Introduction to Philosophy of Science

Questions, brief history and overview remarks

Waseda University, SILS,
Introduction to History and Philosophy of Science

What is scientific knowledge?

- What *types of theories* do the sciences produce? How are these different from the theories of other disciplines.
- What are the *specific methods* that the sciences use to arrive at knowledge claims?
- What makes, say, astronomy different from astrology? How do we define this difference? (Can we appeal to the structure of the knowledge produced? to the methods of producing it? to the attitudes that we take towards this knowledge? to "way things are"?)

What makes a theory *true*?

First, what do we mean by truth?

Correspondence theories: A theory is true if it corresponds to the way "things actually are." (Common view.)

- We might not have access to the way things are.
- Our mature theories of our experiences may be very different from the way things are.

Coherence theories: A theory is true if it coheres with our other "true" theories. (Fairly recent view.)

- There may be contradictory "true" theories. (For individuals and for groups.)
- How do we evaluate truth claims? Who gets to decide what coheres and what does not?

Our theory of truth can be independent of our ideas about how we obtain truth—the latter is a theory of how we produce knowledge, or *epistemology*.

Confirmation reasoning

Induction, symbolically

(C):
1. If T, then Q.
2. Q.

$\therefore$ (probably) T.

This form of argument is called an inductive inference. It shows us that T *might* be true. (In fact, now we have elaborate mathematical methods for making inductive inferences.)

Even if the premises are true, the conclusion is *not* necessarily true.

Claiming that T is certainly true commits a logical fallacy: *affirming the consequent*.

Some example of inductive reasoning

Example (Everyday life)

(C): 1. Every car sold by Shinjuku Motors is rust-proofed.
2. Ken's car is rust-proofed.

∴ Ken's car *might* have been sold by Shinjuku Motors.

Example (Physics)

(C): 1. If gravity exists, when I let go of this pen, it will fall (at 9.8 m/s^2).
2. When I let go of the pen, it fell (at 9.8 m/s^2).

∴ Gravity *might* exist.

An example from the history of astronomy

(C): 1. If

(p1) the earth is still at the center of the universe, and

(p2) all the stars move around the earth once a day, and

(p3) the sun moves around the earth once a year in the opposite direction on an inclined orbit, then

(c) we will have seasons, and the sun and stars will rise in the east and set in the west, etc.

2. We do, in fact, experience those phenomena in (c).

∴ (p1), (p2) AND (p3), together, are *probably* the case.

Disconfirmation reasoning

Deduction, symbolically

(D): 1. If T, then Q.
2. not Q.

$\therefore$ not T.

This form of argument is called a deductive inference. It is a logically *valid* argument that shows that if the premisses are true, then the conclusion is *certainly* true.

In principle, we could use this kind of argument to try to *disprove* a scientific theory.

Actually, however, this is fairly difficult.

Some example of deductive reasoning

Example (Everyday life)

(D): 1. Every car sold by Shinjuku Motors is rust-proofed.
2. Mary's car is not rust-proofed.

∴ Mary's car was not sold by Shinjuku Motors.

Example (Physics)

(D): 1. If gravity exists, when I let go of this pen, it will fall (at 9.8 m/s^2).
2. When I let go of the pen, it didn't fall.

∴ Gravity doesn't exist.

A strange example

(D): 1. If

(p1) the earth is still at the center of the universe, and

(p2) all the stars move around the earth once a day, then

(c) the very distant stars will have to move much faster than the *speed of light*.

2. But nothing moves faster than the speed of light.

∴ (p1), (p2) AND (c) together, are *not* the case.

But this argument is more involved.

- How do we know the distant stars will move faster than the speed of light?
- How do we know that nothing moves faster than the speed of light?

Positivists approaches

- The (logical) positivists claimed that a scientific theory could be expressed in the formal language of mathematical logic.
    - Every theoretical term must be defined by purely observational terms – what they called *correspondence rules*. For example, $t = \sqrt{2d/g}$ expresses the time, t, taken for a body to fall a certain distance, d – both of which are observational terms that can be measured. The gravity at the surface of the earth, g is a theoretical term ($= 9.8\ m/s^2$).
- *Scientific explanation* becomes the *formal deduction* of observed phenomena from general laws.

Simple falsificationism

The hypothetico-deductive method:

1. A theory is proposed.
2. An observational result is predicted.
3. An experimental test is designed.
4. The theory is tested by experimentation:
    - If the theory *passes* the test, then it might be right, but testing must go on.
    - If the theory *fails* the test, then it must be wrong and a new theory must be proposed.

Sometimes this is called “The Scientific Method.”

Popper's falsificationism

- Karl Popper (1902-1994), Austrian philosopher, who settled in England.
- Popper considered falsifiability to be the distinguishing characteristic of a *scientific* theory.
  - This means that Popper believed that in order for a theory to be scientific, it *had to be* falsifiable—that is, it had to expose itself to the *possibility* of being shown to be wrong.

An *evolutionary* theory of scientific development

(PS1) problem solving → (TT1) tentative theories → (EE1) error elimination → (PS2) problem solving

Popper considered error elimination to function like natural selection in biological species. It does not find the "best" theory, it only finds the theory that is most apt for the current set of problems.

The Quine-Duhem Thesis, I

Williard Quine (1908–2000), American philosopher. Pierre Duhem (1861–1916), French physicist and historian.

The Quine-Duhem claim

Any seemingly disconfirming observational evidence can always be accommodated to *any* theory.

In other words, Quine and Duhem claim that a scientific practitioner can never be forced to deny a theory based purely on the evidence.

The Quine-Duhem Thesis, II

Our beliefs face "the tribunal of experience" not individually, but in a group.

When we test a theory we are testing a "web of beliefs"—some are central, some more peripheral.

The full structure of the deductive argument

(Q-D): 1. If T and U and V and W … , then Q.

2. not Q.

∴ not the combination of T, U, V, W …
That is, not T *or* not U *or* not V *or* not W …

Hence, we can always find some "irrelevant" factor and change that.

The Quine-Duhem Thesis, III

Hence, there can be no such thing as a *crucial experiment*—that is, an experiment that decides *once and for all* between two competing theories.

This means that theories are underdetermined by the evidence. That is, the evidence does not, in and of itself, decide on a theory.

In fact, *we* (people, natural philosophers, scientists, politician, journalists, corporations, etc.) decide on a theory and there may be many factors involved in this choice.

Kuhn's "Historical Turn"

- Thomas Kuhn (1922–1996) was an American physicist and philosopher. (Physics Ph.D., but practiced philosophy.)
- In 1962, he published a book called *The Structure of Scientific Revolutions*.
- This book made a number of claims:
  - The development of science sometimes progresses incrementally, and sometimes undergoes radical shifts in thinking and practice, known as *scientific revolutions*.
  - As well as the major revolutions, with which we are all familiar, there are also minor revolutions that affect only a small group of specialists.
  - The sciences have something like a *natural life history*—they are born, they have an infancy, an adolescence, periods of adulthood.
- The key to understanding these phases is what Kuhn called a paradigm.

Kuhn's Paradigm

Definition

A paradigm

1. is centered around a recognized *achievement* that is the model for further work,
2. creates a tradition of procedures and methods,
3. determines the problems which will be most interesting to work on and predicts what their solution will look like,
4. establishes a pedagogy,
5. cannot be characterized by precise rules or sentences,
6. constitutes a metaphysical *worldview*—that is, some set of conscious and unconscious *assumptions* about the way the world actually is and how best to understand it.

Kuhn's Normal Science

Kuhn argued that the incremental aspect of the growth of science should be associated with what he called normal science.

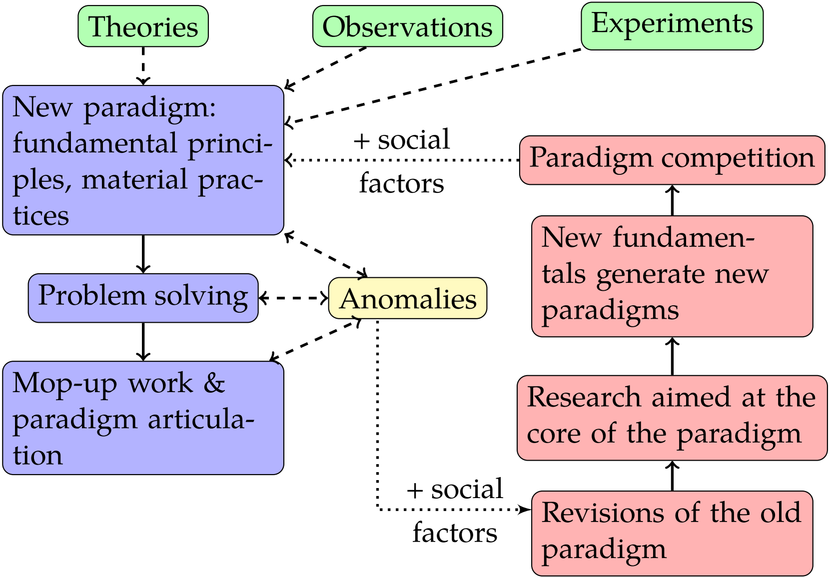
- A paradigm establishes a period of scientific practice known as *normal science*.
- A paradigm sets problems to be solved and normal science works to solve them.
- Normal science studies the physical world at an incredibly fine level of detail.
- Normal science is what most scientists spend the vast majority of their time doing.
- In the process of this detailed research, various *anomalies* are discovered.
- During periods of normal science, anomalies are ignored.

Kuhn's Crisis and Revolutionary Science

Kuhn argued that the revolutionary leaps we see in the history of science should be associated with fairly brief periods of crisis, which he called revolutionary science.

- The anomalies, which crop up in normal science, accumulate to the point where a particular science enters into a revolutionary period.
- Projects are designed specifically to test the paradigm.
  - Experiments are designed to test the core of the paradigm.
  - The paradigm is modified in various fundamental ways.
  - New theories are put forward.
- Eventually, a new achievement creates a scientific revolution, and the science undergoes a paradigm shift.
- Normal science resumes under a new paradigm—a new *worldview*.

A schematic of Kuhn's theory



Instrumentalists and Realists

Definition

Instrumentalists[1] claim that the *value of a scientific theory* depends only on its ability to predict and model.

Definition

Realists claim that its *value* also depends on the degree to which the theory depicts the way things really are.

Most practitioners are realists about certain aspects of a theory and instrumentalists about other aspects of the same theory.

[1] Instrumentalism is the theoretical position that a theory is no more than a tool, an instrument.