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Philosophy of Science

Reviewing K. Popper's Philosophy of science

a plea for revitalization of Critical Rationalism

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Introduction

The purpose of this paper is to consider Popper's philosophy of science in view of the objections that developed after the first positive reactions and to consider the answers given by some philosophers of science. With these answers Popper's original Critical Rationalism (CR) should be updated and could be continued as 'Critical Rationalism of Science'.

1. Summary of Popper's philosophy of science

The conceptual framework of Popper's philosophy of science is completely different from the approach of Hume and others like the Wiener Kreis in their pursuit of certainty in science like the certainty in mathematics and logic. He joins Hume's conclusion that induction cannot be used to prove a theory but states that this is not required, we do not need it, because science is not like logic and mathematics and does not 'work' the same way. The basic element of Poppers approach can be expressed by the statement: *Each theory should be considered as a hypothesis and as subject of a continuous process of justification by scientific investigations*. This process of justification is and should be independent of the psychological process of getting ideas of new theories.

The justification process is a continuous challenge for falsification, to test the theories on their boundaries, a theory is always subject to a potential replacement by an other more preferable one. Today this starting point seems reasonably well accepted but when introduced it was a quite new approach.

In more recent reviews the concept of falsification is often considered as Popper's main message.[1] The main message however as he also stressed in one of his later works is: *'... all knowledge is hypothetical ...'*[2] and *'All theories are hypotheses'*[3]

This summary follows a systematic slightly different from Popper's, whose *demarcation* and *theory selection* are a little more intermixed and spread with different wordings, in the various chapters and books . The references given here are only examples.

Demarcation

With the demarcation of scientific theories from pseudo-sciences Popper aims to disqualify scientific claims not only by astrology but also of speculative theories as those of Marx, and Freud.

He stated that scientific statements have to comply with the following requirements:

1. It shall be Logically consistent and not be a tautology;[4] because a tautology does not add knowledge although it might give the impression to do so;
2. It should be '*inter-subjectively*' testable; .. *'a scientifically significant physical effect may be defined as that which can be regularly reproduced by anyone who carries out the appropriate experiment in the way prescribed*';[5] Although Popper avoids the word, to distinguish his approach from the Wiener Kreis, this could be seen as 'verifiable'.
3. It should be possible to falsify the statement;[6] This requirement should be understood in a methodological way, this means even when it is not possible to falsify the statement yet , it should in principle be possible. Anyone who makes a scientific statement should indicate by which empirical evidence he would withdraw his statement. This criterion is Popper's most important one and the one he uses to distinguish his approach from the logic positivists.

Preferred Theory

As long as a theory corroborated by withstanding all kind of sever efforts to falsify that theory there are good reasons to continue using the theory.

A next step should be made in case there are two competing theories. Popper defined the following set of criteria to make a choice between two (or more) theories.

[1] Popper 1972 p29
[2] [Popper: 'Objective Knowledge' 1972: p30]
[3] Alan Chalmers 'What is this thing called science' 1976/1999: first statement of ch.5 Falsificationism: 'Popper's alternative for induction is what I indicate as falsificationionism'
[4] Popper 1959/1972: p32
[5] Popper 1959/1972: p44, 45 and Popper 1963/1973:p257:
[6] Popper 1959/1972: p40

1. A new theory that constitutes a scientific advance is preferred, for instance it includes the older one, and the extension of the newer one is supported by empirical evidence.[7]
2. Information content: The theory that offers more relevant predictions should be preferred. And as a consequence in general such theory would expose itself more to falsification.[8]
3. The theory which is easier to verify is preferred.[9]
4. When otherwise equivalent, the most clear and simple theories should be preferred.[10]

The role of falsification in Popper's philosophy of science

Falsification indeed plays a significant role in Poppers approach but it is misleading to use the expression falsificationism to characterize his philosophy (as done extensively by Alan Chambers[11], however his presentation of Poppers philosophy is far better than what is done by Salmon & Earman.[12]). Falsification can be found in three parts of his philosophy:

1. As part of the "guidelines" for scientific research;
2. In the demarcation method;
3. In the process of choosing between different theories.

The concept of falsification as a kind of observation and guideline how science works / should work, is often explained with the example of water that boils at 100 °C, Verification of this statement many times under the same circumstances does not add knowledge. A typical scientific method is to verify this under various conditions. In other words take the challenge to find the boundaries of the statement to be true.

2. Objections against Popper's philosophy of science

The main comments / objections against Popper's approach can be clustered in four categories:

1. claims that he still uses one or more forms of induction
2. objections that his theory also runs into the problem of underdetermination;
3. Objections that his concept of theories and of falsification is too simple.

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[7] Popper 1959/1972: p33
[8] Popper 1963/1973: p256
[9] Popper 1963/1973: p386
[10] Popper 1963/1973 p385,386
[11] Alan Chalmers 1976/1999 chapters 5-7
[12] By their scattered attention to only some elements of Popper's philosophy the strength of the concept is lost see: Salmon, Earman: 'Philosophy of science ' 1992/1999

In this section I want to show that the first 2 clusters of these objections are not valid and based on misunderstanding and/or misinterpretation of Popper's philosophy. I think objections of the third cluster are valid and should be handled by extensions of his concept, contributions like those of Lakatos should be included in an ongoing program of Critical Rationalism.

2.1. Popper still makes use of induction

This objection is the most common one. It comes (mainly) from the philosophers that follow the old 'paradigm' of the philosophy of science in a tradition that started by Hume and included among many others of the Wiener Kreis.

The basic objection here is: *Popper's method makes use of empirical data, tests, made in the past, both for the verification and for the falsification, with the assumption that the results can be used for expectations in the future, this is a form of induction.* The first part of this objection is correct but the second part is a misunderstanding / misinterpretation. This interpretation is made from the perspective, mentioned above, that could be indicated as logic positivism. However Popper is not using induction because his philosophy is based on an other, dynamic concept of science as summarized above. Tests are used in case one has to select a preferred theory out of two or more alternatives. Not on the assumption that the preferred one would be a full proven theorie but on the fact of life that also that theory potentially can be replaced by a better one.

Earman & Salmon[13] state that: 'Popper has emphatically stated that the corroboration-rating refers only to past performance, and not to future performance, the corroboration-rating seem to be totally irrelevant to the predictive virtues of the theory'. Two remarks can be made on their statement: 1) In Popper's concept there is always the choice of the preferred theory. So in case of any practical situation, like their example to put an artificial satellite into an orbit around the earth, one should choose the preferred theory by lack of better alternative. 2) Although Popper's focus is not on the application of sciences, there is a short section specific on this question of pragmatic preference in 'Objective Knowledge' where he makes a clear statement regarding this point: 'we should *prefer* as basis for action the best tested theory' [*italic* by Popper).[14] Unfortunately Earman & Salmon seem not to be very knowledgeable about Popper's work.

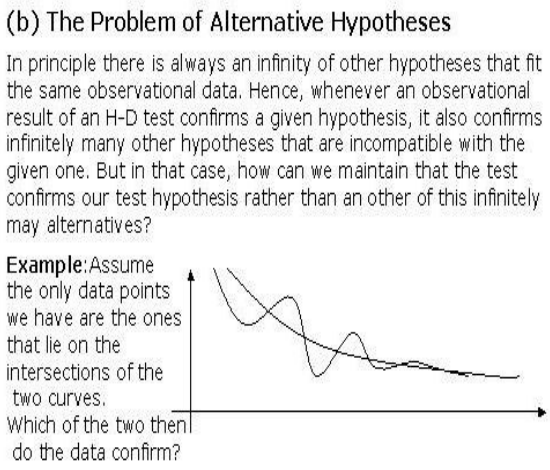
[13] Earman & Salmon 1999 p64
[14] Popper 1972: p22

There is also an objection that Popper's philosophy makes use also of the induction concept at a meta level. As Popper's concept is based on the observations of science as it developed in the past , a kind of induction is applied to extent the concept for future scientific developments. Also at this level the reference to induction is not applicable. Popper's approach should be considered as based on, supported by, the more basic epistemological philosophy of Pragmatism.[15] Although Popper does not refer explicitly to Pragmatism, in his 'Discovery of Scientific Discovery' he mentioned the founder (or one of the founders) of Pragmatism C.Peirce as one of the eight large philosophers of the last two hundred years[16].

2.2. Popper's theory also runs into the problem of under determinism

Durhem, supported by Quine, stated that experiments can never verify all possible instances predicted by a theory, nor test for all potential instances for falsification.

Indeed there might been an infinity number of alternative theories, as long as these are unknown or not articulated they are not relevant. As soon as one alternative theory is articulated Popper's methodology will require measurements that would result in an answer on those point were the two theories strongly differentiate in predicted values. As long as this is not possible selection criterion 4 above states to select the simpler theory, in this example the theory with the monotone decrease.



2.3 Objections against the simplicity of Popper's methodological approach

In 'The Logic of Scientific Discovery' Popper assumes scientific laws to have a content that can be reduced to a single statement and rejected by a single direct observation, such as one black swan that refutes the statement: 'all swans are white'. Quite soon he was attacked on this too simple concept.

The idea that a single observation would cause the rejection of a well established theory indeed is an oversimplification. In such a case one would/should reconsider the results of the

[15] See ao Peirce 1903
[16] Popper 1959/1974 p22

observation, could there be an error, measurement fault etc? Next to that one would reconsider auxiliary theories applied in the framework of the main theory and investigate the possibilities to falsify these. The difference however with the induction concept of science is that this will not be done with an attempt to complete a full induction program but by the dynamics of an intelligent investigation process. (see also above Durhem's underdetermination issue).

In general theories are embedded in a context (paradigm's as introduced by Kuhn). A number of examples used by Popper are related to a change of the paradigm such as the theories of Copernicus, Galileo, Newton and Einstein. The acceptance of these theories are based on a combination of factors. Some of these are part of Poppers method like the choice for simplicity in the case of Copernicus (the empirical evidence at that moment was questionable). In the cases of Galileo and Newton the acceptance was partly also because the world of science was ready to replace Aristotle's physics. In the case of Einstein acceptance by many scientists came even before the evidence was there, one could say the world was ready for it with work done by others like Lorentz.

An other objective is: *Popper's criteria for demarcation of science are not sufficient*. The most obvious example is astrology. Certain statements of astrology are relative easily to verify and falsify, however astrology is not recognized as science. Popper confirms this problem[17] without action to repair this issue, probably because nobody not even the astrologist claim astrology being a science, as he implicitly indicates.[18] This objection is solved by adding to the demarcation criteria the point that the theory should be an element of scientific activities with the claim of progress (similar to what Lakatos introduced as the element of progress in the criteria for preference).

[17] Popper 1963 rev 1972 p40

[18] [id p 53].

3. Critical Rationalism could be extended to cover remaining objections

It seems useful to use the indication Critical Rationalism (CR) introduced by Popper himself for the further extensions on Popper's philosophy to distinguish this from Poppers original work as this indication suggests a philosophical school rather than just a single philosophers approach.

- The first addition should be on Demarcation as indicated above (see 2.3). A theory should be related to a scientific discipline that claims progress of knowledge.
- The falcifiation should be considered as a process not based on one single observation, this was already proposed as 'methodological falsification' by Lakatos[19] and implicitly also agreed by Popper. Objections like those form M.Ruse even made in 1982 are not relevant anymore.[20]
- Also the paradigmatic context of a theory as indicated by Kuhn and integrated by Lakatos [21] has to be considered as part of CR

Conclusion

Karl Popper's work marks a turn in the history of philosophy of science by giving a reasonably well defined concept that fundamentally deviates from the dead-end road of strict induction and logic. It is based on a better understanding of how science works since the start of its successful development in the 17th century. Whether we like it or not we have to give up such ideals and accept science as it is with its strength and weaknesses. One of the activities of philosophy of science is/could be/ should be to reduce the weak points and to support the strengths.

The original success of his CR was not only because it reflected some typical characteristics of scientific processes and based on that derived a normative methodology, CR was also consistent with pragmatism as a philosophical mainstream mainly in USA and not in conflict with the phenomenology in continental Europe. In addition to that it offered a perspective for the philosophy of sciences like economy, sociology and even psychology.
In my opinion most the objections against the basic concept of CR are from the dead-end road and are not valid in the mainstream of western philosophy (both analytical and continental).

[19] Lakatos 1970 section II-B&C
[20] Ruse 1982 p55
[21] Lakatos 1970 section III

The other, more detailed, objections could be solved by the improvements of Poppers approach by those of Lakatos. These should have been given more attention, not only by Popper, who unfortunately did not very welcome these improvements, but also by others. Maybe it is time to revitalize the program of CR and consider whether elements like 'Inference to the Best Explanation (IBE)' could be an addition or a replacement of simplicity (depends whether one considers simplicity pragmatic (≠ pragmatistic) or an experienced based). Such a improved CR (a different program name could also be useful) might be a little less challenging than for example Bayesianism but could be very useful in the education program of sciences. A good example supporting the CR methodology is indicated in the attachment below.

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Attachment

A good more recent example of a scientific activity that fits very well in the CR approach is the experimental prove of the Bell's inequalities, first by Alain Aspect in 1982 and later under various conditions also by others. These test were set up as decisive for the choice between the entanglement hypotheses of quantum mechanics against the principles of locality, causality and 'reality' of classical physics[22].

[22] there are many references about this issue [ao Greenstein: 'The Quantum Challenge' ch 6]