

Addressing Three Popular Philosophic Myths about Karl Popper's Demarcation Criteria

Nathan Oseroff

Introduction

Here are three philosophic myths:

- (1) Falsifiability, Karl Popper's demarcation criterion, sets out the boundaries of the natural sciences from non-science (or pseudo-science).
- (2) The criterion explicitly applies solely to singular theories that are universal in scope.
- (3) It is his sole criterion of demarcation.

These three myths are each expressed in, for instance, the collection of—and commentary on—key philosophical texts, *Philosophy of Science: The Central Issues*: 'According to Popper, a theory is scientific if and only it is falsifiable' (Curd, Cover, and Pincock 2013, p. 1307).

A number of objections against (1)–(3) can be grouped together under the category of *objections from ill-fit*. In brief, Popper's demarcation criteria is (so his many critics claim) too broad or too narrow in scope, thereby failing to include some (or all) paradigmatic 'scientific' theories or exclude some (or all) paradigmatic 'pseudo-scientific' theories. The objections for example, include that it is difficult or impossible to have certainty that a scientific theory has been falsified (and therefore demarcation criteria are too narrow); that paradigmatic 'pseudo-scientific' theories are classified as 'scientific' (and therefore demarcation criteria

are too broad); that only a theoretical system can be falsifiable (and therefore demarcation criteria are too narrow); that paradigmatic 'metaphysical' theories play an integral role in the natural sciences (and therefore demarcation criteria are too broad); and so on. One example of an objection from ill-fit is as follows:

Popper's simple idea does not work. ... [F]alsifiability is both too weak and too strong. It is too weak because it would allow as scientific any number of claims that are testable in principle but that are not, by any stretch of the imagination, scientific. It is too strong because it would rule out as unscientific many of the best theories in the history of science. (Curd, Cover, and Pincock 2013, p. 68)

These objections are both widely accepted and remain influential in reconstructing the history of twentieth-century philosophy of science. To list another example, at least one collected book has been recently published on, in part, deficiencies with Popper's purported demarcation criterion (Boudry and Pigliucci 2013), rehashing a number of objections from ill-fit against (1)–(3). As many of these philosophers of science see it, these objections directly lead to the downfall of the Popperian programme.

However, philosophers of science continue to misrepresent both Popper's problem of demarcation and proposed demarcation criteria. That is to say, it is not disputed that objections from ill-fit are effective against (1)–(3), for hardly anyone can dispute their effectiveness both as a matter of an analysis of the direction taken in history of philosophy of science away from the Popperian programme and taken on the apparent deductive validity of many of these arguments. Nevertheless, *all three myths are demonstrably false*.

These objections from ill-fit are spurious for at least three reasons: (a) they misidentify the scope of the boundaries that are drawn (the natural sciences versus the empirical and non-empirical), (b) what domains the criteria apply to (sets of sentences or individual theories), and (c) the number of criteria (there are two, not one). Clarifying these three points is enough to make much of the popular criticism of these demarcation criteria expressed in objections from ill-fit demonstrably moot. In reality:

- (1*) Popper's demarcation problem is to determine if there are necessary and sufficient conditions for drawing borders between what is *empirical* and what is *non-empirical* (encompassing the metaphysical, analytic, normative, mathematical and logic domains).
- (2*) The criterion of falsifiability explicitly only applies to *large sets of statements*.
- (3*) Popper set forward a *second*—almost entirely neglected—criterion of demarcation that classifies individual statements as either empirical or non-empirical.

Consequently, many philosophers of science have dismissed a philosophical programme based on a mischaracterisation; they have been shadowboxing against a philosophical ghost.

In what follows I set out why these three myths are wrong (§§1-3), how many objections to Popper's demarcation criteria are predicated on accepting these myths and where these objections fall flat (§4) and provide a plausible account of the origin of these myths (§5) that may provide useful advice for writing philosophy, as well as reading the work of philosophers.

1 The first myth: demarcation sets out the boundaries of the sciences from non-science or pseudo-science

The first myth, that *the criterion of falsifiability sets out the boundaries of the natural sciences from non-science (or pseudo-science)*, is widespread. Highly capable philosophers of science will say as such. Take Massimo Pigliucci, for example: 'Popper... wanted to distinguish scientific theories or hypotheses from nonscientific and pseudoscientific ones' (Pigliucci 2013, p. 10). See also (Preston 1994, p. 320). We can call the two problems a *normative* (i.e. 'science' versus 'pseudo-science') and a *territorial* problem of demarcation (i.e. 'science' versus 'non-science'). Other examples are legion (see both above and below).

Territorial demarcation problems are taxonomic: distinctions are made without judgment over their respective values. One formulation of a territorial problem attributed to Popper requires elucidating 'the distinction between science and

nonscience in general' (Mahner 2013, p. 31). This formulation is not unique; it is repeatedly attributed to Popper in the philosophical literature (cf. Boudry 2013, p. 81 and Nickles 2013, p. 101). For one prominent example, the *Stanford Encyclopedia of Philosophy* article on Popper states that the criterion of falsifiability is a 'criterion for demarcating science from non-science' (Thornton 2016). Other popular examples on internet encyclopaedias include Wikipedia ('Popper uses falsification as a criterion of demarcation to draw a sharp line between those theories that are scientific and those that are unscientific' ((n.a.) n.d.)) and the *Internet Encyclopedia of Philosophy* ('Much of Popper's early work in the philosophy of science focuses on what he calls the problem of demarcation, or the problem of distinguishing scientific (or empirical) theories from non-scientific ones' (Shea 2018)).

On the other hand, the normative problem, as traditionally construed, attempts to distinguish 'bona fide science from pseudoscience' (Boudry 2013, p. 79). 'Science' in this sense is intended as an honorific bestowed on certain theories, practices or communities and involves a judgment of their respective values. This formulation of the normative problem is attributed to Popper as well (cf. Laudan (1983, p. 118) and Boudry (2013, p. 80)). The 'conventional wisdom' surrounding Popper's purported motivations is captured in, for example, (Kneale 1974, p. 206): 'His [Popper's] primary aim was to distinguish between the universal propositions of genuine science, whether true or false, and those of pseudoscience', and is almost as popular as the canard that Popper's demarcation criterion separates scientific from non-scientific theories.

Even the authoritative biography of Popper, *Karl Popper - The Formative Years, 1902-1945*, includes such difficult to parse passages as 'Contrary to his [Popper's] autobiographical accounts, he had not yet settled on testability, or falsifiability, as the demarcation between science and pseudoscience, or science and metaphysics' (Hacohen 2002, p. 96) and 'Falsifiability became a marker of scientific statements' (Hacohen 2002, p. 198).

These depictions, however, are inaccurate. The first major error (that is, claiming Popper's stated criterion demarcates the 'scientific' from 'non-scientific') fails to grasp the appropriate territorial boundaries; the second major error (that is, claiming Popper's criterion demarcates the 'scientific' from 'pseudo-scientific') is doubly wrong, and conflates territorial demarcation criteria (e.g. the analytic/synthetic

distinction) with normative criteria (i.e. what sorts of beliefs or behaviours are preferable/dispreferable). But what boundaries, then, do demarcation criteria *demarcate*?

1.1 The truth: falsifiability is about the limits of empirical matters

Contra Boudry (2013, p. 82), Mahner (2013, p. 114), *et al.*, Popper's interests in setting out his demarcation criterion of falsifiability at the time of the publication of *Logik der Forschung* through his later works are not set towards demarcating the natural sciences from non-science or pseudo-science. In fact, he is explicit about this in the 1959 introduction to the English translation: the natural sciences are 'common-sense knowledge writ large... Its very problems are enlargements of the problems of common-sense knowledge' (Popper 1959, pp. xxvi, xix).

When Popper first set out his demarcation criteria, he explicitly was *not* interested in setting out the limits of what is science from non-science (or pseudo-science); rather, Popper attempted to set out a demarcation of what sorts of sentences should be treated as *empirically significant* (or 'empirical' or 'empirical science') and what sorts of sentences should be treated as *empirically non-significant* (or 'non-empirical', 'not empirical' or 'not part of empirical science').

Popper's stated purpose of his proposed falsifiability criterion is, rather, to 'provide a suitable distinguishing mark of the *empirical, non-metaphysical, character of a theoretical system*' (Popper 1959, 11, cf. 14, emphasis added); the problem of demarcation is to find 'a criterion... [that] would enable us to distinguish between the empirical sciences on the one hand, and ... "metaphysical" systems on the other' (Popper 1959, p. 11). Thus any proposed solution to this territorial problem elucidates a theory of the absolute limits of empirical inquiry, not the limits of the natural sciences.

It is of note that Popper repeatedly says variations of what is to demarcated in his oeuvre, for example, in the English translation of his first book, *The Two Fundamental Problems of the Theory of Knowledge*:

What distinguishes the *empirical sciences* from the *non-empirical sciences*...? A criterion that marks out some statements or systems of

statements as empirical, and others as non-empirical... (Popper 2009, p. 383)

So much for the first myth: Popper's criterion does not set out the boundaries of the natural sciences from non-science (or pseudo-science). In fact, Popper's criterion sets out the boundaries of what is empirical from what is not.

2 The second myth: individual, isolated theories are not falsifiable

Let us now turn to the second myth. Popper's falsifiability criterion is routinely said to be the following: a singular theory is scientific if and only if it is falsifiable (Thornton 2016 and Nickles 2013, p. 101). That is, a universal statement counts as belonging to the natural sciences if and only if it is prohibitive: it rules out the possibility of some state of empirical affairs. If the statement is not prohibitive, it is either pseudoscientific or nonscientific. This is Popper's (supposed) famous falsifiability criterion.

This formulation is the one I was told as a student, heard in casual conversation at conferences, and read in numerous articles and books. The number of examples perpetuating this formulation of the criterion of falsification in the available literature is overwhelming.

Reading Popper's *The Logic of Scientific Discovery* would be sufficient for many people to arrive at the conclusion that falsifiability applies only to individual theories. To enumerate a few examples in order, Popper says '... there is the investigation of the logic form of the theory, with the object of determining whether it has the character of an empirical or scientific theory ...' (Popper 1959, p. 9); '... there is the testing of the theory ...' (Popper 1959, p. 9); '... other statements ...are deduced from the theory' (Popper 1959, p. 10); '...if the conclusions have been *falsified*, then their falsification also falsifies the theory from which they were logically deduced ...' (Popper 1959, p. 10); '... no conclusive disproof of a theory can ever be produced' (Popper 1959, p. 28); (cf. Popper 1959, 28, 29, 49, 55ff.). Similar examples can be found in, e.g., Popper (1962), Popper (1963), Popper (1974), and Popper (1983), each

following the format of referring to a *theory* that is falsified by accepting an empirical statement that contradicts the theory.

Perhaps one of the biggest defenders of ‘orthodox’ Popperianism, David Miller, may have (most likely accidentally) helped perpetuate this confusion, saying, ‘This natural, but essential, qualification is Popper’s criterion of demarcation between science and nonscience: a hypothesis may be admitted to the realm of scientific knowledge only if it is falsifiable by experience’ (Miller 1994, p. 7) and ‘A theory, Popper’s criterion of demarcation says, must be falsifiable in principle if it is to belong to empirical science’ (Miller 2006, p. 5). In later sections, Miller, thankfully, clarifies that when he speaks of ‘science’ and ‘nonscience’, he is speaking of the ‘empirical sciences’; however, he, like Popper, does not clarify that the criterion of falsifiability does not apply to individual, isolated theories.

The impartial historian of philosophy, Haim Hacohen, says, ‘Falsifiability would demarcate testable statements as scientific, nontestable statements as metaphysical’ (Hacohen 2002, p. 208). Critics of Popper also routinely claim the falsifiability criterion applies only to theories. Remember, for example, Curd, Cover, and Pincock (2013, 1307, emphasis added): ‘According to Popper, a *theory* is scientific if and only if it is falsifiable’.

As we now know, the falsifiability criterion is not demarcating what is scientific from what is non-scientific or pseudo-scientific. We can put aside the first myth and reformulate the popular conception of Popper’s demarcation criterion as follows: *a universal statement counts as being empirically significant if and only if it is prohibitive: it rules out the possibility of some state of empirical affairs.*

2.1 Falsifiability applies only to theoretical systems

However, an examination of *The Logic of Scientific Discovery* reveals that Popper’s criterion of falsifiability bears little resemblance to the commonly-held conception of the criterion falsifiability. In fact, Popper is explicit that his falsifiability criterion applies only to a large set of statements. Popper first sets out his criterion as follows:

... it must be possible for an *empirical scientific system* to be refuted by experience (Popper 1959, p. 18).

That is to say, a theoretical system T —a large set of sentences, including auxiliary hypotheses, basic statements and a number of scientific and non-scientific (but empirical) theories—must rule out the possibility of some ‘experience’.

But how can ‘experience’ be expressed in a more exact way? According to Popper, this can only be done by some system of statements E ‘of a lesser level of universality’ (Popper 1959, p. 25) when compared to T , that is, E is already classified by an epistemic community as ‘empirical’, and is the sort of expression about what is, in principle, possibly intersubjectively observable, viz. expressions specifying the existence or nonexistence of entities at certain limited spatiotemporal regions, the occurrence or nonoccurrence of specific events at space-time regions, and so on.

Naturally, this formulation does not entail that a theoretical system, were it to contradict another theoretical system ‘of a lesser level of universality’, is therefore *false* in virtue of such a contradiction, nor does the criterion of falsifiability say anything about whether such a refutation must be made actual; Popper’s criterion is merely modal: that it is *possible* that at least one E contradict T . Furthermore, and more importantly for this myth, this formulation is explicitly *not* about singular universal statements, but of *systems of statements*¹

Further textual evidence demonstrates Popper’s repeated insistence that his criterion of falsifiability is directed towards demarcating *systems of statements*, rather than demarcating singular theories that are universal in scope. From, for example, *The Logic of Scientific Discovery*:

... we can indeed falsify only systems of theories (Popper 1983, p. 187)².

Another example, from *Realism and the Aim of Science*, is as follows:

Hence I suggested that testability or refutability or falsifiability should

¹In fact, it would seem the primary distinction to be drawn between Popper and, for example, some interpretations of Quine is that Popper denied only a radical version of Quinean holism and instead explicitly adopted a version of holism that is notably close to Duhem.

²See also Popper (1934/5, pp. 12–13), Popper (1959, p. 18) and Popper (1963, pp. 56, 66) for other examples.

be accepted as a criterion of the scientific character of theoretical systems...' (Popper 1963, pp. 174–5) (See also Popper (1963, pp. 186, 256))³.

A further example from *Realism and the Aim of Science* is even more explicit:

... it is important to remember that [the criterion of demarcation] applies to theoretical systems rather than to statements picked out from the context of a theoretical system (Popper 1983, p. 178).

In *Replies to My Critics*, Popper further directly addresses this myth:

[the problem of demarcation] can be considerably improved if one speaks of *theoretical systems or systems of statements*, as I did ... even if we can apply it to systems of statements, it may be difficult if not impossible to say which particular statement, or which subsystem of a system of statements, has been exposed to a particular experimental test. Thus we may describe a system as scientific or empirically testable, while being most uncertain about its constituent parts. ... *if we falsify it, we falsify the whole system.* (Popper 1974, p. 982)

And from *Conjectures and Refutations*, Popper belabors this point:

... the problem of drawing a line of demarcation between those statements and systems of statements which could be properly described as belonging to empirical science, and others which might, perhaps, be described as 'pseudo-scientific' or (in certain contexts) as 'metaphysical', or which belonged, perhaps, to pure logic or to pure mathematics. ... I proposed ... that the refutability or falsifiability of a theoretical system should be taken as the criterion of its demarcation ... a system is to be considered as scientific only if it makes assertions which may clash with observations' (Popper 1962, pp. 255–56)

³However, Popper's ability to invite confusion is exemplified in the rest of the statement: '... that is to say, as a criterion of demarcation between *empirical sciences on the one hand and pure mathematics, logic, metaphysics, and pseudo-science on the other*', as addressed previously, viz. Popper's lack of clarity concerning the expression 'pseudo-science'

In sum, the textual evidence for falsifiability applying to sets of statements—rather than individual statements—is overwhelming. The second myth has been dismissed with extreme prejudice.

3 The other neglected demarcation criterion

Now it is time to address the last myth: *there is one sole criterion of demarcation and it is the criterion of falsifiability*.

It is difficult to find many philosophers of science explicitly formulate this myth, for it is a myth perpetuated only by way of omission: when Curd, Cover, and Pincock (2013, 1307, emphasis added) say, ‘According to Popper, a theory is scientific *if and only* it is falsifiable’, the explicit use of material equivalence entails that no other demarcation criteria are necessary.

However, Popper sets out a *second* criterion of demarcation, which we can call, after A.J. Ayer, the criterion of ‘predicability’ (what Popper confusingly calls ‘falsifiability’). Following Popper’s reasoning, we see that he is fully in accord with many of his critics:

As a first attempt one might perhaps try calling a theory ‘empirical’ whenever singular statements can be deduced from it. This attempt fails, however, because in order to deduce singular statements from a theory, we always need other singular statements—the initial conditions that tell us what to substitute for the variables in a theory.

Popper, like Duhem, is absolutely correct: a statement that contains variables cannot entail anything. Since statements with variables can be ‘empirical’, it is not merely deduction of a statement that makes it ‘empirical’; the statement must be conjoined with other statements in order to be ‘empirical’. Therefore this first attempt is too strong, permitting too few plausibly empirical statements to be classified as ‘empirical’.

As a second attempt, one might try calling a theory ‘empirical’ if singular statements are derivable with the help of other singular statements serving as initial conditions. But this will not do either; for

even a non-empirical theory, for example a tautological one, would allow us to derive some singular statements from other singular statements'

Again, Popper, like many philosophers of science that address the 'tacking paradox', note that the conjunction of an analytic sentence ('Bachelors are bachelors') and a synthetic sentence ('Here is a black raven') one can derive a singular statement from it ('Here is a raven'). Thus this second attempt is too weak, allowing us to classify a number of paradigmatically metaphysical or analytic sentences as 'empirical'.

Popper continues on to set out further attempts, such as that a conjunction of a statement and initial conditions 'we should be able to deduce *more* than we could deduce from those initial conditions alone' (Popper 1959, p. 64), and notes their deficiencies (it would be too weak, permitting synthetic metaphysical statements like 'Every occurrence has a cause' (Popper 1959, p. 64)) before arriving at his final proposal for classifying individual statements as 'empirical':

... the theory should allow us to deduce, roughly speaking, more *empirical* singular statements than we can deduce from the initial conditions alone. (Popper 1959, p. 65)

This passage is, I admit, confusing, but when rephrased, becomes abundantly clear: a statement S is to be classified as 'empirical' if S , when conjoined with a set of other statements T , $S \cup T \models E$, where E is a statement that is considered 'empirical' by an epistemic community and $T \not\models E$ and $S \not\models \perp$ (Popper 1959, p. 64).

It certainly does Popper no good that in the very paragraph that Popper sets out this criterion of demarcation he then invites confusion, saying, 'Seeing that it would not be very easy to say in detail how a complicated theoretical system helps in the deduction of singular or basic statements, I propose the following definition. A theory is to be called "empirical" or "falsifiable" if ...the class of its potential falsifiers is not empty' (Popper 1959, pp. 65–66) Are we to understand him as setting out

In short, Popper (like Ayer and Carnap) proposed *two* separate necessary and sufficient conditions for demarcation⁴: one for theoretical systems (as mentioned previously), another for members of a theoretical system.

Popper's falsifiability criterion is a restricted version of Carnap's criterion of 'disconfirmability', and applies solely to *theoretical systems*; the second is a restricted version of Carnap's criterion of 'confirmability' criterion, itself a restricted version of Ayer's proposed criterion of 'predictability' Ayer (1946), which determines whether or not any member of a theoretical system is to be considered empirically predictive.

Correcting these three myths

When faced with these three philosophic myths, what remains? We have something like the following:

- (1') Popper's territorial demarcation criteria are designed, roughly, to set out the boundaries of what we can know through experience from what we cannot know through experience.
- (2') Popper's criterion of falsification explicitly applies to theoretical systems that are not reducible to any possible finite set of sentences we classify as 'empirical'.
- (3') Popper's demarcation criterion of falsifiability is one of *two* demarcation criteria, the other being a criterion of predictability, which explicitly applies to members of theoretical systems.

To paraphrase Curd, Cover, and Pincock (2013), the Popperian slogan is better understood as: 'According to Popper, a theoretical system *T* is classified as 'empirical' or says something about possible experience if and only if *T* is falsifiable; a statement *S* is 'empirical' or says something about possible experience if *S*, when

⁴In fact, Ayer's 1936/46 criteria and Carnap's 1956 criteria (Carnap 1956) are either trivial or reduce to Popper's 1934/5 criteria (See: Popper (1959, pp. 65–66), Ayer (1946)).

conjoined with T , entails E , which is another sentence already classified as ‘empirical’ or says something about possible experience, and is not derivable from T alone.

4 The many erroneous objections from ill-fit

While these three myths have been put to rest, how do many of the popular objections from ill-fit hold up? First, it helps to understand the substance of these objections, as well as their prevalence in the literature. Carl Hempel notes territorial criteria are bound to be both too restrictive and too permissive (Hempel 1950; Hempel 1951). While Hempel’s focus is directed at Ayer and Carnap’s criteria, this general method has been appropriated to apply to Popper’s criterion of falsifiability. In what follows, I set out a number of objections from ill-fit, note how they rely on accepting one or all of the philosophic myths and then correct these mistakes.

4.1 Falsifiability is too weak: it lets in false theories

One example arguing that falsifiability is a criterion that is too permissive comes from Larry Laudan in his (in)famous article, *The demise of the demarcation problem*: Popper’s demarcation criterion—so Laudan thinks—‘has the untoward consequence of countenancing as “scientific” every crank claim which makes ascertainably false assertions’ (Laudan 1983, p. 121). Other examples that parrot Laudan can be found in Lakatos (1981, p. 117), Mahner (2013, p. 30) and Boudry (2013, p. 87). Laudan’s objection is thus as follows: *falsifiability is too weak, for it lets in obviously false statements!*

An analogy illustrates the absurdity of Laudan’s reasoning: it would be as fruitful to object to falsifiability of theoretical systems as a territorial criteria (or, for that matter, any demarcation criteria) on these stated grounds as it would to object to criteria for synthetic statements on the grounds that under some stated criterion of synthetic statements, a synthetic statement can be ascertainably false and still be synthetic. Falsifiable systems can be false (and in fact, for any *true* falsifiable system, there will be an exceedingly large number of corresponding

false falsifiable systems).

Laudan has confused normative and territorial criteria, falling victim to the first myth: since the territorial criterion set out by Popper delineates the absolute limits to empirical inquiry, that is, what can be learned from experience; it is not normative (Popper 1959, pp. 14, 16). It does not matter if there exists ascertainably false or other epistemically objectionable empirically significant systems of statements that are falsifiable. This is to be expected for any solution to a territorial criterion proposing the limits to the domain of some form of discourse.

In this case, empirical systems of statements that are known to be false are empirical because that they are *known to be false through empirical inquiry*. In fact, Popper recognises this, saying ‘... theories which have been shown to be false... can nevertheless retain the character of empirical, scientific hypotheses’ (Popper 1983, p. xix). Naturally, *many* pseudo-scientific claims will be falsifiable: these claims are false, are known to be false by many scientists, and yet pseudo-scientists disregard any potential defeating evidence from a ‘low-level’ theoretical system.

Laudan can be forgiven for confusing territorial and normative demarcation criteria, however, since the two problems are often simply referred to as ‘*the* problem of demarcation’. And (as addressed later) such a confusion is practically invited when reading Popper.

While Laudan may not deserve blame, however, individuals that have become aware of the problems with Laudan’s objection from ill-fit may deserve it now that they have discovered the deficiencies with Laudan’s reply: it is more of a thought-terminating cliché than an appropriate rejoinder to Popper’s criterion of falsifiability. In sum, Laudan’s version of the the objection from ill-fit is not a cogent objection.

4.2 Falsifiability is too strong: individual theories cannot be falsified

Philip Kitcher (1982, p. 44), on the other hand, asserts the falsifiability criterion is too restrictive. In his words, ‘one can appeal to naive falsificationism to show that any science is not a science’; Kitcher rightly notes a scientific theory requires auxiliary hypotheses, background knowledge and initial conditions in order to make

any predictions, thus no theory qualifies as ‘scientific’ if it is divorced from a theoretical system. (See also Thornton (2016) and Putnam (1974) for other examples in the literature.) Another example is as follows:

... notable theories of science are typically unfalsifiable by observation statements, because they only make empirical predictions in association with certain auxiliary theories. Should any such prediction turn out to be false, logic does not compel us to regard the principal theory as untrue, since the error may lie in one or more of the auxiliaries.’ (Howson and Urbach 2006, p. 104)

In sum, Kitcher’s objection is: *falsifiability is too strong, for it applies to individual theories, and individual theories are not falsifiable!*

Note the objection from Kitcher that scientific theories on their own lack any predictive capacity is predicated on two of the previously mentioned mistakes in exegesis:

First, Kitcher has fallen victim to the first myth, as addressed in §1, that Popper’s demarcation criterion sets out the boundaries of the natural sciences from non-science. In reality, the purpose of the falsifiability criterion is not about whether a theory is *scientific* or *non-scientific*; falsifiability is a criterion for *empirical significance*.

Second, Kitcher has accepted the second myth, that falsifiability applies solely to singular theories. However, as addressed in §2, falsifiability applies to theoretical systems: singular theories are *not* what is demarcated by the criterion of falsifiability; rather, *theoretical systems* are (Popper 1959, p. 25). Instead, Popper’s limiting case of Carnap’s criterion of confirmability (acceptance of ‘low-level’ theoretical systems) determines whether a statement within a theoretical system should be considered empirically predictive.

Kitcher, along with other philosophers that object to the criterion of falsifiability on the basis that it applies to individual theories, rather than to theoretical systems as a whole, will be thankful to discover that Popper is fully in agreement with his critics, and anticipated these objections in the formulation of his falsifiability criterion. So much for the objection that since falsifiability applies to individual theories the falsifiability criterion is too strong.

4.3 Falsifiability is too strong: falsifications must be certain / falsifications are conjectural

Another objection that often appears in the literature can be put as follows:

... as an attempt to understand the practice of science, Popper's ideas bear little fruit. First of all, the claim that scientific theories are falsifiable by "possible, or conceivable, observation" raises a difficulty, because an observation can only falsify a theory (in other words conclusively demonstrate its falsity) if it is itself conclusively certain. Yet as Popper himself appreciated, no observation falls into this category; they are all fallible.' (Howson and Urbach 2006, p. 103)

He were face an objection from ill-fit that focuses on a version of the Duhem thesis. We can frame this holist objection as follows: *the criterion of falsifiability is too strong, for it is not possible to ever conclusively falsify!*

A similar holist objection is present in Hübner (1978):

But every falsification, too, we can reply, has some premises, such as axioms of certain observational theories. Now if these premises are conjectural ... the falsification is conjectural too. This conjecture may be purely arbitrary, and consequently the falsification would be practically meaningless (Hübner 1978, p. 280).

This similar objection can be framed as: *the criterion of falsifiability is too strong, for any purported falsification is necessarily conjectural!*

One last holist objection comes from Feyerabend:

A principle of falsification that removes theories because they do not fit the facts would have to remove the whole of science (or it would have to admit that large parts of science are irrefutable)' (Feyerabend 1975, p. 303)

We can summarise this objection as: *all theories contradict accepted empirical statements, therefore all theories that are classified as empirical are either false or are non-empirical!*

Now these objections present by Howsonm Hübner and Feyerabend are, in part, correct, but *only in the most trivial sense*, since we are interested in what sorts of statements and theoretical systems should be classified as *empirical*, not whether we can determine whether certain empirical statements are known to be true or false.

As is the case of Laudan's objection, it would be as helpful to object to a criterion for syntheticity that one cannot know with a high degree of confidence that certain synthetic statements are true or false. Thus one can grant for the sake of argument that no empirical statement can ever be known to be true or false and nevertheless accept the proposed demarcation criteria from Popper:

A statement or theory is, according to my criterion, falsifiable if and only if there exists at least one potential falsifier—at least one possible basic statement that conflicts with it logically. It is important not to demand that the basic statement in question be true. The class of basic statements must be characterized in such a way that a basic statement describes a logically possible event of which it is logically possible that it might be observed' (Popper 1983, p. xx)

The mistake that Howson and Hübner make is to adopt a subsidiary myth, namely that Popper's modal account—i.e., a theoretical system is falsifiable if it can contradict a *possible* statement classified as 'empirical'—hinges on the modal account being satisfied. But it is far more appropriate to understand Popper's criterion not as one of *discovering that a theoretical system is false*, but rather that *the theoretical system contradicts an 'empirical' statement*. If history were to be replayed, perhaps rather than adopting the label 'falsificationism', a more appropriate label would have been 'possible empirical contradictionism'.

In sum, however, we see that these three versions of the objection from ill-fit fail to engage with the demarcation criteria Popper proposed. So much for this form of objection from ill-fit.

4.4 Falsifiability is too weak: Popper's criteria for 'empirical' statements is arbitrary

A fairly subtle objection (that hinges on a subtle mistake) is exemplified as follows:

...rejecting of theories for Popper ... [is] a matter of mob psychology'. This leads to the uncomfortable conclusion that any acceptance of a basic statement and its corresponding theoretical system 'paves the way for any arbitrary system to set itself up as an "empirical science" (Newton-Smith 1980, p. 152).

We can rephrase this objection as follows: *the criterion of falsifiability is too weak, for Popper's criteria for 'empirical' statements is arbitrary, thus any theoretical system can be classified as 'empirical'!*

What appears at first glance to be a powerful objection from ill-fit, however, can be turned on its head: Popper's demarcation criterion is about the classification of sentences in ways that do not correspond to any extra-linguistic matters of fact; rather, it is about classifying sentences according to particular rules followed by an epistemic community. It is to be expected that for some epistemic communities, they will treat some basic statements as empirical; other epistemic communities will reject them as non-empirical.

Some epistemic communities will have greater *epistemic access* than others, and will have available to them forms of technology that impinge on what exists (or what is purported to exist), such as telescopes, microscopes, SONAR, RADAR, compasses, timekeepers, and so on; other epistemic communities will be limited to, by their material and social conditions, to a comparatively smaller amount of basic statements. Thus what is classified as a 'basic statement' will be indexed to a particular epistemic community's epistemic abilities, broadly construed. This, however, is to be *expected* if a demarcation criterion is to be territorial *and* not map on to any extra-linguistic categories, but rather pick out what is to be classified as empirical *for an epistemic community*.

In summation, Newton-Smith's objection relies on taking the criterion of falsifiability as expressing some extra-linguistic or extra-social fact, separate from the

epistemic community; but that is not what the criterion attempts to do, thus the objection from ill-fit is mistaken.

4.5 Falsifiability is too weak: it lets in metaphysical theories

Donald Gillies presents another subtle objection to the falsifiability criterion by way of the ‘tacking paradox’ or tacking problem (Gillies 1993, p. 210). In it, Gillies claims the falsifiability criterion fails to ‘exclude obvious metaphysical statements’, and this failure can be shown as follows: take an arbitrary theoretical system T that is falsifiable, then append to it a statement M that is metaphysical. Hence $T \cup M$ is empirical. But then M is empirical. Therefore metaphysical statements are empirical. But this conclusion is absurd, therefore the criterion of falsifiability is too weak.

As (Keuth 2005, p. 47) rightly notes,

But why should [the conjunction] be obviously metaphysical? Gillies seems to assume tacitly that, according to Popper’s criterion of demarcation, scientific statements must not have any metaphysical content. Actually, the criterion excludes only statements that do not have any empirical content.

In short, the problem with Gillies’ objection is as follows:

All falsifiable hypotheses have unfalsifiable consequences: logical truths inevitably, and weak metaphysical statements in most cases. It does not follow that these unfalsifiable statements qualify on their own account as scientific, nor that the falsifiable hypotheses in whose content they reside are unscientific. The presence of dead cells within its body does not deprive an organism of life, and the vitality of the organism is not transmitted to the cells that have died. (Miller 2006, p. 96)

Let metaphorically, theoretical systems can be classified as falsifiable or not; if they are correctly classified as falsifiable, the theoretical system has empirical

content. But nothing forbids the theoretical system from having a far greater amount of non-empirical content (which it will inevitably have).

But consider a far more problematic objection, a variation on the tacking problem: the falsifiability criterion does not exclude an obvious metaphysical statement M , for the conjunction of all statements will be empirical. Thus the falsifiability criterion is *trivial*, for it does not exclude any statement from being classified as a member of an empirical theoretical system.

A response to this is as follows: Popper's *second* criterion of demarcation for sentences prevents Popper's criterion of falsification from reducing to a triviality, since although any metaphysical statement M may be conjoined with a theoretical system T , one can determine if M is empirical or not. Therefore there exists criteria that exclude some statements (if we choose to exclude them) as hangers-on, riders that are carried along into theoretical systems by the coattails of a theoretical system, and are identifiable as such.

4.6 Falsifiability is too strong: it excludes isolated existential statements

A last series of objections from ill-fit is, at least at first glance, quite debilitating:

This [demarcation criterion] commits him to the paradoxical thesis that all unrestricted existential propositions ...[e.g. 'There exists at least one X that is Y '] are metaphysical and nonempirical. To call them all metaphysical is very curious, because most of them have nothing at all to do with metaphysics as understood by Aristotle or any other philosopher until the positivists of this century began to use 'metaphysical' in a grossly extended sense for purposes of abuse. (Kneale 1974, p. 206)

Thus *isolated existential statements are not falsifiable, but isolated existential statements are not metaphysical, and it is an abuse of language to classify these statements as 'metaphysical'!*

An obvious reply to this objection would be to note that the classification is between empirical and non-empirical–metaphysical statements, analytic state-

ments and some synthetic statements are categorised as 'not empirical' or 'non-empirical', not as 'metaphysical'⁵.

But suppose there is a stronger objection from ill-fit. How can we try to formulate it? Perhaps, as Kneale believes:

Suppose that on some occasion when I have been rashly dogmatic about the behaviour of fish out of water a biologist reminds me, in an unrestricted existential statement, that there are after all lungfish which can breathe on dry land (Kneale 1974, p. 207) (207).

This objection is not quite right either: here we have a case of equivocation, since what really happens here is that it is an elliptical statement taking the place of a statement about lungfish that have been observed. Similarly, when one accepts an unrestricted (or isolated) existential statement of the form 'There exists an *X* that is *Y*', it is taken as an elliptical expression for 'There exists an *X* that is *Y* at spatio-temporal region *Z*', or some other statement that satisfies Popper's second criterion for the empirical status of individual sentences.

A third attempt from Kneale is as follows:

Furthermore, there is a strange departure from the ordinary use of words in maintain that hypotheses of natural law are empirical, because they are open to refutation by experience, while denying that unrestricted existential propositions can ever deserve the same title. (Kneale 1974, p. 207)

In sum, isolated or unrestricted existential statements are not falsifiable; however, they are obviously empirical, therefore falsifiability is too strong!

Here we have an objection from ill-fit that has some weight to it. As Popper recognises,

⁵Miller (1994, p. 83) provides an elementary example:

... [the] hypothesis that physical objects go out of existence when no observer (person, animal, or instrument) is observing them. Skillfully formulated, this hypothesis simply cannot be tested.... So it may not, Popper says, be introduced into empirical science.

Purely existential statements are not falsifiable—as in Rudolf Carnap’s famous example “There is a colour (‘Trumpet-red’) which incites terror in those who look at it.’ Another example is: ‘There is a ceremony whose exact performance forces the devil to appear.’ (Popper 1983, pp. xx–xxi)

However, the response is quite simple: first, falsifiability applies to theoretical systems, not individual statements. Are isolated or unrestricted existential statements empirical if they are conjoined with a theoretical system, that is, do they entail at least one basic statement? No, because isolated existential statements do not specify any spatio-temporal region.

Strictly existential statements are not a large conjunction of theories, auxiliary hypotheses, background statements, and theory-laden observation reports; in fact, strictly existential statements are typified as being divorced from such a conjunction (although they are, like analytic sentences, derivable from it).

By the lights set out in these two demarcation criteria, isolated existential statements are not empirically significant.

A pedant may say, in response to the concern that a strictly existential statement is not falsifiable by noting that neither are isolated universal statements, or for that matter any statement that is isolated from a theoretical system, even if, on its own, it specifies the existence or nonexistence of certain entities or events at specific spatio-temporal locations.

But if one wishes to provide a more elaborate (and perhaps satisfactory) reply, one can note that strictly existential statements are, furthermore, not empirically predictive as well, and therefore, if we accept these two demarcation criteria, we would naturally refuse to accept these statements (along with analytic statements) as being empirically predictive; they are, like analytic statements, hangers-on that ride on the coattails of the empirical system.

But what if one wished for more, that is, an explanation for why we ought to consider strictly existential statements as non-empirical? Popper provided such an explanation several times, and it does not need to be elaborated on at any length, for as far as I can determine by examining the literature, there has been as of now no available reply to Popper’s retort:

I hope this example will also provide a reply to the often repeated criticism that it is perverse to exclude purely existential statements from empirical science... My example consists of the following purely existential theory: “There exists a finite sequence of Latin elegiac couplets such that, if it is pronounced in an appropriate manner at a certain time and place, this is immediately followed by the appearance of the Devil—that is to say, of a man-like creature with two small horns and one cloven hoof.” Clearly, this untestable theory is, in principle, verifiable. Though according to my criterion of demarcation it is excluded as non-empirical ... It would of course be easy enough for me to amend my criterion of demarcation so as to include such purely existential statements among the empirical statements. ... But I believe that it is better not to amend my original falsifiability criterion. For our example shows that, if we do not wish to accept my existential statement about the spell that summons the devil, we must deny its empirical character (Popper 1962, pp. 249–50).

4.7 Probability statements

‘...probability would deal a fatal blow to falsifiability.’ (Hacohen 2002, p. 253)

5 Where did these origins from ill-fit come from?

An inquisitive philosopher may ask: *if so many philosophers of science have been misreading Popper for so long, how did these three myths become so widespread and entrenched within the discipline?*

The almost exclusive conflation between theories and theoretical systems, with clarification that one deals with theoretical systems, in Popper’s work, relegated to the Postscript, a few small mentions in key parts, etc. This is a genuine case of a philosopher that requires a massive amount of reading to grasp, and the ‘orthodox’ position presented in the literature isn’t reflected in the more technical writing.

There are a number of potential explanations. Popper, as well as his student

W.W. Bartley, seemed to believe there was a grand conspiracy against him and his work (see: Bartley 1990). Perhaps he was too curmudgeonly, rude, or went against the philosophic grain. This explanation, though parsimonious, relies on making a form of inference Popper himself excluded (Popper 2013, p. 306): positing a grand conspiracy.

Here is, I believe, a far more reasonable explanation that is also parsimonious: philosophers don't usually take the time to read through the entire works of other philosophers. That takes time. If the philosopher is generally considered to be old hat or outdated then why bother? This, of course, only describes the general attitude of philosophers towards another philosopher seen today; it doesn't describe *how* this attitude developed. If this dismissive attitude is not due to a conspiracy, then, where could it come from?

The objections from ill-fit looks *prima facie* promising upon a surface reading of Popper's 1959 book, *The Logic of Scientific Discovery* and his 1962 collection, *Conjectures and Refutations*, as well as a surface reading of a number of his other books. Thus there is something wrong in these books: Popper's books practically invite the reader to engage in a rudimentary mistake in exegesis due to failures in signposting and the use of rarely unexplained or confusing technical terminology.

The reason for these mistakes is that *Karl Popper was not a clear writer*. That is not a particularly damning conclusion. It is difficult to be a clear writer. Many philosophers are not clear in their writing. However, in this instance, lack of clarity and precision has lead to perpetuation of these myths: there exist numerous cases of Popper failing to signpost both that when he refers to 'scientific theories' he meant 'empirical-scientific theoretical systems' until much later, where he will explicitly as such.

5.1 The origins of the first myth

Popper's failings provide a helpful guide for present-day philosophers: be clear upfront about terminology, signpost important but subtle points, and be clear when one shifts from one problem to the other.

An attentive philosopher may interject at this point: *What is meant by the 'empirical sciences', then? Surely Popper is speaking about the limits of the sciences, not the*

limits of empirical inquiry!

There must be some *explanation* for why so many philosophers have routinely erred in basic exegesis. Here is one major problem with Popper's translation of *Logik der Forschung*, as well as his choice of language and belated attempts at clarification in his later works, that has led to the perpetuation of the myth that falsifiability is a criterion that sets out the boundaries of the natural sciences from non-science (or pseudo-science).

Popper explicitly defines 'empirical science' ('*empirischen Wissenschaft*' in the 1934/5 German edition) as follows: 'The system called "empirical science"... must satisfy the criterion of demarcation, ... i.e. it must not be metaphysical, but must represent a world of possible experience' (Popper 1959, pp. 16–17; see also Popper 1934/5, pp. 11–12). Popper's use in *Logik* of the phrase '*empirischen Wissenschaft*' tracks the German use of this technical term. For one example of its technical use, I quote from Weibl and Herdina's English-German technical philosophical dictionary:

'empirical science' is defined as '*empirische Wissenschaft* ... empirical knowledge, knowledge by experience, empirical generalisation' (Weibl and Herdina 1997, p. 120).

In contrast to his technical term 'empirical science' when referring to 'empirical knowledge', Popper uses the technical term, 'natural science' ('*naturwissenschaft*'), when referring to the sciences (Popper 1959, pp. 18, 48, 58). Thus 'empirical science' extends to cover knowledge possibly gained from experience *in toto*, not limited to knowledge gained from the natural sciences.

In short, Popper, like A.J. Ayer and Rudolf Carnap (Ayer 1936, pp. 97–99, Carnap 1956), attempted to introduce a new set of categories in philosophical taxonomy to join the likes of the analytic/synthetic, a priori/a posteriori and necessary/contingent distinctions.

How did such a failure to signpost a key technical term enter the English translation of *Logik* and subsequent English books by Popper? The translators of the English translation of *Logik*—Popper, Julius and Ian Freed—set out to be faithful to the text. From the introduction to the 1959 translation, we have the following:

‘The original text of 1934 has been left unchanged for the purpose of the translation’ (Popper 1959, p. xiv).

This aim in translation is impossible: a change to a text is necessary in translation. Examining the original edition and translation side-by-side, there is a strict adherence to sentence-by-sentence translation in the first chapter. What has not changed, however, is the order of sentences. Furthermore, whenever possible a ‘literal’ one-to-one English equivalent of a German term is given.

This choice in translation sets the reader of the English translation up for exegetical confusion in the very passage in which Popper first set out the demarcation criterion. The German edition says the following:

Ein empirisch-wissenschaftliches System muß an der Erahrung scheitern können (Popper 1934/5, p. 13).

Popper translates ‘empirisch-wissenschaftliches System’ as ‘an empirical scientific system’ (Popper 1959, p. 18), in accordance to its technical meaning in German. However, this can be understood to the English eye as either ‘an *empirical*-“scientific” system’, i.e. as a system of empirical knowledge, *à la* a form of *Wissenschaft*, or ‘an empirical *scientific*-system’, i.e. as the system of theories limited to the natural sciences.

Popper’s use tracks the use of their corresponding German technical terms, in which the closest analogue in English to the word *Wissenschaft* is the catchall term ‘science’. The only differentiation made by Popper to each term is the choice to translate these key terms by amending ‘empirical’ (*empirischen*) or ‘natural’ (*natur*) to ‘science’ (*Wissenschaft*); their technical meaning is—naturally—not signposted by Popper, for the ‘original text ... has been left unchanged’. This adherence to this rule of translation is to the English version’s detriment, up to and including the choice of the title of the English translation, which were it to adhere more closely to the original German implication, would be more suitably titled, ‘The Logic of [Empirical] Investigation [or Inquiry]’.

This very failure in understanding on Popper’s part is exemplified in an end-note in *The Myth of the Framework*: ‘Since in English “science” means “empirical science”, and since the matter is sufficiently fully discussed in my book...’ (Popper 1997, 29, en. 41).

These problems are nonexistent in the German edition (Popper 1934/5). In fact, after an exhaustive search of the available philosophic literature, I could only place variations of this formulation of the objection from ill-fit after 1959, and could find no instances of this objection from ill-fit in any German texts from 1934/5 to 1959. If this explanation accounts for the available evidence, then so much for Popper's acumen at translation: he picked the closest English term available to the German term '*Wissenschaft*', then failed to revise the translation to reflect the implicature of the term 'science' in English.

Note also that Popper introduces a definition of this technical term several pages after he sets out his formulation of the demarcation problem. This failure to signpost this technical term has directly helped this myth spread. Due to this choice in translation and how early the criterion is set out in *Logic*, this is one likely source of this confusion over Popper's demarcation criterion. Rather than define his technical term on the first page in an added footnote or aside, the definiens is introduced after Popper had used the term eighteen times (Popper 1959, pp. 3–4, 9, 11–12, 14–16).

Furthermore, this problem is compounded: in these sixteen pages before the definiens, Popper frequently uses the terms 'empirical scientific', 'scientific' and 'natural sciences' in ways that repeatedly invite equivocation if the reader is not aware that they are each themselves technical terms in German philosophical discourse, and reflected as such in the original German edition.

This exact same problem of using technical language involving the distinctions between 'empirical science' and 'natural science' without immediate clarification occur in Popper's *Die beiden Grundproblememe der Erkenntnistheorie*⁶, *Conjectures and Refutations* (Popper 1962, pp. 249–50), *Replies to My Critics* (Popper 1974), *Realism and the Aim of Science* (Popper 1983) and *The Myth of the Framework* (Popper 1997, p. 29).

In fact, after an extensive survey of Popper's oeuvre, any attempt to clarify what is to be demarcated leads to difficulty, since Popper will frequently refer to

⁶In set in draft form sometime between 1930 and 1933, published in German in 1979 and translated into English as *The Two Fundamental Problems of the Theory of Knowledge*, with the problem of demarcation clarified only slightly in the second half of the book (Popper 2009, pp. 383–85).

the empirical sciences, that is, *empirische Wissenschaft*, as 'science' (cf. Popper 1974, p. 981). At other points Popper does not clarify what 'pseudo-scientific' means in particular contexts, that is, whether theories that are classified as 'pseudo-scientific' are theories that pretend as if they are 'empirically scientific'. This failure to clarify these key terms is exemplified in, for example, *Realism and the Aim of Science*: '... how can you distinguish the theories of the empirical sciences from pseudo-scientific or non-scientific or metaphysical speculations?' (Popper 1983, p. 159).

Given that Popper repeatedly clarified that only theoretical systems could be falsified, and only by 'lower level' theoretical systems, the prevalence of the mistaken formulation as falsifiability applying to a singular theory is concerning. How could this happen?

One likely answer to this misunderstanding is as follows: Popper first introduced his falsifiability criterion in German, and with a high degree of clarity; he turned his attention elsewhere in his later writings, specifically to the *normative* problem of demarcation, and rarely differentiated between the two problems; consequently, his later popular writing in English reflecting on his past positions are at times incredibly opaque. It is only clear from context whether he is referring to whether certain *decisions or actions of an epistemic community* are 'pseudo-scientific' (i.e., dispreferable) or 'scientific' (i.e. preferable) (i.e. the normative problem of demarcation) or whether certain *systems of statements* should be categorised as empirically significant or not.

This opaqueness is most noticeable in his collected volume of collected essays, *Conjectures and Refutations* (1963). Consider the following passage:

... statements or systems of statements, in order to be ranked as scientific, must be capable of conflicting with possible, or conceivable observations' (Popper 1962, p. 39).

Were a philosopher to read *Conjectures and Refutations* without checking *The Logic of Scientific Discovery*, they would conclude two things: Popper's falsifiability criterion applied to both singular theories and theoretical systems, and Popper's criterion demarcates science from non-science or pseudo-science. And yet, in his earlier writings, Popper explicitly repudiated that falsifiability was concerned with demarcating science from non-science or pseudo-science and that singular

sentences were falsifiable. In this public lecture, Popper's exegesis is almost as deficient as the exegesis of his critics.

5.2 The origins of the second myth

Popper keeps using the same sort of language all the time. For any one example of Popper being clear about what is to be demarcated (i.e. theoretical systems) he is not clear when he says 'theory or theories' or simply truncates this to 'theory'.

5.3 The origins of the third myth

The neglect of the second demarcation criterion, sadly, is due to another failure on Popper's part: his choice to give the two demarcation criteria similar-sounding names.

And no other philosopher mentioning this (with the exception of, for example, Sebastian Lutz, in an offhanded comment).

6 Conclusion

In summary, the objections from ill-fit confuse the problem as normative when it is territorial; as concerned with a singular theory and not empirical theoretical systems; and as setting out the differences between science and non-science when it is about setting out the absolute limits to empirical inquiry. Dismissing Popper's territorial problem based on the objections from ill-fit and characterising Popper's stated territorial problem and criterion as such are both predicated on mistakes in exegesis. These confusions are most likely due to Popper's refusal to immediately explain how he used the technical term 'empirical science' in the 1959 English translation of *Logik der Forschung*, and exacerbated by Popper's most popular writings providing a simplistic, obfuscatory gloss of his more technical work.

Should any philosophic moral be drawn from this extended exegetical examination? There are at least two:

First, philosophers of science and historians of philosophy of science should stop perpetuating these previously presented objections as if they target Popper's territorial demarcation criteria. To perpetuate these myths as if they accurately reflected the position of one of the most widely known twentieth-century philosophers of science, as well as claiming the objections from ill-fit put to rest the position, is to engage in bad history of twentieth-century philosophy.

Second, and more generally, philosophers of science and philosophy students should be extremely careful when accepting that purportedly definitive objections to a philosophical programme are accurate. If an objection against a target can be raised with a moment's thought, more reflection is due on whether the crosshairs are properly aligned. This may be doubly concerning in regards to history of twentieth-century philosophy of science, however: if Popper, one of the most popular philosophers of science, was so easily misunderstood, it is worth examining whether other twentieth-century philosophers of science were also routinely misread.

Lastly, there may be other reasons to reject Popper's territorial demarcation criteria or, for that matter, the demarcationist programme in general; however, these objections are not worth teaching to philosophy students, nor are they worth taking seriously by philosophers: objections from ill-fit are much ado about nothing, potshots aimed at an intellectual ghost.

References

- Ayer, A.J. (1936). *Language, Truth and Logic*. 1st ed. London: Victor Gollanz.
- (1946). *Language, Truth and Logic*. 2nd ed. London: Victor Gollanz.
- Bartley, W.W. (1990). *Unmeasured Knowledge, Unmeasured Wealth: On Universities and the Wealth of Nations*. La Salle: Open Court Press.
- Boudry, M. (2013). "Loki's Wager and Laudan's Error". In: *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*. Ed. by M. Boudry and M. Pigliucci. Chicago: Chicago University Press.
- Boudry, M. and M. Pigliucci, eds. (2013). *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*. Chicago: Chicago University Press.

- Carnap, R. (1956). "The Methodological Character of Theoretical Concepts". In: *The Foundations of Science and the Concepts of Psychology and Psychoanalysis*. Ed. by Feigl and Scriven. Minneapolis: University of Minneapolis Press.
- Curd, Martin, J.A. Cover, and Christopher Pincock (2013). *Philosophy of Science: The Central Issues*. Ed. by Martin Curd, J.A. Cover, and Christopher Pincock. 2nd. W.W. Norton & Company.
- Feyerabend, Paul (1975). *Against Method: Outline of an anarchistic theory of knowledge*. London: Atlantic Highlands: HUMANITIES PRESS.
- Gillies, Donald (1993). *Philosophy of Science in the Twentieth Century: Four Central Themes*. Oxford: Oxford University Press.
- Hacohen, Malachi Haim (2002). *Karl Popper - The Formative Years, 1902-1945: Politics and Philosophy in Interwar Vienna*. Cambridge: Cambridge University Press.
- Hempel, C. (1950). "Problems and Changes in the Empiricist Criterion of Meaning". In: *Revue Internationale de Philosophie* 41.11.
- (1951). "The Concept of Cognitive Significance: A Reconsideration". In: *Proceedings of the American Academy of Arts and Sciences* 80.1.
- Howson, Colin and Peter Urbach (2006). *Scientific Reasoning: The Bayesian Approach*. 3rd ed. La Salle: Open Court Press.
- Hübner, Kurt (1978). "Some Critical Comments on Current Popperianism on the Basis of a Theory of System Sets". In: *Progress and Rationality in Science*. Ed. by Radnitzky and Andersson. Dordrecht: Reidel.
- Keuth, Herbert (2005). *The Philosophy of Karl Popper*. Cambridge: Cambridge University Press.
- Kitcher, P. (1982). *Abusing Science: The Case Against Creationism*. Cambridge: MIT Press.
- Kneale, William C. (1974). "The Demarcation of Science". In: *The Philosophy of Karl Popper*. Ed. by Paul Arthur Schilpp. The Library of Living Philosophers. La Salle: Open Court Press, pp. 205–17.
- Lakatos, I. (1981). *The Methodology of Scientific Research Programmes*. Ed. by J. Worroll and Gregory Currie. Vol. 1. Cambridge: Cambridge University Press.
- Laudan, L. (1983). "The Demise of the Demarcation Problem". In: *Physics, Philosophy and Psychoanalysis*. Dordrecht: Reidel.

- Mahner, M. (2013). "How to Demarcate after the (Alleged) Demise of the Demarcation Problem". In: *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*. Ed. by M. Boudry and M. Pigliucci. Chicago: Chicago University Press.
- Miller, David (1994). *Critical Rationalism: A Restatement and Defence*. La Salle: Open Court Press.
- (2006). *Out of Error: Further Essays on Critical Rationalism*. Burlington, VA: Ashgate.
- (n.a.) (n.d.). *Falsifiability*. In *Wikipedia*. URL: <https://en.wikipedia.org/wiki/Falsifiability>.
- Newton-Smith, W.H. (1980). "Comments on Miller 1980". In: *Applications of Inductive Logic*. Ed. by L. Jonathan Cohen and Mary Hesse. Oxford: Clarendon.
- Nickles, T. (2013). "The Problem of Demarcation: History and Future". In: *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*. Ed. by M. Boudry and M. Pigliucci. Chicago: Chicago University Press.
- Pigliucci, M. (2013). "The Demarcation Problem. A (Belated) Response to Laudan". In: *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*. Ed. by M. Boudry and M. Pigliucci. Chicago: Chicago University Press.
- Popper, K.R. (1934/5). *Logik der Forschung: Zur Erkenntnistheorie der modernen Naturwissenschaft*. Vol. 9. Schriften zur wissenschaftlichen Weltauffassung. Vienna: Verlag von Julius Springer.
- (1959). *The Logic of Scientific Discovery*. Trans. by K. Popper, Julius Freed, and Ian Freed. References are to (Popper 2000). London: Hutchinson & Co.
- (1962). *Conjectures and Refutations: The Growth of Scientific Knowledge*. New York: Basic Books.
- (1963). "The demarcation between science and metaphysics". In: *The Philosophy of Rudolf Carnap*. Ed. by P.A. Schilpp. Vol. XI. Library of Living Philosophers. La Salle: Open Court Press.
- (1974). "Replies to My Critics". In: *The Philosophy of Karl Popper*. Ed. by Paul Arthur Schilpp. Vol. xiv. The Library of Living Philosophers. La Salle: Open Court Press.
- (1983). *Postscript to the Logic of Scientific Discovery: Realism and the Aim of Science*. Ed. by W.W. Bartley. Vol. iii. Originally circulated as private galley proofs in 1956/1957. London: Routledge.

- Popper, K.R. (1997). *The Myth of the Framework*. Ed. by M.A. Notturmo. London: Routledge.
- (2009). *The Two Fundamental Problems of the Theory of Knowledge*. Ed. by Troels Eggers Hansen. London: Routledge.
- (2013). *The Open Society and Its Enemies: New One-Volume Edition*. Originally published in two volumes in 1945 by Princeton University Press. Princeton, NJ: Princeton University Press.
- Preston, J. (1994). “Methodology, Epistemology and Conventions: Popper’s Bad Start”. In: *PSA 1994.1*.
- Putnam, H. (1974). “The Corroboration of Theories”. In: *The Philosophy of Karl Popper*. Ed. by Paul Arthur Schilpp. Vol. xiv. The Library of Living Philosophers. La Salle: Open Court Press.
- Shea, Brandon (2018). *Karl Popper: Philosophy of Science*. URL: <http://www.iep.utm.edu/pop-sci/#H2>.
- Thornton, S. (2016). *Karl Popper*. Ed. by Edward N. Zalta. URL: <https://plato.stanford.edu/archives/win2016/entries/popper/>.
- Weibl, E. and P. Herdina, eds. (1997). *German Dictionary of Philosophical Terms*. Vol. 2: English-German. London: Routledge.