How to Overcome Antirealists' Objections to Scientific Realism

Abstract
Van Fraassen contends that there is no argument that rationally compels us to disbelieve a successful theory, T. I object that this contention places upon him the burden of showing that scientific antirealists' favorite arguments, such as the pessimistic induction, do not rationally compel us to disbelieve T. Van Fraassen uses the English view of rationality to rationally disbelieve T. I argue that realists can use it to rationally believe T, despite scientific antirealists' favorite arguments against T.

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1. Introduction

Scientific realism affirms, whereas scientific antirealism denies, that a successful theory, T, is (approximately) true. Hilary Putnam (1975) and Bas van Fraassen's (2007, 2017) positions fit these definitions of scientific realism and antirealism, respectively. This paper concerns the question: Can we *rationally* believe T? One might suspect that scientific realists would answer "Yes," whereas scientific antirealists would answer "No." Van Fraassen's (2007, 2017) answer, however, is not as simple as it initially appears. He disbelieves T, but claims that we can rationally believe T. How can he disbelieve T, and yet contend that we can rationally believe T? The answer lies in his appeal to the English view of rationality (EVR).

This paper aims to show that scientific realists can also invoke the EVR to overcome scientific antirealists' objections to scientific realism, such as the pessimistic induction. In Section 2, I unpack the EVR, contrasting it with the Prussian view of rationality (PVR). In Section 3, I expound how van Fraassen (2017) utilizes the EVR to respond to David Papineau (2007) and Alan Musgrave (2017). In addition, I argue that van Fraassen's response to these scientific realists carries with it the burden of showing that scientific antirealists' favorite arguments do not rationally compel us to disbelieve T. In Section 4, I argue that scientific realists can use the EVR to get around the pessimistic induction and the problem of unconceived alternatives (Stanford, 2006). In Section 5, I reply to an objection and answer two questions from two reviewers of this journal.

This paper has a message to scientific antirealists who aim to strengthen scientific antirealism and weaken scientific realism: their insightful and sophisticated ideas might ironically be utilized by realists to strengthen scientific realism and to weaken scientific antirealism.

2. The Prussian and English Views of Rationality

In this section, I expound two views of rationality, the PVR and the EVR, beginning with the PVR because it is more straightforward.

The PVR holds that "what is rational to believe is exactly what one is rationally compelled to believe" (van Fraassen, 1989: 171). On this account, it is rational to believe T, only when we have an argument that rationally compels us to believe T. Without such an

argument, it would be irrational for us to believe T. What if we have an argument that rationally compels us to disbelieve T? In such a case, it would be rational to disbelieve T, and irrational to believe T.

By contrast, the EVR holds that "what it is rational to believe includes anything that one is not rationally compelled to disbelieve" (van Fraassen, 1989: 171–172). The converse aspect of the EVR is that what it is rational to disbelieve includes anything that one is not rationally compelled to believe. On this account, in the absence of an argument that rationally compels us to believe T, we can rationally disbelieve T, and in the absence of an argument that rationally compels us to disbelieve T, we can rationally believe T. In sum, without any argument that rationally compels us to either believe or disbelieve T, we can choose between belief and disbelief, and whichever we may choose, our stance is reasonable.

Under the EVR, we can rationally believe T in the following two cases: First, we have an argument that rationally compels us to believe T. In such a case, we are rationally compelled to believe T, both under the EVR and the PVR. Second, we have no argument that rationally compels us to believe or disbelieve T. In such a case, the EVR allows us to rationally believe T.

Under the EVR, we can rationally disbelieve T in the following two cases. First, we have an argument that rationally compels us to disbelieve T. In such a case, we are rationally compelled to disbelieve T, both under the EVR and the PVR. Second, there is no argument that rationally compels us to believe or disbelieve T. In such a case, the EVR allows us to rationally disbelieve T.

3. Problems with Van Fraassen's Use

Van Fraassen adopts the EVR over the PVR. In this section, I explicate how he uses the EVR to develop his position and to cope with criticisms. I also argue that his position places upon him the burden of undermining the arguments that antirealists have constructed over the past several decades to refute realism.

Is the belief of T reasonable? Van Fraassen thinks that *there is no argument that rationally compels us to disbelieve T.* Thus, under the EVR, we can rationally believe T. Is the disbelief of T reasonable? He thinks that abduction is a problematic rule of inference, so we do not have an argument that rationally compels us to believe T. Thus, under the EVR, we can rationally disbelieve T. The two considerations—the EVR and the absence of any rationally compelling argument for either the belief or disbelief of T—allow us to choose between believing or disbelieving T. Either choice is reasonable.

Van Fraassen says that the belief of T is "supererogatory" (2007: 343, 2017: 99). What does it mean to say so? Let me use an analogy to answer this question. It is supererogatory for you to donate your entire salary to charity. It is moral for you to do so, but you do not need to do it. Even if you do not do it, no one can accuse you of being immoral. In short, it is beyond the call of morality for you to do it, i.e., morality does not require that you donate your entire salary to charity. Similarly, to say that it is supererogatory for you to believe T means that it is reasonable for you to believe T, but you do not need to do it. Even if we do not do it, no one can accuse us of being unreasonable. In short, it is beyond the call of rationality for you to do it, i.e., rationality does not require that you believe T.

Now that we are clear about van Fraassen's position, we are ready to explore how he confronts criticisms from realists, such as Papineau and Musgrave. Papineau states, "According to van Fraassen's 'constructive empiricism' … we ought never to believe in the truth of any theory which goes beyond the observable phenomena" (1996: 8). Van Fraassen retorts repeatedly that "I do not advocate agnosticism about the unobservable, but claim that belief is supererogatory as far as science is concerned; you may if you like, but there is no

need" (2007: 343, 2017: 99). Musgrave states that "*it is reasonable to believe that* H is true" (2017: 80). Van Fraassen replies that "such a belief is reasonable enough, but supererogatory" (2017: 102). We should keep two things in mind about van Fraassen's position here. He disbelieves T on the grounds that his belief of T would be supererogatory. Thus, his position fits the definition of antirealism mentioned in Section 1. He contends, however, that we can reasonably choose either to believe or disbelieve T.

Van Fraassen's position would surprise both realists and antirealists. It would be surprising to realists that van Fraassen shares their view that we can rationally believe T. It would be surprising to antirealists that he disagrees with them over whether we have an argument that rationally compels us to disbelieve T. Over the past several decades, antirealists have raised forceful objections to realism, such as the pessimistic induction, non-realist accounts of the success of science, and the problem of underdetermination. They constructed these objections to show that we are rationally compelled to disbelieve T. Van Fraassen's position, however, implies that these objections do not rationally compel us to disbelieve T. So he has put himself in the ironic situation of having to attack these objections to show that they do not rationally compel us to disbelieve T. This ironic situation has been neglected in the literature, so it is worth exhibiting it in detail.

The problem of underdetermination holds that T competes with rival theories, i.e., they make identical assertions about observables but different assertions about unobservables, so observation cannot tell us which is true and which others are false. Van Fraassen claims that we do not have an argument that rationally compels us to disbelieve T, which implies that even if T competes with empirically equivalent rivals, we are not rationally compelled to disbelieve T. Under these conditions, the EVR asserts that we can rationally believe T. Thus, it would be a mistake to attribute to him the reasoning that since T competes with empirically equivalent rivals, we cannot rationally believe T, and that we can only rationally believe that T is empirically adequate. Antirealists would wonder whether he is on their side or on the realists' side.

Antirealists have advanced many non-realist accounts of the success of science[1] in order to undercut Hilary Putnam's proposal that science is successful because "the theories accepted in a mature science are typically approximately true" (Putnam, 1975: 73). For example, Timothy Lyons (2003: 900, 2018: 147) proposes that T is successful because observational events occur as if T were true. Such non-realist explanations undermine the contention that realism best accounts for the success of science. Van Fraassen, however, claims that there is no argument that rationally compels us to disbelieve T, which implies that the non-realist explanations of the success of science do not rationally compel us to disbelieve T. Hence, under the EVR, the non-realist explanations are not obstacles to rationally believing T. Again, antirealists would wonder whether van Fraassen is on their side or on the realists' side.

Relatedly, van Fraassen (1980: 40) advances the selectionist account of the success of science to undercut Putnam's realist account of the success of science. The selectionist explanation attributes the success of science to the fact that successful theories defeat unsuccessful ones in the struggle for existence. What are we to make of this explanation? Even if it is a strong competitor to the realist explanation, it does not count as a rationally compelling argument for the disbelief of T. Hence, under the EVR, it is not an obstacle to rationally believing T. One may wonder what van Fraassen has achieved by advancing his selectionist account of the success of science.

[1] See Park (2014) for the discussion of the non-realist explanations.

Let me turn to the pessimistic induction (PI). It holds that "we are in the midst of an ongoing historical process in which our theoretical conceptions of nature will continue to change just as profoundly and fundamentally as they have in the past" (Stanford, 2015: 875). To take an example: we believed that heat was caloric fluid. We now believe that it is the mean kinetic energy of molecules. Our theoretical conception of heat has undergone a profound and fundamental change. The PI implies that it will repeatedly undergo profound and fundamental changes. Similar stories can be given of other theories in science. The PI is endorsed by many scientists and philosophers, such as Henri Poincaré (1905/1952: 160) and Thomas Nickles (2017: 153). It is the most powerful argument against realism according to many participants in the realism debate, including John Worrall (1989: 101) and Howard Sankey (2017: 201).

If the PI is cogent, we are rationally compelled to disbelieve T. After all, if T is fated to be thrown out, we are rationally compelled to disbelieve it. Surprisingly, however, van Fraassen claims that there is no argument that rationally compels us to disbelieve T, which implies that the PI does not rationally compel us to disbelieve T. It follows that the PI is not an obstacle to realists' rationally believing T.

How could van Fraassen show that the PI does not rationally compel us to disbelieve T? He could appeal to objections that realists have already raised in the literature.[2] For example, he could appeal to the realist objection that the PI "commits the fallacy of biased statistics" (Park, 2018a: 11). He could then argue that since the PI is a fallacious argument, it does not rationally compel us to disbelieve T. Note that he has put himself into the ironic situation where he has to ally with realists in the fight against the PI. Perhaps this is the reason why he has been silent about the PI for the past several decades, even though it is generally regarded as the strongest objection to realism.

Van Fraassen faces a dilemma with respect to the PI. He can say either that the PI rationally compels us to disbelieve T, or that it does not. If he says that it does, he cannot say to Papineau and Musgrave that he agrees that we can rationally believe T. On the other hand, if he says that it does not, he can say to Papineau and Musgrave that he agrees that we can rationally believe T. He would then, however, find himself in the ironic situation where he should ally with realists to undermine the PI. It is not clear how he would get around this dilemma.

Similar dilemmas can be constructed against van Fraassen with respect to the problem of underdetermination and the non-realist explanations of the success of science. I, however, do not spell them out because they can be extrapolated from the one sketched above with respect to the PI.

Van Fraassen might reply that even if the PI is cogent, we can nevertheless rationally believe T. In general, a cogent argument against T does not amount to an argument that rationally compels us to disbelieve T, and a cogent argument for T does not amount to an argument that rationally compels us to believe T. A cogent argument is not rationally compelling any more than abduction is rationally compelling. Since a cogent argument is not rationally compelling, the EVR implies that the PI against T, even if cogent, does not rationally compel us to disbelieve T, and that we can rationally believe T. So might van Fraassen argue.

It is not clear, however, that van Fraassen would go this far. Recall that he thinks that there is no argument that rationally compels us to believe T because he rejects abduction. The other side of the coin is that if he thought that abduction was a reliable rule of inference, he

[2] See Park (2018: 11) for an overview of the realist objections to the pessimistic induction.

would think that we have an argument that rationally compels us to believe. Given that abduction can, at best, be cogent, he would take a cogent argument to be rationally compelling.

Moreover, the following three problems would arise if van Fraassen were to take the position that a cogent argument does not amount to a rationally compelling argument. First, he would have to justify his position rather than merely stating it, and it is not clear what argument he could use to justify it. His critics would be interested in whether his argument is rationally compelling or not. Second, the PI is regarded as the strongest objection to realism. If such a cogent argument does not equal a rationally compelling argument for the disbelief of T, it is not clear whether there is any argument that would rationally compel us to disbelieve T. Thus, the prospect is dim that antirealists could ever come up with an argument that would bar realists from rationally believing T. Third, van Fraassen would have to provide at least one example of an argument that would rationally compel us to disbelieve T. Otherwise, it is empty of content to say that the PI does not rationally compel us to disbelieve T.

In this section, I argued that van Fraassen's position puts the burden on him of showing that antirealists' objections to realism do not rationally compel us to disbelieve T. In the next section, I argue that realists can use the EVR to get around the two famous antirealist objections to realism, the PI and the PUA.

4. Realists' Uses

4.1. The Pessimistic Induction

One strategy to refute the PI is to say that current theories have higher predictive, explanatory, and manipulative powers than earlier ones (Musgrave, 1985; Mizrahi, 2013a). This difference between earlier and current theories motivates a view that I call *empirical progressivism*, which holds that new theories have greater predictive, explanatory, and manipulative powers than old theories. Empirical progressivism nullifies the PI. Since new theories are empirically better than old theories, we cannot infer the demise of the former from that of the latter. Consequently, we do not know whether current theories will undergo scientific revolutions.

Empirical progressivism has elicited an apt antirealist response from Florian Müller, who states that it "is not at all obvious why science, or at least our current best theories, should have achieved a degree of success that warrants their truth" (Müller, 2015: 406). In other words, empirical progressivism does not show that present theories are plausible. It only shows that they are more plausible than their precursors. There is a huge difference between being plausible and being more plausible, as K. Brad Wray (2008: 323) and Moti Mizrahi (2013b: 401) note. The idea is that although T_1 is more plausible than T_2, both might be far from being plausible. Thus, realists have the burden of showing that present theories are successful enough to conclude that they are true. Müller's challenge is quite a daunting one, and no realist has yet responded to it.

In this context, the EVR can help realists. Empirical progressivism nullifies the PI, as noted above. Since the PI is fallacious, it is not an argument that rationally compels us to disbelieve current theories. Moreover, Müller has no argument that rationally compels us to disbelieve that present theories are successful enough to conclude that they are true. Rather, he merely challenges realists to prove that present theories are sufficiently successful. Under these circumstances, the EVR asserts that we can rationally believe that present theories are sufficiently successful, and hence that they are true. To block realists from rationally believing that current theories are sufficiently successful, Müller should present an argument that rationally compels them to disbelieve that current theories are sufficiently successful.

Thanks to the EVR, realists do not need to prove that current theories are sufficiently successful. Realists can rationally believe that current theories are sufficiently successful without bearing the burden of proving it, as long as there is no argument that rationally compels them to disbelieve that they are sufficiently successful. Thus, antirealists should rather shoulder the burden of proving that realists are rationally compelled to disbelieve that current theories are sufficiently successful. In sum, realists can use the EVR to shift the burden of proof from them to their opponents.

4.2. The Problem of Unconceived Alternatives

The PUA holds that "the history of scientific inquiry itself offers a straightforward rationale for thinking that there typically are alternatives to our best theories equally well-confirmed by the evidence" (Stanford, 2006: 20). On this account, present theories are not just unwarranted, but false. In other words, the PUA asserts not just that we should be agnostic about current theories, but rather that they are false. In addition, P. Kyle Stanford (2006: 133) claims that there are an unlimited number of theories. Samuel Ruhmkorff (2011) replies that there are a limited number of theories. This section tackles the PUA under both conditions.

Suppose that there are a limited number of theories. Under this condition, realists can argue that scientists have removed enough false theories, and that they do not need to remove more false theories from the possibility space of theories, so present theories must be true. Pessimists would object that scientists have not yet removed enough false theories, so present theories must be false. On the pessimist account, scientists need to remove more false theories, including current theories, before arriving at true theories. Note that the realists' and pessimists' positions confront each other (Park, 2019: Section 3.1).

In this context, the EVR can help realists. According to the EVR, in the absence of an argument that rationally compels us to disbelieve T, we can rationally believe T. Pessimists do not have an argument that rationally compels realists to disbelieve that scientists have pulled out enough false theories from the space of alternatives. It follows that realists can rationally believe that scientists have pulled out enough false theories, and that current theories must be true. To block realists from rationally believing so, they should present an argument that rationally compels realists to disbelieve so. Thus, the EVR acts as a burden-shifter for realists.

Suppose that there are an unlimited number of theories. Under this condition, realists can argue that there are two possibility spaces: the possibility space of true theories, and the possibility space of false theories. Realists would admit that scientists pulled past theories from the space of false theories. They can, however, argue that scientists have pulled present theories from the possibility space of true theories, so present theories must be true. In the history of science, scientists have pulled theories from the space of successful theories after pulling theories from the space of unsuccessful theories.[3] So we cannot rule out the possibility that scientists have pulled present theories from the space of true theories, although they pulled past theories from the space of false theories. Pessimists would retort that scientists pulled present theories from the space of false theories, just as they pulled past theories from that space, so present theories must be false too. Note that realists' and pessimists' positions confront each other (Park, 2019: Section 3.2).

In this context, the EVR can help realists. Obviously, pessimists do not have an argument that rationally compels realists to disbelieve that scientists have pulled present theories from the space of true theories. It follows that realists can rationally believe that

[3] See Carl Hempel (1966: 3–6) for such an example.

scientists have pulled present theories from the space of true theories, and that present theories must be true. To block realists from rationally believing so, they should present an argument that rationally compels realists to disbelieve so. Again, the EVR acts as a burden-shifter for realists.

5. Objections and Replies

5.1. The EVR Proper and the Converse EVR

The EVR holds that "what it is rational to believe includes anything that one is not rationally compelled to disbelieve" (van Fraassen, 1989: 171–172). I claimed in Section 2 that the converse aspect of the EVR is that what it is rational to disbelieve includes anything that one is not rationally compelled to believe.

Opponents might raise the following objection. The converse EVR is not equivalent to the EVR proper. Neither, for that matter, does the former follow from the latter. It is not entirely clear whether this paper uses the former or the latter to support the thesis that the EVR can be used to defend scientific realism. If this paper uses not the EVR proper but its converse, then the paper fails to achieve the aim declared in the introduction that scientific realists can invoke the EVR to overcome scientific antirealists' objections.[4]

Admittedly, the EVR proper and its converse are not equivalent, given that the former is about what it is rational to believe while the latter is about what it is rational to disbelieve. Suppose that there are T_1, T_2, and T_3, and that we are rationally compelled to believe T_1, neither to believe nor to disbelieve T_2, and to disbelieve T_3. The EVR proper implies that we can rationally believe T_1 and T_2, but not T_3. By contrast, the converse EVR implies that we can rationally disbelieve T_2 and T_3, but not T_1. In short, the EVR proper and the converse EVR have different implications for T_1, T_2, and T_3.

Consider, however, that van Fraassen thinks that there is no argument that rationally compels us to believe T_1 and to disbelieve T_3. It follows that the EVR implies that we can rationally believe T_1, T_2, and T_3, and that the converse EVR also implies that we can rationally disbelieve T_1, T_2, and T_3. In sum, what it is rational to believe is coextensive with what it is rational to disbelieve. Let me add that van Fraassen relies not on the EVR proper but rather on the converse EVR to contend that it is rational to disbelieve T. This paper operates under his conception of the EVR.

5.2. Abduction and the EVR

This paper takes for granted van Fraassen's views about abduction and the EVR. But why should abduction be abandoned? Why is the EVR preferable to the PVR?[5]

Let me introduce what I take to be van Fraassen's most influential argument against abduction called *the argument from a bad lot*:

> So our selection may well be the best of a bad lot. … For me to take it that the best of set X will be more likely to be true than not, requires a prior belief that the truth is already more likely to be found in X, than not. (van Fraassen, 1989: 143)

To put differently, T might compete with theories that we have not yet conceived of. So even if it best explains phenomena, i.e., even if it is better than its conceived rivals, we cannot conclude that it is true. In order to conclude that it is true, we should first prove that it is

[4] I thank a reviewer for this sharp criticism.
[5] I thank another reviewer for these questions.

better than its unconceived competitors. This argument is further developed by James Ladyman et al. (1997: 309) and Wray (2008: 321) in the literature.

Let me turn to the second question above. Van Fraassen does not present any argument to show that the EVR is preferable to the PVR. Park (2017: 27) argues, however, that van Fraassen needs to show not only that the EVR is better than the PVR but also that the EVR is better than the theories of rationality that we have not yet conceived of. In other words, Park runs the argument from a bad lot against the EVR.

Suppose that van Fraassen has constructed an argument to show that the EVR is better than the PVR. What would we need to make of it? We would need to determine whether it rationally compels us to believe that the EVR is better than the PVR. If it did not have such a power, we would be able to rationally disbelieve that the EVR is better than the PVR.

Van Fraassen needs to show not only that the EVR is better than the PVR but also that the EVR is the correct view of rationality. After all, it is one thing to say that the EVR is better than the PVR; it is another to say that EVR is the correct view of rationality, as Wray (2008: 323) and Mizrahi (2013b: 401) would point out. Moreover, once van Fraassen has constructed an argument to show that the EVR is the correct view of rationality, we would need to determine whether it rationally compels us to believe that the EVR is the correct view of rationality. If it did not have such a power, we would be able to rationally disbelieve that the EVR is the correct view of rationality. In addition, we would need to determine whether van Fraassen's argument for the EVR is more powerful than scientists' arguments for T. He disbelieves T on the grounds that scientists' arguments for T rely on abduction and do not rationally compel us to believe T. So if his argument for the EVR relies on abduction, and if it is not more powerful than scientists' arguments for T, we can rationally disbelieve the EVR.

Keep in mind, however, that this paper sets aside all these criticisms against the EVR, and that it rather grants that the EVR is the correct view of rationality, as van Fraassen's (2017) paper does. This paper merely uses the EVR to defend realism from antirealist objections.

5.3. Belief and Acceptance

This paper uses the phrases 'the belief of T' and 'the disbelief of T' many times. What do they mean? How do they differ from the acceptance of T?[6]

L. Jonathan Cohen (1992) famously distinguishes between belief and acceptance. He says that to believe T is "to *feel* it true" (1992: 4), whereas to accept T is to include T "among one's premises for deciding what to do or think in a particular context" (1992: 4). On this account, you can use T as a premise without feeling that it is true, i.e., you can accept T without believing it. For example, you can use Newtonian mechanics to send a rocket to the moon without feeling that it is true, i.e., you can accept Newtonian mechanics to send a rocket to the moon without believing it.[7]

Cohen's definition of acceptance is similar to that of van Fraassen. According to van Fraassen, to accept a theory is to "confront any future phenomena by means of the conceptual resources of this theory" (van Fraassen, 1980: 12). For example, evolutionary biologists accept evolutionary theory, which means that they confront the biological phenomena in terms of evolutionary theory. When they do so, they may believe that evolutionary theory is true, empirically adequate, useful, etc. According to scientific realism, "*acceptance of a scientific theory involves the belief that it is true*" (van Fraassen, 1980: 8). By contrast,

[6] I thank the second reviewer for these questions.

[7] Several problems with merely accepting T are summarized in Park (2018b).

according to constructive empiricism, "*acceptance of a theory involves as belief only that it is empirically adequate*" (van Fraassen, 1980: 12). So scientific realism and constructive empiricism imply that evolutionary biologists believe that evolutionary theory is true and empirically adequate, respectively.

6. Conclusion

Van Fraassen contends that there is no argument that rationally compels us to disbelieve T. He has put himself in the ironic situation where he needs to attack antirealists' favorite arguments, such as the pessimistic induction, to show that they do not rationally compel us to disbelieve T. He uses the EVR to rationally disbelieve T. In response, realists can use it to rationally believe T, despite Müller's penetrating objection that realists have the burden of showing that current theories are sufficiently successful, and despite pessimists' assertions that scientists have not yet removed enough false theories from the space of alternatives, or that scientists pulled present theories from the space of false theories. I conclude this paper with a motto: "Realists welcome the EVR."

References

Cohen, L. Jonathan (1992). *An Essay on Belief and Acceptance*. Oxford: Oxford University Press.

Hempel, Carl (1966). *Philosophy of Natural Science*. New Jersey: Prentice-Hall.

Ladyman, James, Igor Douven, Leon Horsten, and Bas van Fraassen (1997). "A Defense of van Fraassen's Critique of Abductive Inference: Reply to Psillos", *The Philosophical Quarterly* 47 (188): 305–321.

Lyons, Timothy (2003). "Explaining the Success of a Scientific Theory", *Philosophy of Science* 70 (5): 891–901.

---------- (2018). "Four Challenges to Epistemic Scientific Realism", *Spontaneous Generations: A Journal for the History and Philosophy of Science* 9 (1): 146–150.

Mizrahi, Moti (2013a). "The Pessimistic Induction: A Bad Argument Gone Too Far", *Synthese* 190 (15): 3209–3226.

---------- (2013b). "The Argument from Underconsideration and Relative Realism", *International Studies in the Philosophy of Science*. 27 (4): 393–407.

Müller, Florian (2015). "The Pessimistic Meta-induction: Obsolete Through Scientific Progress?", *International Studies in the Philosophy of Science* 29 (4): 393–412.

Musgrave, Alan (1985). "Realism vs. Constructive Empiricism", In Paul M. Churchland & Clifford A. Hooker (eds.), *Images of Science: Essays on Realism and Empiricism*. Chicago: The University of Chicago Press.

---------- (2017). "Strict Empiricism Versus Explanation in Science", In Evandro Agazzi (ed.), *Varieties of Scientific Realism: Objectivity and Truth in Science*. Switzerland: Springer International Publishing, 71–93.

Nickles, Thomas (2017). "Cognitive Illusions and Nonrealism: Objections and Replies", In Evandro Agazzi (ed.), *Varieties of Scientific Realism: Objectivity and Truth in Science.* Switzerland: Springer International Publishing, 95–108.

Papineau, David (1996). *The Philosophy of Science*. Oxford: Oxford University Press.

Park, Seungbae (2014). "A Pessimistic Induction against Scientific Antirealism", *Organon F* 21 (1): 3–21.

---------- (2017). "Scientific Antirealists Have Set Fire to Their Own Houses", *Prolegomena* 16 (1): 23–37.

---------- (2018a). "The Grand Pessimistic Induction", *Review of Contemporary Philosophy* 1 7: 7–19.

---------- (2018b). "Philosophers and Scientists are Social Epistemic Agents", *Social Epistemology Review and Reply Collective* 7 (6): 31–43.

---------- (2019). "New Objections to the Problem of Unconceived Alternatives", *Filosofia Unisinos* 20 (2): (to be assigned).

Poincaré, Henri (1905/1952). *Science and Hypothesis*. New York: Dover.

Putnam, Hilary (1975). *Mathematics, Matter and Method (Philosophical Papers, vo. 1),* Cambridge: Cambridge University Press.

Ruhmkorff, Samuel (2011). "Some Difficulties for the Problem of Unconceived Alternatives", *Philosophy of Science* 78 (5): 875–886.

Sankey, Howard (2017). "Realism, Progress and the Historical Turn", *Foundations of Science* 22 (1): 201–214.

Stanford, P. Kyle (2006). *Exceeding Our Grasp: Science, History, and the Problem of Unconceived Alternatives*. Oxford: Oxford University Press.

---------- (2015). "Catastrophism, Uniformitarianism, and a Scientific Realism Debate That Makes a Difference", *Philosophy of Science* 82 (5): 867–878.

van Fraassen, Bas (1980). *The Scientific Image.* Oxford: Oxford University Press.

---------- (1989). *Laws and Symmetry*. Oxford: Oxford University Press.

---------- (2007). "Reply: From a View of Science to a New Empiricism", In Bradley Monton (ed.), *Images of Empiricism: Essays on Science and Stances, with a Reply from Bas van Fraassen*. Oxford: Oxford University Press, 337–383.

---------- (2017). "Misdirection and Misconception in the Scientific Realism Debates", In Evandro Agazzi (ed.), *Varieties of Scientific Realism: Objectivity and Truth in Science.* Switzerland: Springer International Publishing, 95–108.

Worrall, John (1989). “Structural Realism: The Best of Both Worlds”, *Dialectica* 43: 99–124.

Wray, K. Brad (2008). “The Argument from Underconsideration as Grounds for Anti-Realism: A Defence”, *International Studies in the Philosophy of Science* 22 (3): 317–326.