Third Equal Prize

What is the difference between science and pseudoscience?

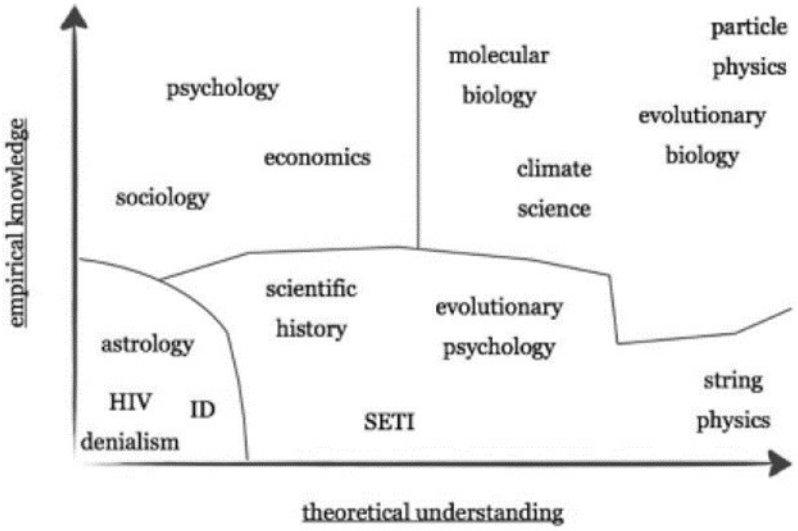
By Piet Van Assche

This essay starts from Larry Laudan's argument for the demise of the demarcation problem and critiques it with Massimo Pigliucci's response.

Larry Laudan in his article '*The demise of the demarcation problem*' (Laudan, 1983) outlines briefly the issue of demarcation within the historical epistemic framework. Based on Aristotle's '*apodictic certainty*', the certainty of principles and comprehension of first causes, the concept of certainty was used as a demarcating feature all the way up to the time of Newton and Kant. Kant, in his '*Metaphysical Foundations of Natural Science*' (1786), proposed very restrictive criteria for the demarcation of natural sciences. It required that cognition be systematically ordered according to rational principles and be known *a priori* with apodictic certainty (Watkins, 2014). The demise of the concept of epistemic certainty and the extraordinary utilitarian successes of science, from the beginning of the 19th century onwards, posed a double challenge to philosophers of science. Not only was the certainty of method lost, any new concepts for the method of science that were proposed, frequently proved at odds with the successful pragmatic methods of the scientists and engineers at the coal face of the industrial revolution. Ironically, the moment science reluctantly had to abandon its claim on access to the absolute truth, it became extraordinarily successful on the utilitarian front, ultimately leading to the formal problem of demarcation as posed by Popper.

Laudan (1983) argues that demarcation is not between the endeavours of scientific and non-scientific knowledge-seeking, but between claims with substantial empirical evidence and conceptual credibility about the world, and those lacking such evidence and credentials. To him this demarcation applies to all epistemic claims rather than only to scientific ones. For Laudan demarcation between science and non-science is irrelevant. What is relevant to him is: "*…to protect ourselves and our fellows from the cardinal sin of believing what we wish were so rather than what there is substantial evidence for…*" (Laudan, 1983, p. 125). In their criticism of Laudan's argument for the demise of demarcation, Pigliucci and Boardy introduce the Wittgensteinian family resemblances of concept clusters to demarcate science from pseudo-science and non-science (Pigliucci, 2013). They propose two dimensions to map demarcation, empirical support and internal coherence and logic. This allows epistemic endeavours, that

resemble science, to be mapped in a two-dimensional plane as illustrated in the following figure.



Copied from Pigliucci, 2013, figure 1.3)

From this two-dimensional mapping, a form of continuous resemblance demarcation can be observed. From particle physics (enjoying both strong empirical support and internal theoretical coherence) in the top-right corner diagonally down to astrology (lacking both) in the opposite corner. As such, Pigliucci argues for a continuous change of family resemblances rather than for a strict demarcation. This is illustrated by the example of string theory (bottom right of the figure), which has very strong theoretical coherence but no empirical support. Pigliucci does not declare string theory a pseudo- but rather proto-science because further research and testing might provide more empirical support and move it up along the vertical axis or might falsify it altogether. On the other hand, astrology, lacking both theoretical internal coherence and empirical support, should be declared as simply not making

epistemic sense. It clearly resembles more to a pseudo-science. Pigliucci admits that the two dimensions he opted for can be contested. However, whatever dimensions are chosen, the science family resemblance clusters pose a hard dilemma for pseudo-science. It can only claim to truly belong to the science family by rejecting the solidity of respected family members such as physics (in case of astrology) or evolutionary biology (in case of intelligent design). By the same measure, genuine non-scientific knowledge seeking (such as religion and philosophy), that have no desire to resemble empirical science, are also demarcated from pseudo-science, which craves resemblance.

Pigliucci deviates from previous approaches to formalise demarcation criteria. Mono-criterion approaches, such as Popper (falsification), Kuhn (puzzle-solving), Lakatos (theoretical progressive research programmes), and multi-criteria approaches, e.g, Thagard demarking pseudoscience as less progressive and not comparing its theory with other theories whilst being selective with evidence (Thagard, 2013, p. 32) - all attempt to address the six traditional assumptions for demarcation. Hirvonen and Karisto propose the following six traditional assumptions: (i) defining only science, (ii) necessary and sufficient conditions, (iii) universality, (iv) focus on end products, (v) scarcity of criteria and (vi) focus on formal features (Hirvonen and Karisto, 2022). Similar assumptions are presumed by Laudan when challenging demarcation. Pigliucci resemblance approach does not adhere to all assumptions because he also evaluates pseudo-science within the family resemblance concept (against (i)), does not aim for universality (against (iii)) and ignores the scarcity of criteria (against (v)). Boardy (2011, p. 246) and Pigliucci therefore only partially respond to Laudan. However, in the understanding that they do not strictly adhere to all six assumptions (as Laudan would expect), they do address Laudan's three specific questions; *"(1) What conditions of adequacy should a proposed demarcation criterion satisfy? (2) Is the criterion under consideration offering necessary or sufficient conditions, or both, for scientific status? (3) What actions or judgments are implied by the claim that a certain belief or activity is 'scientific' or 'unscientific'?"* (1983, p. 117). With his Wittgensteinian family resemblance concept for science and pseudoscience, Pigliucci does respond to each of Laudan's questions. He argues that demarcation should to a large extent agree with the intuitive distinction of the philosopher, scientist and knowledgeable laypersons between science and pseudo-science (ad 1) and that a multidimensional continuous classification (for example his two-dimensional strong empirical support and internal theoretical coherence proposal, possibly formalised by a many-valued

logical system, such as fuzzy logic) is able to quantify the degree of resemblance as a sufficient condition (ad 2). Laudan's third question is more axiological in nature and so is Pigliucci response when arguing for the scientist's active contribution to the development of critical thinking and evaluative judgement in the broader society (Pigliucci, 2013, p. 26).

Pigliucci considers the quantification of resemblance essential for demarcation. Kant would agree, as he argued; *"in any special doctrine of nature there can be only as much proper science as there is mathematics therein"* (Kant, 1786, 4:470). For Kant the demarcation of "proper" science from other non-scientific knowledge seeking was the a priori intuitive construct provided by mathematics. Geoffrey Gorham et al (2016) and Margaret White (1999) both emphasise the close relation between mathematics and science, Gorham with respect to the emerging science of the 17th century and White on the "mathematisation" of contemporary sciences such as biology and psychology, traditionally not employing mathematics, but starting to use more and more arithmetic through data science and other big data analysing techniques.

In conclusion, Laudan's demise of demarcation demonstrated that, when insisting on strict demarcation presumptions, any attempt to demarcate science is bound to fail. However, as Ladyman argues (2013, pp. 48–52), maybe this failure is due to the very strict traditional presumptions rather than the infeasibility of the demarcation endeavour. I agree that Pigliucci and Boudry's concept of scientific family resemblance based on theoretical internal coherence and empirical support, freed to a certain degree of the strict constraints of the six traditional assumptions, offers a valid alternative to the traditional demarcations attempts. The price to pay is not wanting to attain strict demarcation by admitting examples of intuitive pseudoscience (for example astrology) into the family clusters and settle for continuous family resemblance based on a continuous multi-criteria approach that accepts that no set of criteria will demarcate all members in a certain cluster from members in another cluster.

As a coda, both Kant and Pigliucci touched upon the importance of arithmetic. For Kant there could not be proper science without mathematics. Pigliucci suggests fuzzy-logic to quantify resemblance. Venturing into speculative territory, maybe for an epistemic endeavour to be scientific it has (in theory) to be expressible by a Peano type arithmetic? Maybe it is only possible for science to make realistic sense, to converge to Kant's "thing in itself", to be realistically

demarcated from non-science if the mathematics therein makes sense? Maybe Émilie Du Châtelet, influenced by Newton and Leibniz, was prescient when arguing that sciences must represent qualities using abstract mathematics. Her view was that, due to the limitations of our cognitive powers, we cannot reason about a large number of particulars without abstracting to be able to represent their relational, quantitative features (Du Châtelet, 1740).

It would show a lack humility to suggest that Popper was mistaken when he argued that demarcation distinguishes empirical sciences on one hand from mathematics and logic on the other (Popper, 1934). However, the idea that abstract mathematics might play a role in the demarcation problem would deserve further work. Notwithstanding the danger intrinsic to data manipulation and statistics, it might well prove one day that abstract arithmetic can protect us from the cardinal sin of believing what we wish were so, a sin Laudan warned against when preaching the demise of the problem of demarcation.

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