in the phenomena that selects one way over others.

Implicit Nominalist Assumption: There is no fundamental kind-structure to the world; we can describe it in many ways (we can cut Nature along any lines we see fit). Each way is underdetermined by our practices (i.e., evidence). Hence physicists can be said to construct quarks in the sense of choosing one mode of description over others (note: such modes really constitute the phenomenal world for a Kantian).

(Note further: This underdetermination thesis is not exactly identical to the Duhem-Quine thesis.

The DQ thesis is compatible with realism.)