Philosophy of Science

Lecture 5: Scientific Revolutions
Special Topic: Case Studies

Dr. Ioannis Votsis (NCH)

ioannis.votsis@nchlondon.ac.uk
www.votsis.org

Introduction

Logical positivists

- The logical positivists were the dominant force in the philosophy of science from the 1920s to 1950s.
- They largely ignored historical considerations in their analyses and offered normatively-driven reconstructions.
- In their view, science is guided by universal methods that progressively provide more knowledge.

Prominent Project: *The Encyclopedia of Unified Science*.

Edited by Rudolf Carnap, Charles Morris and Otto Neurath.

The historical turn

- This attitude changed in the 1960s when philosophers and other scholars begun to consult history more systematically.

- Thomas Kuhn (1962) and Paul Feyerabend (1962) are famous for having urged a form of historicism.

- They saw themselves as providing a more accurate image of what goes on in science.

- Gone are the unity of scientific method and the steadily increasing accumulation of knowledge.

Thomas Kuhn’s Scientific Revolutions

The notion of a paradigm

- Broadly construed, a Kuhnian **paradigm** consists of:

  a central theory
  auxiliary hypotheses
  heuristic models
  methods
  techniques
  standards
  instruments
  training procedures
  …

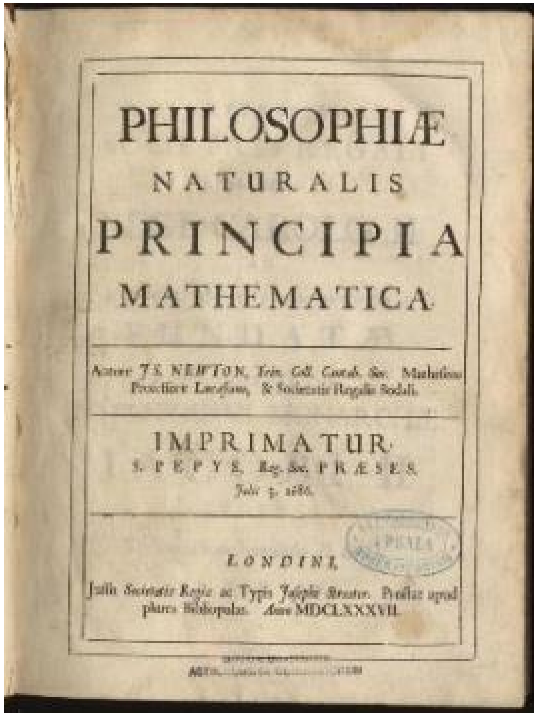
  NB: Kuhn sometimes refers to them as **disciplinary matrixes**.

Exemplars

- More narrowly construed, paradigms are **exemplars**.

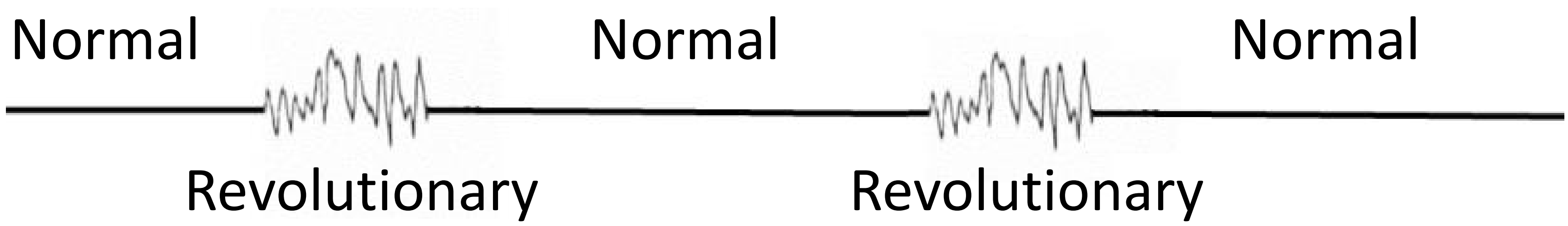
- These are commendable models of puzzle-solving typically codified in epoch-making books or papers.

- <u>Examples</u>:
  * Aristotle's *Phusike Akroasis*
  * Ptolemy's *Almagest*
  * Copernicus' *De Revolutionibus Orbium Coelestium*
  * Newton's *Principia Mathematica*
  * Lavoisier's *Traité Élémentaire de Chimie*
  * Maxwell's *A Dynamical Theory of the Electromagnetic Field*



Normal and revolutionary science

- The history of mature science alternates between stable growth (normal science) & upheaval (revolutionary science).



- **Normal**: Science as practiced most of the time under a ruling paradigm. Knowledge (solutions) to problems accumulate(s).

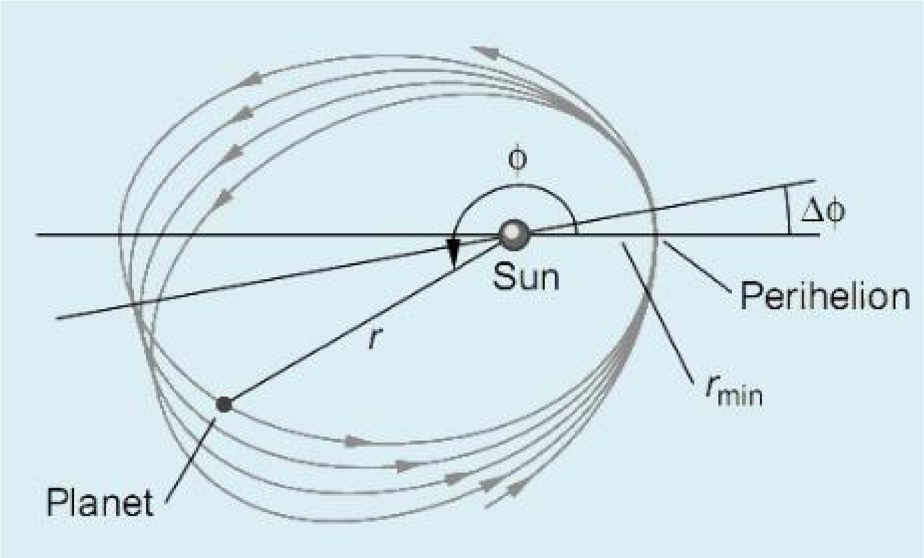
- **Revolutionary**:
  "Scientific revolutions… those noncumulative developmental episodes in which an older paradigm is replaced in whole or in part by an incompatible new one" (p. 86).

Anomalies

- Puzzles or problems that a paradigm is unable to solve.

- They help motivate a crisis and the development of rival paradigms that ultimately bring about a scientific revolution.

  Example: The precession of Mercury's perihelion.



Paradigm shifts

- On Kuhn’s view, changes are wide-ranging and may include all of the aforementioned components of paradigms.

  “Successive paradigms tell us different things about the population of the universe and about that population’s behavior... These are **substantive differences**... But paradigms differ in more than substance... They are the source of the **methods**, **problem-field**, and **standards** of solution accepted by any mature scientific community at any given time” (p. 95) [emphasis added].

Incommensurability: Methodological and semantic

- This view of change is fuelled by Kuhn's (and Feyerabend's) idea that rival paradigms or theories are **incommensurable**.

- Three kinds of incommensurability:

  (1) **Methodological**

  Example: mechanical vs. non-mechanical explanations

  (2) **Semantic**

  Example: "the physical referents of these Einsteinian concepts are by no means identical with those of the Newtonian concepts that bear the same name" (p. 102).

Incommensurability: Observational

(3) **Observational/Perceptual**

Example: "In a sense I am unable to explicate further, the proponents of competing paradigms practice their trades in different worlds... One is embedded in a flat, the other in a curved, matrix of space. Practicing in different worlds, the two groups of scientists see different things when they look from the same point in the same direction" (p. 150).

NB: What we have elsewhere called 'theory-ladenness'.

The political revolution analogy: Malfunction

- Scientific revolutions are akin to political ones in three respects, holds Kuhn:

  (1) Initiated by a growing sense of ‘malfunction’ (/anomalies) in a narrow part of the political (/scientific) community.

- That is, the feeling is that existing institutions (/the reigning paradigm) are inadequate to solve a given set of problems.

The political revolution analogy: Radical change

- Scientific revolutions are also akin to political ones in another sense:

  (2) Political (/scientific) revolutions aim to change things in ways that the original institutions (/paradigm) forbid.

- In the case of political revolutions this involves changes to the constitution.

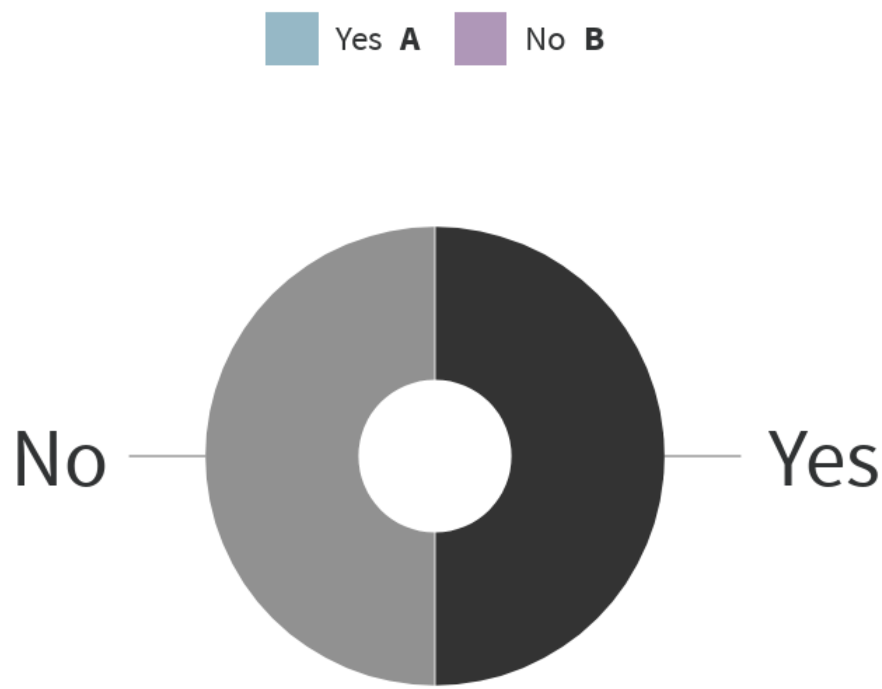
- In the case of scientific revolutions this involves changes to the methods and even the problem sets.

The political revolution analogy: Irrationality

(3) Once conflict begins, rational discourse fails and parties resort to mass persuasion, including force.

- Paradigm choice cannot be determined "merely by the evaluative procedures characteristic of normal science, for these depend **in part** upon a particular paradigm, and that paradigm is at issue" (p.88).
- "There are **no external standards** to permit a judgment of that sort..." (p. 99).
- If there are no common standards, meaning and evidence, then choice between rival paradigms is largely irrational.

Are anomalies sufficient to bring about a scientific revolution for Kuhn?



Start the presentation to see live content. Still no live content? Install the app or get help at **PollEv.com/app**

List Kuhn's three kinds of incommensurability:

Start the presentation to see live content. Still no live content? Install the app or get help at **PollEv.com/app**

Critiques

Incompatibility implies commensurability

- Kuhn’s logical mistake: “The normal scientific tradition that emerges from a scientific revolution is **not only incompatible but** often actually **incommensurable** with that which has gone before” (Kuhn [1962]1998: p. 95).

- Achinstein (1964) was first to point out the mistake:

  If one paradigm contradicts another, the two have at least one common measure, namely the contradicted claim.

  Example:
  Phlogiston theory predicts that rusting metals should lose weight as phlogiston is freed up whereas the *Oxygen theory* predicts that they should gain weight through oxidation.

Resistance to change via commensurability

- There is certainly resistance to change but the majority of scientists understand rival theories and their consequences.

- Resistance doesn't manifest itself via incommensurability but rather via the modification of auxiliaries.

- Scientists routinely devise experiments to test rival theories.

- The methodology employed is for the most part common, e.g. Copernicans and Ptolemaics both used sextants to measure angles between celestial objects.

Scientists are aware of rival theory strengths

- Consider, for example, the discussion between the **caloric** and the **motion theorists**:

  "We will not decide at all between the two foregoing hypotheses [i.e. the two theories of heat]. Several phenomena seem favourable to the second [i.e. the motion theory], such as the heat produced by the friction of two solid bodies..." (Laplace and Lavoisier's *Mémoire sur la Chaleur* quoted in Psillos 1999, p. 118).

Kuhn's turn-around

- In what seems like a turn-around, Kuhn (1977) denies strong constructivist interpretations of his work.

- Indeed, he claims that there is some common ground upon which to judge paradigms.

- To be precise, he lists five criteria:

  (1) accuracy
  (2) consistency (internal and external)
  (3) broad scope
  (4) simplicity
  (5) fruitfulness

Is it really a turn-around?

- But even such criteria, he insists:

  “function not as rules, which determine choice, but as values, which influence it” (p. 331).

- How much influence they mete out depends on the particular interpretation we assign to them.

- And this, he seems to suggest, varies.

- So, on his view, rational considerations are still marginalised (perhaps even eliminated) in paradigm/theory choice.

Special Topic:
Case Studies

Continuity or discontinuity?

- The discussion between Kuhnians and their detractors has often turned on the issue of knowledge cumulativity.
- Note that this issue is something that should be able to be decided by looking at the history of science.
- A new industry has thus emerged of philosophers and other scholars of science conducting case studies.
- The hope is that the accrual of such cases will lead to some generalisable lessons about science, its past and future.

Example: The caloric theory

- It has often been argued that the caloric theory of heat is a clear case of total discontinuity in scientific theory change.

- Antoine Lavoisier (1743-1794) developed this theory based on an idea whose roots go back to antiquity.

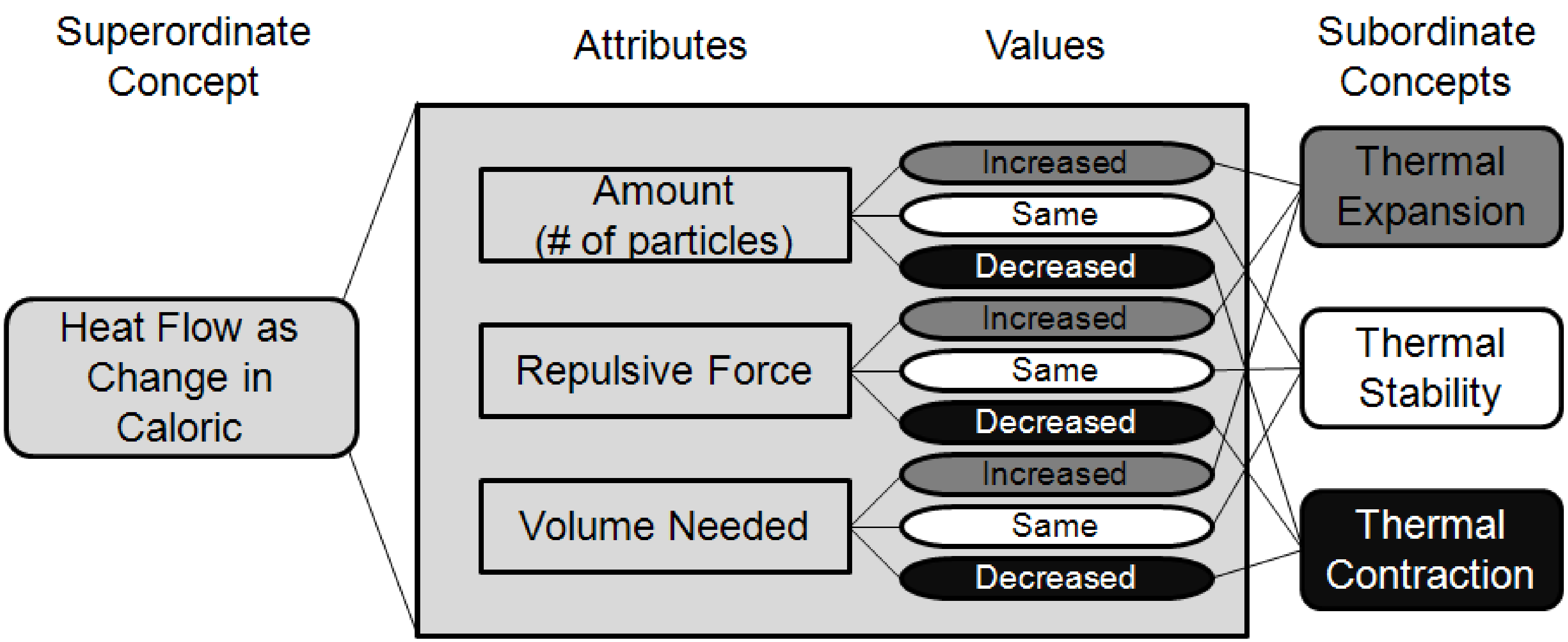
- Heat, on this view, is a special kind of substance. In more detail, caloric:

  * flows from warmer to colder bodies and
  * is subject to two forces (one repulsive, one attractive).

- Votsis and Schurz (2012), among other works, questions the total discontinuity of this case.

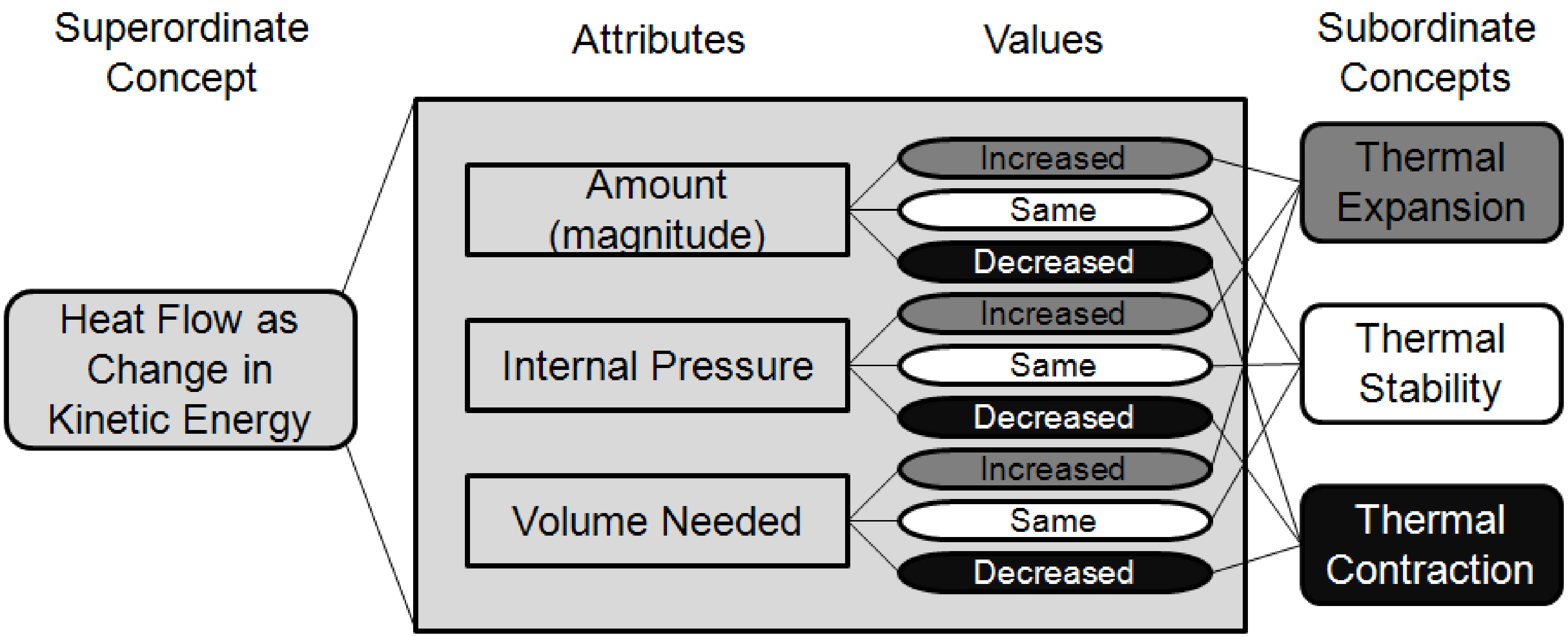
Caloric theory: Thermal expansion and contraction

- Votsis and Schurz (2012): The caloricists explained thermal expansion and contraction by arguing that the first involves addition of caloric while the second involves its removal.



Kinetic theory: Thermal expansion and contraction

- Kinetic energy increase results in internal pressure increase. The result is an increase in the body's volume – **expansion**.
- We get **contraction** by decreasing the kinetic energy amount thereby decreasing its internal pressure and volume needed.



Debate rages on

- Votsis and Schurz (2012) argue for a structural continuity between certain kinds of successive theories.
- Others argue for different kinds of continuity, e.g. low-level theoretical claim continuity.
- Needless to say, even if successfully argued for, individual cases are only meant to give *some* inductive support.
- We come back to this dispute next week when we take a closer look at the realism debate.

The End