Philsoc Student Essay Prize, Hilary term, 2021 – 2nd Prize

Does theory change in the history of science undermine scientific realism?

By Stéphanie Lefortier

Looking at the history of science, empirically successful theories that were once widely accepted have now been rejected and replaced by other theories. Does this fact undermine the belief in the approximate truth of our best current theories that realists have, and thus scientific realism? I will consider and discuss different answers to this question, concluding that yes, it undermines scientific realism.

A response to this question, known as the pessimistic meta-induction argument, is that this fact does provide good grounds to believe that our best current theories will also be rejected and replaced in the future.

This argument has the following structure (Ladyman 2002, pp 236-237):

"(i) There have been many empirically successful theories in the history of science that have subsequently been rejected and whose theoretical terms do not refer according to our best current theories.

(ii) Our best current theories are no different in kind from those discarded, and so we have no reason to think they will not ultimately be replaced as well.

(iii) By induction we have positive reason to expect that our best current theories will be replaced by new theories, according to which some of the central theoretical terms of our best current theories do not refer.

Therefore, we should not to believe in the approximate truth or the successful reference of theoretical terms of our best current theories."

Laudan (1981) gives a strong case in support of this argument. He provides a list of theories that were empirically successful but that have been rejected and whose theoretical terms do not refer according to our best current theories. Laudan here argues that a scientific theory cannot be approximately true if its terms fail to refer to anything. Laudan (1981, p.35) further argues that *"for every highly successful theory in the past of science which we now believe to be a genuinely referring theory, one could find half a dozen once successful theories which we now regard as substantially non-referring".*

Different responses have been proposed by the realists to this argument, by challenging the premises or the inference.

A challenge to premise (ii) has been to argue that our best current theories are different in kind from those discarded. Due to the exponential growth in terms of scientific instruments and observations in the last century, our best current theories have much more empirical support than past theories (Doppelt 2007, Devitt 2007). Newer theories built on older theories, incorporating their successes and solving at least some of the challenges they faced (Bird 2007, Lipton 2000). Thus premise (ii) does not hold.

Another response has been to challenge the inference (iii). For the inductive reasoning to be grounded, it is not enough that many past theories were rejected, it requires most past theories to have been rejected. Laudan cites the ratio of 6:1, but it is unclear where this ratio comes from. Moreover, his list should be a random sample for the inference to be strong, which is not the case. His list is further biased because it only concerns scientific theories from before the 20th century, and science exploded in the 20th century

(Park 2011, Fahrbach 2011). Fahrbach (2011, p.150) argues that inspecting Laudan's list, *"all corresponding theory changes occurred during the time of the first 5% of all scientific work ever done by scientists"*. For the inference to work, the list of theories should be representative of the whole science, not only the first 5%. Mizrahi (2013) challenges the inference by collecting a number of past theories and randomly choosing 40 out of them. He then classifies them into accepted, abandoned and still debated. The results were respectively 29, 6 and 5. Thus, most past theories are actually still accepted, so there is no ground for the inference.

The inductive argument against scientific realism, based on theory change in the history of science, is thus a weak one.

However scientific realism can still be challenged by the occurrence of at least one theory that fits premise (i). The reason is that, by showing that there can be empirical success without approximate truth and successful reference, it breaks the necessary connection made by realists between empirical success and approximate truth, that approximate truth explains empirical success. Thus, for any individual theory on Laudan's list, any theory change in history appears to potentially undermine scientific realism.

To this, the realists reply first by limiting the theories that could actually be used for this argument by arguing that scientific realism does not apply to all theories but only to mature theories that made successful novel predictions. A difficulty with this approach is the definition of novel prediction. Novel is a relative term and can refer to temporal novelty, use novelty, or epistemic novelty, which all have challenges when trying to define them. In any case, even without a precise definition, some theories listed by Laudan are agreed upon to be mature theories that made successful novel predictions. Two theories in particular meet this criterion and have been highly discussed: the ether theory of light and the caloric theory of heat.

A response offered by realists is then to argue against premise (i) by arguing that the abandoned theoretical terms of past theories do actually continue to refer. For this, realists use a causal theory of reference developed by Putnam (1975). The idea is that reference is not fixed by the sense or descriptions of a theoretical term, but by the phenomena that caused the introduction of the term. In the case of the ether theory of light for example, ether was introduced as the medium to propagate light waves. The ether then was replaced by the electromagnetic field. Psillos (1999) argues that ether actually continues to refer, now to the electromagnetic field, as they both are the medium in which light waves propagate. Similarly, the term caloric can be said to still refer, to molecule motions which are now believed to cause heat. The problem with this approach is that it is very permissive, as a term will thus always successfully refer once it has been introduced. This undermines the link between successful reference and approximate truth. An approach could be developed of a more balanced causal-descriptive theory of reference, where a term continues to refer when the cause of its introduction still applies and its sense, description stays at least in part the same, and has some continuity. However, then the term ether would no longer refer. Electromagnetic field theory has now been replaced by quantum field theories. It appears artificial, implausible to argue that ether referred all along to a quantum field, as ether has a completely different structure, description from a quantum field. Similarly, the term caloric would also not refer because it was regarded as a material substance and there is no continuity in structure, description with molecules in movement.

Another response is to argue that the theoretical terms of past theories that do not refer according to our best current theories were not essential, did not contribute to the generation of successes of the theories and that realism only believes in the approximate truth of the parts of a theory that are essential (Psillos 1994, 1996, 1999). A problem here is that the concept of essential is vague and can only be defined in retrospect. Ladyman (2002, p.248) also points out the problem of linking particular parts of a science to success, and of defining such dependency. In any case, ether is widely recognized as an essential part of the past theory of light. Looking at the example of the caloric theory of heat, Psillos (1994, 1996) argues that caloric was not a central theoretical term, so that the successes of the theory were independent of the description of caloric, i.e., of the assumption that caloric was a material substance. The successful part of the theory, the laws of experimental calorimetry, was what has been retained. Such argument appears to work in the case of the caloric theory of heat. However, a problem with it and with this response in general is, as noted by Ladyman (2002, p.248), that scientific realism is about believing in the theoretical terms of our best current theories. However, the response here actually tells us that we do not have to believe in them after all, or at least not all of them, because they might be non-essential parts of the theory, not linked to its success. Such response appears thus in itself to undermine scientific realism.

Thus, the pessimistic meta-induction argument from theory change in the history of science against scientific realism is a weak one. On the other side, the argument based on a particular historical theory change, such as the replacement of the ether theory of light or the caloric theory of heat, to break the necessary connection made by realists between approximate truth and successful reference on one side and empirical success on the other side, does not appear to have been replied to convincingly by the realists yet and thus undermines scientific realism.

Bibliography

Bird, Alexander, 2007, “What is Scientific Progress?”, *Noûs*, 41(1): 64–89.
Devitt, Michael, 2007, “Scientific Realism”, in Frank Jackson and Michael Smith (eds), *The Oxford Handbook of Contemporary Philosophy*, Oxford University Press, 767–791.
Doppelt, Gerald, 2007, “Reconstructing Scientific Realism to Rebut the Pessimistic Meta-induction”, *Philosophy of Science*, 74(1): 96–118.
Fahrbach, Ludwig, 2011, “How the Growth of Science Ends Theory Change”, *Synthese*, 180(2): 139–155.
Ladyman, James, 2002, *Understanding Philosophy of Science*, Routledge.
Laudan, Larry, 1981, “A Confutation of Convergent Realism”, *Philosophy of Science*, 48(1): 19–49.
Lipton, Peter, 2000, Tracking Track Records, I, *Proceedings of the Aristotelian Society*, Supplementary Volume, 74(1): 179-205.
Mizrahi, Moti, 2013, “The Pessimistic Induction: A Bad Argument Gone Too Far”, *Synthese*, 190(15): 3209–3226.
Park, Seungbae, 2011, “A Confutation of the Pessimistic Induction”, *Journal for General Philosophy of Science*, 42(1): 75–84.
Psillos, Stathis, 1994, “A philosophical study of the transition from the caloric theory of heat to thermodynamics: Resisting the pessimistic meta-induction”, *Studies in the History and Philosophy of Science*, 25(2): 159–190.
Psillos, Stathis,1996, “Scientific Realism and the ‘Pessimistic Induction”, *Philosophy of Science*, 63(5): S306–S314.

Psillos, Stathis, 1999, *Scientific Realism: How Science Tracks Truth*, Routledge.
Putman, Hilary, 1975, “The Meaning of ‘Meaning’”, *Minnesota Studies in the Philosophy of Science*, 7: 131–193.