Chapter 12

Scientific Progress

12.1 Homework

Readings –Kuhn, two texts (Bb)

Study Questions – Give a short answer to the following questions:

- On "The Nature and Necessity of Scientific Revolutions"
  1. Explain the analogy between political and scientific revolutions
  2. What is Kuhn's main claim in this paper (try to formulate the main point of the paper in one single sentence)?
  3. What is Kuhn main argument for his claim (try to formulate it as concisely as possible)?
  4. Explain in witch circumstance scientific development is cumulative
  5. Explain Kuhn's argument in the bottom of p. 90 and top of p. 91
  6. Why is it that the shift from Newton to Einstein cannot be seen as a cumulative progress? Why is Newton's theory *not* a "special case" of Einstein's theory?
  7. Explain what Kuhn means when he writes: "But paradigms differ in more than substance, for they are directed not only to nature, but also back upon the science that produced them."
  8. What does Kuhn want to show in relating the relationships between the ideal of mechanistic explanations and the notion of gravity?
- On "Objectivity, Value Judgment, Theory Choice"
  1. What are the five typical criteria for a good scientific theory?
  2. Does Kuhn claim that there are *no* objective criteria for theory choice? If no, what does he claim instead?

3. Beginning p. 110, Kuhn develops a more positive view of theory choice: to what does he compare the criteria above? What are the advantages of this view?
4. p. 117, Kuhn writes : "I simply assert the existence of significant limits to what the proponents of different theories can communicate to one another" – Explain the analogy between theory learning and language learning. What are the limits of this analogy?

12.2 Introduction

Thanks to our study of Aristotle and Plato, we have come to understand what a *worldview* is (Kuhn would call it a paradigm). We have come to realize that we cannot hold the common view that older scientific theories were false while our current scientific theories are true. First, the notion of truth is more tricky than it seems. Second, the older theories were not as crazy as it seems. At the end, we feel like we are very much likely to be in a similar situation as past scientists were: we have a worldview, and it is likely that this worldview will be shown to be inaccurate.

Thanks to our study of the Scientific Revolution, we have come to refine our view of scientific method. The common way to think about scientific method is that we can logically induce our theories from empirical data, and these theories can be logically confirmed or disconfirmed through experimentation. Every bit of this view is problematic: the problem of induction (or the various versions of it) and the Duhem-Quine Thesis show it. We have seen how this played a role in the history of the scientific revolution: the Copernican system and the Newtonian system were not simply dictated by the data and logic. Data and logic do not dictate our scientific theories. Other assumptions, DeWitt's "conceptual beliefs", always play a crucial role. So, the issue of how scientific theories are constructed, and how they are accepted is much more complex than we thought.

We came up with the view that while the naive view is untenable, the purely relativistic view is not good either: it is not true that any theory will do, it is not true that we are not able to get out of our worldview, and hence, it is not true that scientific theories are totally arbitrary. We have come up with a definition of the scientific *stance* or attitude, which is to take empirical evidence as crucial, and to be ready to take risks, and to see our favorite theories falsified.

In a sense, this is reversal of the naive view: the scientist is precisely the one who does not think his theory is the last word.

Thanks to our study of relativity, we have come to realize that some of our core conceptual beliefs, which are part of the Newtonian worldview, cannot be correct. Newton's theory faces serious problems, makes inaccurate predictions. Relativity theory has the right predictions, but commits us to change radically our views of time, space and simultaneity.

In this chapter, I would like to use our knowledge of both the scientific revolution and the shift from Newton to Einstein to think about the notion of *scientific progress*. The question is : given all the above, is there any sense in which we can still talk about scientifc progress?

On the one hand, we feel that there must be one: simply because there is genuine progress between Aristotle and Newton, and between Newton and Einstein. On the other hand, we foresee that the naive view of scientific progress as the accumulation of truths over truths is not going to do. We need to refine our view of scientific progress.

12.3 Thomans Kuhn and his vocabulary

Thomas Kuhn :

Thomas Kuhn – we've encountered him before – remember the first sentence of the *Structure of Scientific Revolution*

"History, if viewed as more than a repository of chronology and anecdote, can produce a decisive transformation in the image of science of which we are now possessed." (Kuhn 1963, 1)

- From logic to history : history, not logic, is more likely to teach us what science is about

- His main claim concerning scientific revolutions: reason and evidence play a limited role in the outcome of a scientific revolution so that we must abandon the traditional view of scientific progress as cumulative, with theories getting always closer to the truth

- Criticism leveled agaisnt Kuhn's view: Kuhn was criticized for making science irrational and subjective and for taking an instrumentalist stance on science

- Kuhn's Response:

First concern: there are some shared values, but the ultimate outcome of theory choice depends on irrational, personal, and social circumstances

Second concern: remains instrumentalist

Vocabulary – Important notions to know:

Paradigm : worldview

Paradigms include methodological guidelines, standards of evidence, and are generally normative, i.e. guide theory development and application.

Normal science : science within a paradigm.

Scientists engaged in normal science figure out how to fit empirical phenomena into the conceptual framework provided by a paradigm (problem solving). Includes assimilating phenomena already accounted for by other theories as well as pushing the theory to discover new empirical phenomena and account for them.

Normal science is cumulative. The stack of solved problems increases. New knowledge is produced.

Anomaly : A persistent problem that evades solution within the context of a paradigm.

Crisis Science : A mode of scientific activity in which the currently acceptable paradigm accumulates anomalies that evade continued efforts by the community to solve within the context of a paradigm. Scientists start working outside the bounds of a paradigm.

Scientific Revolutions : Those episodes that are non-cumulative developmental episodes in which an older paradigm is replaced in whole or in part by an incompatible new one. (definition from the text p.86)

12.4 Kuhn, *The Nature and Necessity of Scientific Revolutions*

⟶ *Kuhn is deviating from the view that scientific knowledge is cumulative. He argues in NNSR that experiment and logic alone are not sufficient to determine which paradigm is better than another.*

Analogy between political and scientific revolutions :

1. A segment of the (scientific) community believes that the existing institutions(theories) cannot meet the demands of the environment that they have partially created.
2. This failing creates a crisis prelude to revolution.
3. The significance of a revolution depends on one's perspective. Those who are working on domains which the anomaly does not touch are much less concerned.
4. Revolution involves change in ways existing institutions (paradigms) prohibit.
5. There is uncertainty during the revolution.
6. Groups organize to promote different strategies. Eventually there is polarization around competing institutions (paradigms).
7. Once polarization takes place, there is no supra-institutional (paradigm) framework for adjudicating disputes. Groups resort to persuasion.

Kuhn aims to support the analogy. What does it mean for theory choice?

Main claim and Main argument :

> "[...] the choice is not and cannot be determined merely by evaluative procedures characteristic of normal science, for these depend in part upon a particular paradigm, and that paradigm is at issue" (p.88)

So, Kuhn aims to show that paradigm choice is not a matter of logic and experiment alone.

Essentially that is because the standards for evaluation of scientific argumentation are relative to a paradigm.

Hence in order to argue for a paradigm, one must assume the paradigm. Hence arguments are bound to be circular.

All one can do is present examples of how the paradigm works in hopes of attracting adherents.

So, the argument is :

1. A scientific revolution is a paradigm shift
2. A paradigm includes methods and evaluation standards
3. So: a scientific revolution is a shift in methods and evaluation standards

First Part of the paper: to what extent could there be cumulative progress :

Cases in which scientific development can be seen as cumulative :

This is normal science: new phenomena are not conflicting with the current paradigm

Success of normal science due to "the ability of scientists regularly to selct problems that ca ve solved with conceptual and instrumental techniques close to those already in existence" (p.89-90)

BUT: there are phenomena which *do conflict* with the current paradigm: the "recognized anomalies"

The case against cumulative progress :

In the case in which a new theory is accepted due to recognized anomalies, then *scientific progress cannot be seen as cumulative*. Rather, there is a necessary rupture in history.

New theories = new predictions p. 90-91

History has shown that theories encounter unexpected novel phenomena with which they can not cope.

If that is the case, then necessarily the new theory (the one that does account for the novel phenomena) will differ in empirical predictions from extant theories.

From Einstein to Newton : Counter argument and answer p. 91

Certain superficial kinds of continuity can be emphasized. One might restrict the range and meaning of prior theories such that within that range they generate true predictions.

Example: Newton's theory is "derivable" from Einstein's if certain limits are taken as true, i.e. the speed of light is infinite.

This is objectionable because: (p.92)

1. It limits the application of theories to phenomena already observed, and this seems absurd.

2. it is patently anachronistic.

3. the limited laws of Einstein's theory, though formally identical with Newton's laws, are not "semantically" or ontologically identical to Newton's. I.e. "m" means something different in Newton's theory than Einstein's.

Kuhn can be understood here to be pointing out that though in certain circumstances Einstein's theory can generate the same predictions as Newton's theory, the ontology associated with the theories are very different.

Back to main argument and main claim: logic and experiment are not enough – p.95

Paradigms include more than substance "But paradigms differ in more than substance, for they are directed not only to nature, but also back upon the science that produced them."

Paradigms, in addition to a new ontology, also bring along a new set of standards of solution, explanation, accuracy, etc.

Examples:

1. from the mechanical philosophy to force based physics: "Unable either... p.96 bottom

2. Lavoisier

3. Maxwell

Paradigms have a normative role :

The world is too complex to explore at random. Paradigms indicate what the world consists of, and how it behaves, and how to articulate a paradigm.

Conclusion :

- So, in the text, Kuhn makes two main points against the idea that scientific progress is cumulative:

  1. Scientific revolutions involve true crisis and abandonment of the current worldview.

  2. Such crisis are *not* and cannot be solved solely on the basis of empirical evidence and logical reasoning (because the standards are included in the worldview)

- Question: What does it mean for the notion of scientific progress?

  - From a realist point of view?

  - From an intrumentalist point of view?

  $\longrightarrow$ *The instrumentalist is fine! Scientific progress is not understood as the accumulation of truths, but as getting better and better tools for predictions. This is true progress. So, only the realist is in trouble.*

- Is it true that there are no paradigm independent standards that can be appealed to? Isn't it possible to think that some standards would reach across the line, and be accepted in various paradigm otherwise conflicting?

  $\longrightarrow$ *Kuhn only showed that the new theory has to be conflicting with the old one on* some *points, he did not show that they have to conflicts on everything!*

So, are there some paradigm-independent standards?

12.5 Kuhn, *Objectivity, Value Judgment, and Theory Choice*

This is a postscript that Kuhn added to a later edition of the *Structure*, in which he gives his answer to the criticisms against him. The criticisms were that he made the development of science irrational and subjective.

Five typical features of a good theory – Kuhn admits that there are some standards which are largely shared:

1. Accuracy (qualitative and quantitative).
2. Consistency (internal and external).
3. Scope.
4. Simplicity.
5. Fruitfulness.

This is "the shared basis for theory choice", but...

Why the shared standards are not decisive – Kuhn suggests that these features cannot be used as definitive criteria of theory choice.

Justification :

- These features are imprecise

-These preferred features often come into conflict with one another – for example: simplicity and scope

-There is no preferred weighting.

Example – Copernicus vs. Ptolemy

- accuracy is not definitive

- consistency is not definitive (pb with terrestrial physics)

- simplicity: Kuhn says that Cpernicus is more simple – he is actually mistaken on this: this is more on the side of his view though!

$\longrightarrow$ *Conclusion: the criteria are not sufficient:*

"When scientists must choose between competing theories, two men fully committed to the same list of criteria for choice may nevertheless reach different conclusions" (p.105)

$\longrightarrow$ *If we want to explain the actual choices of scientists, even more must be said about "subjective" factors*

"My point is, then, that every individual choice between competing theories depends on a mixture of objective and subjective factors, or of shared and individual criteria. " (p.106)

Answers from philosophers – don't we want to talk only about the objective standards, and leave the subjective ones behind?

Argument 1 – normative vs. descriptive

Philosophers concerned with a normative algorithm for theory choice are concerned not entirely with describing exactly what happens in scientific practice exactly. After all, scientists may come up short.

Kuhn's answer: they are not even close to getting the practice of science right. He suggests that philosphers are better at reconstructing *textbook science*, than describe actual situations of theory choice.

Example: The 'empirical data" or "crucial experiments" that textbooks give as evidence for a theory are most often not significant historically

Argument 2 – the objective side will win at the end

Another justification for ignoring subjective factors that philosophers provide is that the objective features of a theory eventually swamp the subjective factors of the individual scientist.

Kuhn's answer: even if that's true, it doesn't mean the subjective factors weren't used, or weren't important, and don't remain important.

Passage of Bayes: let's pass

The objective criteria as values – Kuhn suggests that the above "criteria" actually function in the way values do.

Description of how values function:

Advantages:

- Accounts for disagreement

-Accounts for scientific behavior without deeming it irrational.

-Allows these criteria to function all the time, not only when all the evidence is in. If the criteria only function when all the evidence was in, new theories would not be able to be developed. An account of scientific rationality should make it possible for two scientists to work on two conflicting research projects.

Interesting corollary: values and value weightings are subject to change in the course of scientists adopting new theories.

Kuhn cautions against straw man arguments against his position w.r.t "subjectivity". Sujective does not mean "a matter of taste" or indiscussable.

Incommensurability : let's pass

Conclusion – Kuhn has made three points:

1. There *are* objective, shared standards for theory choices, *but these are not sufficient.*

2. So, subjective standards must come into play. These subjective standards are significant enough that philosophy of science must account for them. They are not "eliminable imperfections".

3. The objective standards function as values function

12.6 Conclusion

Kuhn and the reception of his ideas :

So, Kuhn advocated that we change our view of scientific progress: the naive view according to which scientific progress is cumulative, due to new empirical data from which we can logically induce new theories, is untenable.

Now, even if he had an important influence on the philosophical community, not everybody is ready to accept all what he claims. At first, he was heavily criticized. This was largely due to misunderstandings. Kuhn made his position clearer later on.

Other main figures in the field : Lakatos, Laudan, Feyerabend, more recently, Howard Sankey

How radical was Kuhn? – Kuhn was less radical than it seems in his early writings

- not a crazy relativist: different standards does not mean relativism (no objective standards, and no standards better than others)

- one notion which remains controversial: incommensurability

What about that middle ground? – Our best bet is probably to take seriously the challenges that Kuhn raised, but to avoid to draw too radical conclusions from it.

- Distinction Objective / Subjective and Rational / Irrational: subjective standards can still be rational !

  What would be rational to do for a scientist?

  - Do not need to accept a theory to make research about it

  - Engage research in programs that look promising

  - "What is promising" is here measured by the problem-solving power of the

  - It is rational to pursue the research with the highest problem-solving power

  $\longrightarrow$ *Scientist might not choose the research program closest to the "ultimate truth", but sill have rational ways to make decisions.*

- Multiple research and overlap
  Two big assumptions in Kuhn's thought:
  1. Only one paradigm at a time
  2. Nothing in common between paradigms
  Both these assumptions can be challenged:
  - More than one program at a time / more than one paradigm at a time
  - Scientists *are* able to work in various programs
  - Distribution of scientists over different programs may be good for science
  This is something we'll encounter in the foundation of quantum theory!