Stability and Modularity:
Essential Characters of Scientific Knowledge[1]

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1. Introduction

Japan has succeeded in the acceptance of Western natural science since the beginning of modernization in the 19th century.[2] Japan has produced Nobel prize winners, and today most of Japanese accept the theory of evolution, which makes a contrast to the situation in the United States, where many people are against it.

What made it possible to accept Western natural science in Japan? This question is interesting but difficult to answer, but what I want to stress here is this: the acceptance of Western science occurred just after the transition from natural philosophy to modern natural science in Europe, and this is considered as a lucky incident for the acceptance.

Before the 18th century, natural philosophy and early modern science related to issues of God, human being, society and culture. But the study of nature has gradually lost comprehensive and universal explanations. In the 19th century it came to aim at finding detailed results by restricting its research field and methods to secular and concrete ones. And this tendency enabled the association of science to technology.[3]

As stated above, the acceptance of natural science in Japan did not bring about cultural and religious conflict because, I think, this process was well synchronized with the transition of science. To understand this situation explicitly, it is necessary to reconsider the character of modern science. This is the subject of the following argument, but my concern is not historical but philosophical one.

2. Knowledge in traditional epistemology

Natural Science consists of activities directed to acquire the knowledge of natural reality. In the context of Western epistemology, Plato claimed that mathematics represents genuine knowledge, and some reason or justification is required if one insists on having a knowledge.[4]

The most influential answer to the problem of justification was given by Aristotle's Posterior Analytics. His methodology consists of, on the one hand, systematisation of knowledge by means of logical deduction, and on the other hand, acquisition of principles by means of induction from concrete experience. For him the ideal form of knowledge is the deduction from true universal principles and this has been effective in mathematics, clearly indicated in Euclidean geometry.

This way of thinking had the great influence over Western epistemology. For example, Cartesian natural philosophy takes the position of anti-Aristotle, but Descartes' system requires certain principle too. And today's ordinary arguments for justification are similar to that of Aristotle. The reason of this similarity is that new mathematical logic had advanced since the end of the 19th century, so logic has now high status in epistemology as Aristotle considered so.

Some scientists and philosophers may have the ideal of unified science founded on fundamental laws of physics. But for them there remains a task of difficulty to assure the certainty of such laws. In fact, many principles were historically denied or abandoned later.

On the other hand, in the tradition of empiricism, the origin of which is also Aristotle's theory of knowledge, direct or concrete experience is considered as the foundation of knowledge. But Bacon, Hume argued that the ordinary induction was not enough to attain principle with certainty. In the 20th century Goodman[5] and others posed new riddles of induction. Up to now the traditional epistemology and foundationalist theory of knowledge does not resolve these difficulties.

3. Philosophy of science in the 20th century

But another way of thinking, new kind of philosophy of science, was proposed by Kuhn, Hanson, Feyerabend and others. The history of natural philosophy and science often shows that many examples of adopted evidence, reason and standard in the past seem suspicious for us. From their point of view, this indicates the difference between research `paradigm' or way of research in the past and our paradigm. The content of observed facts varies when concept or meaning of terms changes, and the latter occurs when paradigm or principal theory changes. So paradigm or theory effects on the interpretation of observation or experiment. That is the thesis of theory-ladenness.[6] They claim that transformations of paradigms have no rational ground and they are holistic and discontinuous.

> Holism insists that it is only rather large systems of hypotheses which are open to empirical scrutiny. ¥ldots that the individual components which make up one of these systems or paradigms can never be directly challenged by experience and observation.[7]

In the field of philosophy Quine criticized empiricism by denying the dualism of a priori knowledge (logic and mathematics) and knowledge verifiable by direct experience.[8]

Therefore it is said that we can not determine in science which hypothesis is better than another by means of experience only, and this argument supports relativism. But we can doubt whether such consideration is appropriate to the modern mature natural science. The success of natural science is indicated by the theoretical advancement, but the latter depends on the improvement in scope and precision of various experiments and observations. Without noticing this, we can not examine the character of scientific knowledge properly, and therefore the analysis by the traditional theory of knowledge is insufficient.

4. Existing knowledge generates new knowledge

The strategy of the traditional foundationalism is to refuse all dubious presuppositions and reconstruct justified knowledge from certain principle alone. The objection to this strategy was asserted by such philosophers as Peirce[9] and Neurath. Their argument is that it is fictitious and impossible to abandon any existing belief as one's disposal.

> Even if we wish to free ourselves as far as we can from assumptions and interpretations we cannot start from a tabura rasa as Descartes thought we could. We have to make do with words and concepts that we find when our reflections begin. Indeed all changes of concepts and names again require the help of concepts, names, definitions and connections that determine our thinking. - - - We are like sailors who on the open sea must reconstruct their ship but never able to start afresh from the bottom. Where a beam is taken away anew one must at once be put there, and for this the rest of the ship is used as support. In this way, by using the old beams and driftwood, the ship can be shaped entirely anew, but only by gradual reconstruction.[10]

So we can't take the foundationalist position.

Against foundationalist empiricism who consider direct experience as the secure foundation of knowledge, Sellars argues

> that observational knowledge of any particular fact, e.g. that this is green, presupposes that one knows general facts of the form X is a reliable symptom of Y. And to admit this requires an abandonment of the traditional empiricist idea that observational knowledge `stands on its own feet'.[11]

And science is also not built on any foundation, but takes another way.

> For empirical knowledge, like its sophisticated extension, science, is rational, not because it has a foundation but because it is a self-correcting enterprise which can put any claim in jeopardy, though not all at once.[12]

Then in the case of natural science, what plays the role of such `general facts' and performs such a `self-correcting enterprise'? For this question, Feigl answers:

> While it may well be the case that all theories were (or are) `born false' i.e. that they all suffer from empirically demonstrable anomalies, there are thousands of empirical laws, that --at least within a certain range of the relevant variables-- have not required any revision or corrections for decades, --some even for centuries of scientific development.
>
> While I admit that `theories come and go' (but nevertheless favor a realist over an instrumentalist philosophy of theories), I insist that the growth of scientific knowledge depends upon the relative (comparative) stability of empirical laws. - - - The successive securing of theoretical knowledge-claims rests upon the (tentative!) reliance upon the (approximate) correctness, within the pertinent range of the relevant variables, of the empirical laws which characterize the functioning of the instruments of observation, experiment, measurement (or statistical designs).[13]

This is correct view of modern experimental science. Since the 17th century, various instruments for observation or measurement have been used with well-defined units to get over bounds of the human senses and to obtain objective data. To ensure the reliability of observation or experiment, we must have in advance some knowledge to make and control instruments and to understand the process of generating data. Therefore, experimental science requires much of available background knowledge and therefore must be accumulative so as to enable new observation and experiment.[14]

So in the above sense the theory-ladenness of fact and data holds. But in general the background knowledge in use is already established by other fields, and is independent of the knowledge to be investigated.

That the accumulation of background knowledge is essential to natural science is also indicated by the duration necessary to complete historical changes of paradigms. Some fundamental principles or theories today, e.g. heliocentric theory of the solar system, classical mechanics, electromagnetism, evolutionary biology, plate tectonics, were subjected to enormous modification, or made some important implication which the founders of them, Copernicus, Newton, Maxwell, Darwin, Wegener, did not assume at all. The reason is that new theory can be verified or corrected only after the appeareace of effective knowledge from other fields. Modern natural science indicates that without any available knowledge (or reliable belief) we can't get new knowledge (or reliable belief) .

5. Pluralistic character of natural science

To understand above characterization of natural science further, we should reexamine the constitution of natural science. Every field of natural science consists of many components such as domain of validity, formal or mathematical structures and models, means of calculation, semantical interpretations, available apparatus and instruments, and others. When change or innovation happens in science, some existing research or their components may be abandoned, but others may remain because of their usefulness and applicability, and coexist with new one by redefining their domain of validity.[15]

> the lower-level ``laws'' associated with our theories often manage to survive the demise of the deep-structure theories with which they were once associated.[16]

Therefore some reliable background knowledge or `laws' remain available for applications in new research. Such construction of science may bring the following pluralism.

> Metaphysical nomological pluralism is the doctrine that nature is governed in different domains by different systems of laws not necessarily related each other in any systematic or uniform way; by a patchwork of laws. Nomological pluralism opposes any kind of fundamentalism.[17]

To verify this argument, we must examine the meaning of reality in science. But the traditional epistemology, asserting that knowledge must be necessarily true and universally valid, is not appropriate to understand scientific knowledge. What is required for scientific knowledge is not universality but stability, that is, being true within some range of applications.

To build up such background knowledge, it is desirable that the research is independent of another research. Otherwise we need further available knowledge.

A component of a large system is called module if it has independent structure and function of other components in the system. This concept became popular in philosophy of mind and cognitive science by Fodor.[18] A module is defined as

> an informationally encapsulated computational system---an inference-making mechanism whose access to background information is constrained by features of cognitive architecture[19]

From the claim that perception is realized by modular system, it follows that perception is not penetrated by background beliefs.

> there is, in perception, a radical isolation of how things look from the effect of much of what one believes.[20]

If some objects or phenomena are isolated from their environment and their properties are not influenced by outer factors, the study of such objects may be well-defined, and resultant knowledge would have the modularity stated above, being informationally encapsulated and isolated, neutral with respect to another `paradigm' or theory. Therefore to restrict the domain of study and attain such result is essential and important for the success of science. Conversely, if some phenomena can not be studied properly in isolation, as many cases in social science, it is difficult to analyze and explain them by scientific method.

Therefore these characters, stability and modularity, are essential for the modern mature natural science.

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[1] Stabilité et modularité: caractères essentiels de la connaissance scientifique

[2] An example of historical explanation is in: *The Formation of Science in Japan*, Yale Univ. Press, (1989).

[3] An concise description is found in: J.Henry, *The Scientific Revolution and the Origins of Modern Science*, Palgrave, (1997,2002), and: `De-centring the ``Big Picture'': *The Origins of Modern Science* and the Modern Origins of Science', in M.Hellyer(ed.), *The Scientific Revolution*, Blackwell, (2003).

[4] *Meno* 98a、another related argument: *Theaetetus* 201d.

[5] So-called grue paradox. N.Goodman, *Fact, Fiction, and Forecast*, Harvard Univ. Press, (1954,1983).

[6] This thesis is anticipated by P.Duhem: *La Théorie Physique, son Objet, sa Structure,* (1905), chapter.6.

[7] L.Laudan, *Science and Relativism*, Univ. of Chicago Press, (1990), p.71.

[8] W.V.Quine, *From a Logical Point of View*, Harvard Univ. Press, (1953), chapter 2.}

[9] For Peirce's anti-Cartesian critical commonsensism, see C.J.Misak, *Truth and the End of Inquiry*, Oxford Univ. Press, (1991,2004), chapter 2.

[10] O.Neurath, *Anti-Spengler*, (1921), the English-translation is in O.Neurath, *Empiricism and Sociology*, Reidel, (1973), pp.198-9.

[11] W.Sellars, *Empiricism and the Philosophy of Mind*, Harvard Univ. Press, (1997), pp.75-6, (first appeared in 1956), also in W.A.deVries, T.Triplett, *Knowledge, Mind, and the Given*, Hackett, (2000).

[12] W.Sellars, op.cit. p.79.

[13] H.Feigl, `Empiricism at Bay?', R.S.Cohen, M.W.Wartofsky(ed.), *Boston Studies in the Philosophy of Science, XIV*, Reidel, (1973), p.9.

[14] On the importance and probability of the background theories, see P.Lipton, `Is the Best Good Enough?', *Proceedings of the Aristotelian Society*, 93/2,(1993), in D.Papineau, *The Philosophy of Science*, Oxford Univ. Press, (1996). On the character of scientific instruments see: J.Golinski, *Making Natural Knowledge*, Cambridge Univ. Press, (1998), chapter 5.

[15] I owe this argument to F.Rohrlich, `Pluralistic Ontology and Theory Reduction in the Physical Theory', *British Journal for the Philosophy of Science*, 39, (1988), pp.295-312.

[16] L.Laudan, *op.cit.*, p.40.

[17] N.Cartwright, *The Dappled World*, Cambridge Univ. Press, (1999), p.31.

[18] J.Fodor, *The Modularity of Mind*, MIT Press, (1983).

[19] J.Fodor, *A Theory of Content and Other Essays*, MIT Press, (1992), pp.200-201.

[20] J.Fodor, *op.cit.*, p.243.