Methodological Naturalism and Scientific Success: Lessons from the Scientific Realism Debate

(Forthcoming in European Journal for Philosophy of Religion)

Author: Yunus PRASETYA (0000-0003-3902-888X)

Affiliation: Universitas Pelita Harapan

E-Mail Contact: yunus.prasetya@gmail.com

Keywords: naturalism; theism; methodological naturalism; science and religion; realism

Abstract

Several metaphysical naturalists argue that the success of science, together with the claim that scientists adhere to methodological naturalism, amounts to strong evidence for metaphysical naturalism. I call this the scientific-success argument. It is argued that the scientific-success argument is similar to the no-miracles argument for realism in philosophy of science. On the no-miracles argument, the success of science is taken as strong evidence that scientific theories are (approximately) true. Based on this similarity, some considerations relevant to one argument may also be relevant to the other. One particular consideration is explored: the selectionist response to the no-miracles argument states that the theories we have are successful because they are the survivors of a rigorous selection process. The selectionist response also applies to the scientific-success argument. If scientific theories are selected for success, we do not need to explain the success of science by appealing to metaphysical naturalism.

I. Introduction

Methodological naturalism is the view that scientists should not appeal to supernatural entities in constructing scientific theories.[1] Metaphysical naturalism, in turn, is the view that there are no supernatural entities.[2] Let us also say that a scientific theory is natural, or, exhibits naturality,

[1] Alvin Plantinga, "Methodological Naturalism?", *Perspectives on Science and Christian Faith* 49 (1997); Barbara Forrest, "Methodological Naturalism and Philosophical Naturalism: Clarifying the Connection", *Philo* 3 (2000); Paul Draper, "God, Science, and Naturalism", in *The Oxford Handbook of Philosophy of Religion*, ed. William J. Wainwright (Oxford University Press, 2005); Martin Mahner, "The Role of Metaphysical Naturalism in Science", *Science & Education* 21 (2012).

[2] There are, of course, other uses of the term, "methodological naturalism." For example, David Papineau, "Naturalism", *The Stanford Encyclopedia of Philosophy*, 2020. Papineau uses the term to describe a practice in

just in case it adheres to methodological naturalism in virtue of not postulating supernatural entities. How are methodological and metaphysical naturalism related to one another? To start, a metaphysical naturalist, it seems, should also be a methodological naturalist—unless she is also an instrumentalist about scientific theories and she believes that supernatural entities can be useful postulates to have in a scientific theory. On the other hand, many argue that a methodological naturalist does not need to be a metaphysical naturalist.[3]

However, some argue that the success of science, together with the fact that scientists have largely adhered to methodological naturalism, strongly support metaphysical naturalism. Paul Draper argues that "the success of science in providing natural explanations of natural phenomena [….] strongly supports metaphysical naturalism over both supernaturalism in general and theism in particular."[4] Boudry et al. argue that the history of science speaks to the "successful track record of natural explanations and the miserable track record of supernatural explanations."[5] This, they claim, provides strong evidence for metaphysical naturalism. Several other philosophers have made similar claims—scientific activity assumes metaphysical naturalism, so the success of science amounts to strong evidence that its assumption, metaphysical naturalism, is true.[6] Let us call this the scientific-success argument.

I will argue that the scientific-success argument is similar in important ways to the no-miracles argument for realism in philosophy of science. Both arguments start by noting that science is successful. The no-miracles argument takes this as strong evidence that scientific theories are true, or at least approximately so. The scientific-success argument takes the evidence to show that metaphysical naturalism is true. I will argue that naturality can be construed as a superempirical virtue—a criterion of theory choice and construction, in the same category as virtues such as simplicity and mathematical elegance. In this way, the scientific-

---

philosophy, rather than in science. However, for our purposes, we are interested in methodological naturalism in science.

[3] See Michael Ruse, "Methodological Naturalism under Attack", *South African Journal of Philosophy* 24, no. 1 (2005); Elliott Sober, "Did Darwin Write the Origin Backwards?", *Proceedings of the National Academy of Sciences of the United States of America* 106 (2009); "Why Methodological Naturalism?", in *Biological Evolution-Facts and Theories, A Critical Appraisal 150 Years After "The Origin of Species"*, ed. M. Leclerc, G. Aulette, and R. Martines (Gregorian Biblical Press, 2011); Hans Halvorson, "Why Methodological Naturalism", in *The Blackwell Companion to Naturalism*, ed. Kelly J. Clark (Blackwell, 2016); Peter Harrison, "Naturalism and the Success of Science", *Religious Studies* 56 (2020). Of course, this is compatible with the view that certain versions of metaphysical supernaturalism carry implications that are incompatible with methodological naturalism. See Andrew B. Torrance, "Should a Christian Adopt Methodological Naturalism?", *Zygon* 52, no. 3 (2017). Torrance argues that a Christian should not adopt methodological naturalism.

[4] Draper, "God, Science, and Naturalism," 299.

[5] Maarten Boudry, Stefaan Blancke, and Johan Braeckman, "How Not to Attack Intelligent Design Creationism", *Foundations of Science* 15 (2010), 228.

[6] See Forrest, "Methodological Naturalism and Philosophical Naturalism: Clarifying the Connection"; Alexander Rosenberg, "Disenchanted Naturalism", in *Contemporary Philosophical Naturalism and Its Implications*, ed. Bana Bashour and Hans D. Muller (Routledge, 2014); Brian L. Keeley, "Natural Mind", in *The Blackwell Companion to Naturalism*, ed. Kelly J. Clark (Blackwell, 2016).

success argument takes the success of science as evidence for the truth-conduciveness of a particular superempirical virtue. If I am right about the similarities between these arguments, we may be able to make much progress on discussions surrounding the scientific-success argument by looking at discussions on the no-miracles argument.

In particular, I'll argue that metaphysical supernaturalists (those who deny metaphysical naturalism) may defend themselves from the scientific-success argument by appealing to the selectionist response to the no-miracles argument. According to the selectionist response, our best scientific theories are survivors of a selection process in which unsuccessful theories are rejected.[7] This fact, the selectionist argues, makes realism explanatorily superfluous. I will argue that if the selectionist response to the no-miracles argument is successful, then it will work as a response to the scientific-success argument, too.

I want to emphasize that my aim is not to argue that the selectionist response is ultimately successful in showing that realism is explanatorily superfluous. That would require settling a highly controversial debate in philosophy of science. However, the selectionist response is considered a serious and challenging objection to the no-miracles argument.[8] I will be happy if we start to consider a similar selectionist-style response as a serious and challenging objection to the scientific-success argument as well. Of course, one way to achieve this aim is to provide and defend a selectionist-style response to the scientific-success argument, which I will do in this paper.

II. Definitions: Supernatural and Natural Entities

The scientific-success argument uses several key terms that need defining. First, the distinction between natural and supernatural entities needs to be specified because metaphysical naturalism denies the existence of the latter kind of entities. Draper provides several nested definitions for the terms that he uses in the scientific-success argument. He provides the following definition of supernatural entities:

> x is supernatural =df. x is not part of nature and x can affect nature.[9]

[7] K. Brad Wray, "A Selectionist Explanation for the Success and Failures of Science", *Erkenntnis* 67 (2007); "Selection and Predictive Success", *Erkenntnis* 72 (2010); Kenneth Boyce, "The Coincidentalist Reply to the No-Miracles Argument", *Erkenntnis* 83 (2018).

[8] For example, Wray claims that "it has become almost obligatory for any realist to give at least a passing assessment of [the selectionist] explanation." Wray, "Selection and Predictive Success," 366.

[9] Draper, "God, Science, and Naturalism".

On this definition, our understanding of supernatural entities depends on our understanding of nature. Draper uses the following definition of nature:

> Nature =df. the spatiotemporal universe of physical entities together with any entities that are ontologically or causally reducible to those entities.[10]

Nested definitions have to terminate at some point, and this is where Draper's end. Draper does not define physical entities. He does, however, claim that the entities currently studied by chemists and physicists are physical.

Critics of the scientific-success argument often object that these definitions are unhelpful. Much of science is still progressing and its practitioners will postulate new entities in constructing new scientific theories. To merely claim that the entities currently studied by scientists are physical says nothing about whether the entities that will be postulated in future theories are also physical.[11]

Why is this a problem? Presumably, when we claim that science is successful, we do not simply mean that *current* science is successful. We attribute success to past science and project success to future science as well, insofar as we can reasonably expect science to continue its success. Indeed, many of the philosophers who endorse some version of the scientific-success argument cite the success of past scientific theories as well as the likely success of future natural scientific theories.[12] But some entities studied by past scientists are no longer studied in current science. Consider the various theories about ether throughout the history of physics. Descartes postulated an ether that explains the motion of the planets.[13] Physicists of the 19th century postulated luminiferous ether to explain the propagation of light. Einstein's special theory of relativity removed the need to postulate luminiferous ether.[14] If all we say about physical entities is that the entities studied in contemporary physics and chemistry are physical, we've said nothing about whether Cartesian ether and luminiferous ether are physical. We've also said nothing about the kind of ether that may be studied by future physicists. So, if we are to attribute the success of past and future science to methodological naturalism, we need to say more about what physical entities are.

---

[10] Draper, "God, Science, and Naturalism".

[11] Halvorson, "Why Methodological Naturalism"; Harrison, "Naturalism and the Success of Science".

[12] Draper, "God, Science, and Naturalism"; Boudry, Blancke, and Braeckman, "How Not to Attack Intelligent Design Creationism"; Keeley, "Natural Mind".

[13] Rene Descartes, *Les Principes de La Philosophie* (Kessinger Publishing LLC, 1724).

[14] For a brief history of the development of theories of ether, see Elaine M. P. de Andrade, Jean Faber, and Luiz Pinguelli Rosa, "A Spontaneous Physics Philosophy on the Concept of Ether throughout the History of Science: Birth, Death and Revival", *Foundations of Science* 18 (2013).

There is also the real danger of metaphysical naturalism failing to be a thesis at all. Several authors go as far as claiming that the lack of a fixed definition of physical entities shows that metaphysical naturalism is not, in fact, a thesis. Rather, it is better classified as a stance or a research program.[15]

In this paper, I wish to set aside the problem of defining physical entities. The strategy I pursue for resisting the scientific-success argument utilizes the selectionist response, which does not depend on whether we have a stable and non-circular definition of physical entities.

III. The Scientific-Success Argument: A Probabilistic Formulation

For the sake of precision, I will formulate the scientific-success argument using the tools of Bayesian epistemology. I think this is a fair representation of the argument. Most proponents of the argument already use terms like *explanation*, *strong support, likelihood, evidence*, and so on. All of these terms fit comfortably in a Bayesian framework.[16]

Strictly speaking, confirmation is a three-way relation between a piece of evidence (E), a hypothesis (H), and background information (K). However, many formulations of Bayes's theorem leave out background information. This gives us the following well-known equation:

$$P(H|E) = \frac{P(E|H)P(H)}{P(E)}$$

For the scientific-success argument, we are interested in metaphysical naturalism (N) as our hypothesis. What about the piece of evidence used to support the hypothesis? Proponents of the scientific-success argument claim that science is an activity that reliably produces explanatorily successful theories. It has produced explanatorily successful theories in the past, its current theories are explanatorily successful, and we can count on it to produce more explanatorily successful theories in the future. What's more, science reliably produces explanatorily successful theories that are natural.[17] So, for the scientific-success argument, let's take as our piece of evidence,

[15] Michael C. Rea, *World Without Design: The Ontological Consequences of Naturalism* (Oxford University Press, 2002); Bas van Fraassen, *The Empirical Stance* (Yale University Press, 2002); Halvorson, "Why Methodological Naturalism".

[16] Since I will compare the scientific-success argument to the no-miracles argument, it's worth noting that some philosophers of science resist probabilistic formulations of the no-miracles argument.For example, Stathis Psillos, *Scientific Realism: How Science Tracks Truth* (Routledge, 1999)..

[17] Forrest, "Methodological Naturalism and Philosophical Naturalism: Clarifying the Connection"; Draper, "God, Science, and Naturalism"; Boudry, Blancke, and Braeckman, "How Not to Attack Intelligent Design Creationism"; Keeley, "Natural Mind".

S: science produces explanatorily successful theories.

Finally, let us stipulate that it is part of our background information that science adheres to methodological naturalism. Scientific theories, at least typically, are natural.

Substituting N and S into Bayes's Theorem leads to the following pair of equations:

(1) $P(N|S) = \frac{P(S|N)P(N)}{P(S)}$

(2) $P(\sim N|S) = \frac{P(S|\sim N)P(\sim N)}{P(S)}$

The conclusion of the scientific-success argument is that the success of science (S) strongly supports metaphysical naturalism (N) over metaphysical supernaturalism (~N). In probabilistic terms, this means P(N|S) is much higher than P(N) by a factor, and P(~N|S) is much lower than P(~N) by a factor.[18]

We can also make use of the following equation.

$$P(S) = P(S|N)P(N) + P(S|\sim N)P(\sim N)$$

Substituting this into the denominators gives us the following pair of equations:

(3) $P(N|S) = \frac{P(S|N)P(N)}{P(S|N)P(N)+P(S|\sim N)P(\sim N)}$

(4) $P(\sim N|S) = \frac{P(S|\sim N)P(\sim N)}{P(S|N)P(N)+P(S|\sim N)P(\sim N)}$

Given (3) and (4), the intended conclusion of the scientific-success argument, that P(N|S) is higher than P(N) and P(~N|S) is lower than P(~N), requires the following claims:

(5) $P(S|N) > P(S|N)P(N) + P(S|\sim N)P(\sim N)$

[18] Note that this conclusion is consistent with the claim that P(N|S) is lower than P(~N|S). This latter claim depends, in part, on the initial probabilities of N and ~N, which we will leave to the reader to ascertain.

(6) $P(S|{\sim}N) < P(S|N)P(N) + P(S|{\sim}N)P({\sim}N)$[19]

Now note that if P(S|N) is greater than P(S|~N), then (5) and (6) are both true.[20] Indeed, the greater the difference between P(S|N) and P(S|~N), the stronger the support that S provides for N over ~N.

Thus, proponents of the scientific-success argument can establish their claim by showing that P(S|N) is high and P(S|~N) is relatively low. There is some *prima facie* intuitive force behind these assignments of probability. Science assumes metaphysical naturalism, i.e., it adheres to methodological naturalism. We grant that this is part of our background information. So, if the assumption of metaphysical naturalism is true, it is likely that science would be successful.

Several proponents of the scientific-success argument provide reasons that motivate these probability assignments. Draper claims that P(S|N) is high because we have good reasons to think that most natural events have causes and, on metaphysical naturalism, those causes are natural. On the other hand, P(S|~N) is relatively low. Even though we have good reasons to think that most natural events have causes, supernaturalism does not predict that those causes are natural. Draper claims that if supernaturalism were true, it would be quite surprising that science can explain so much without appealing to supernatural entities. Since P(S|N) is high and P(S|~N) is relatively low, it follows that S strongly supports N.[21] Boudry et al. cite both the success of natural theories in science and the failure of scientific investigations of the supernatural phenomena. They then claim, in arguing against intelligent design creationism, that "unless the alleged supernatural Creator is involved in a cosmic conspiracy that makes his existence completely undetectable to us, it would not be terribly difficult to look out for scientific evidence for his presence."[22] In other words, if theism, the most widely held form of metaphysical naturalism, were true, science should not enjoy explanatory success while assuming metaphysical naturalism, and science should enjoy more success in investigating supernatural phenomena.

---

[19] We can show that (5) and (6) are necessary for the conclusion by noting that the Bayes's factor, P(S|N)/P(S), which is equal to P(S|N)/(P(S|N)P(N) + P(S|~N)P(~N)), has to be greater than 1 in order for S to support N. If the Bayes's factor is greater than 1, then P(S|N) is greater than P(S).

[20] We can show this algebraically. P(S|N) = P(S|N)(1) = P(S|N)(P(N) + P(~N)) = P(S|N)P(N) + P(S|N)(P(~N). From this equation, we can see that if P(S|N)P(~N) is replaced by any lower value (e.g. P(S|~N)P(~N)), then the RHS would be greater than the LHS. In other words, if P(S|N) is greater than P(S|~N), then (5) is true. A similar proof applies to (6): P(S|~N) = P(S|~N)P(~N) + P(S|~N)P(N). So, if P(S|~N)P(~N) is replaced with a higher value (such as P(S|N)P(~N)) the RHS will be less than the LHS. Therefore, (6) is true.

[21] Draper, "God, Science, and Naturalism".

[22] Boudry, Blancke, and Braeckman, "How Not to Attack Intelligent Design Creationism," 241.

IV. A Comparison: The No-Miracles Argument for Realism

There is another argument, often employed in philosophy of science, that appeals to the explanatory success of scientific theories: the no-miracles argument for realism. According to realism, the methods that are employed in scientific inquiry aim at—and are good for—producing true theories and, consequently, our best scientific theories are true (or, at least, approximately true). According to the no-miracles argument, our best scientific theories are explanatorily successful and realism is the only view that does not make this a miracle.[23] Like the scientific-success argument, the no-miracles argument points to the explanatory success of scientific theories as a surprising piece of evidence. It also claims that its conclusion, realism, explains and makes the surprising pieces of evidence expectable.

One version of the no-miracles argument is called "the miraculous choice argument." On this version, the fact that science is good at choosing explanatorily successful theories is used as a surprising piece of evidence. Realism is the only acceptable view that accounts for this. Science chooses explanatory theories because the methods, commitments, and assumptions employed in science are truth-conducive, i.e., apt for finding true theories.

However, the antirealist can also claim that some of the methods, commitments, and assumptions employed in science are truth-conducive. For example, on Bas van Fraassen's view, science aims to produce empirically adequate theories.[24] Furthermore, van Fraassen considers empirical adequacy to be truth-conducive; all else being equal, an empirically adequate theory is more likely to be true than an empirically inadequate theory.[25] So, how can the miraculous choice argument favor realism over antirealism? There must be a set of scientific commitments that, on the antirealist's views, are not truth-conducive and the miraculous choice argument must support the realist view that these commitments are truth-conducive.

Science's use of the superempirical virtues fits these requirements. Realists and antirealists usually agree that the superempirical virtues—simplicity, fruitfulness, scope, etc.—play the role of secondary criteria for theory choice and appraisal in science. However, realists believe that the superempirical virtues are truth-conducive, while antirealists believe that the

[23] Hilary Putnam, "What Is Mathematical Truth", *Historia Mathematica* 2 (1975).
[24] Bas van Fraassen, *The Scientific Image* (Oxford University Press, 1980).
[25] On the one hand, this is a euphemism. On van Fraassen's view, empirical adequacy is necessary for truth. On the other hand, this is just the definition of truth-conduciveness. A theoretical virtue is truth-conducive just in case, all else being equal, a theory which has that virtue is more likely to be true than a theory which lacks that virtue. However, we don't need to agree with van Fraassen on this point.

superempirical virtues embody pragmatic considerations for theory choice and appraisal.[26] Plausibly, then, when a realist endorses the miraculous choice argument in defense of realism, she is claiming that the success of a scientific theory is strong evidence that the superempirical virtues are truth-conducive criteria.[27]

Methodological naturalism can be interpreted as the view that naturality is a superempirical virtue. According to methodological naturalism, scientists (ought to) use naturality as a criterion of theory choice and appraisal. This puts naturality in the same category as simplicity and fruitfulness. They are criteria of theory choice and appraisal that go beyond empirical strength. This interpretation fits well with even modest versions of methodological naturalism. Draper endorses a version on which "scientific explanations may appeal to the supernatural only as a last resort."[28] Boudry et al. defends provisory methodological naturalism, a "commitment to naturalistic causes and explanations, which *in principle* is revocable by extraordinary empirical evidence."[29] (2010, 229). On either of these versions, methodological naturalism functions like a superempirical virtue. We should generally prefer natural theories over supernatural theories. However, if we can find no way to explain observed phenomena under a natural theory, then we are permitted to postulate supernatural entities in our scientific theories.

Once we interpret naturality as a superempirical virtue, we can see how the scientific-success argument is similar to the miraculous choice argument. Proponents of the scientific-success argument often cite the "excellent track-record" of natural explanations and theories.[30] They attribute explanatory success to the natural theories that science has accepted throughout history and they claim that this would be miraculous unless naturality is truth-conducive.[31] In other words, if naturality can be construed as a superempirical virtue, then the scientific-success argument is a species of the miraculous choice argument. On the miraculous choice argument, the explanatory success of scientific theories provides strong evidence that science, its methods, commitments, and assumptions are apt for producing true theories. On the scientific-success

[26] For discussions on the superempirical virtues in the context of the realism vs. antirealism debate, see Paul M. Churchland, "The Ontological Status of Unobservables: In Praise of the Superempirical Virtues", in *Images of Science: Essays on Realism and Empiricism with a Reply from Bas C. van Fraassen*, ed. Paul M. Churchland and Clifford A. Hooker (University of Chicago Press, 1985).

[27] I am indebted to an anonymous reviewer for this point.

[28] Draper, "God, Science, and Naturalism," 297.

[29] Boudry, Blancke, and Braeckman, "How Not to Attack Intelligent Design Creationism," 229.

[30] Draper, "God, Science, and Naturalism"; Boudry, Blancke, and Braeckman, "How Not to Attack Intelligent Design Creationism".

[31] In this way, the scientific-success argument is dissimilar to the other version of the no-miracles argument, namely, the miraculous theory argument. On the miraculous theory argument, realism is presented as the only acceptable explanation for why the particular theories we have are explanatorily successful. See Larry Laudan, "Explaining the Success of Science: Beyond Epistemic Realism and Relativism", in *Science and the Quest of Reality*, ed. Alfred I. Tauber (University of Notre Dame Press, 1997); Emma C. Barnes, "The Miraculous Choice Argument for Realism", *Philosophical Studies* 111, no. 2 (2002).

argument, the explanatory success of scientific theories provides strong evidence that a particular (provisory) commitment employed in scientific inquiry—the commitment to natural theories—is truth-conducive. If this comparison is accurate, then the two arguments are strongly linked. Objections that apply to one of them may also apply to the other. I will turn to one such objection in the following sections: the selectionist response to the miraculous choice argument.

V. The Strategy of the Objection: Screening-Off Metaphysical Naturalism

In this section, I outline the form of the selectionist response to the no-miracles argument using the tools of Bayesianism. The strategy of the selectionist response is to provide a statement, Q, such that Q screens off realism with regard to the explanatory success of scientific theories, but not conversely. The screening-off relation is defined as follows:

Where $A \neq B$, A screens off B with regard to H iff $P(H|A\&B) = P(H|A)$.[32]

In other words, A screens off B with regard to H iff given A, H and B are probabilistically independent.

To see how the screening-off relation can be relevant to our discussion, consider the following example. Suppose that Jamie did not get pregnant this month (~J). If Jamie has been taking birth control pills (B), that would make ~J unsurprising. Indeed, less surprising than given ~B. In probabilistic terms, P(~J|B) is higher than P(~J|~B). So, ~J supports B.

But now suppose we learn that Jamie had a hysterectomy last year (H). This piece of information removes any probabilistic effect B had on ~J. If Jamie had a hysterectomy, taking birth-control pills does not affect the likelihood of Jamie getting pregnant. Indeed, if Jamie had a hysterectomy, then the fact that she's been taking birth control pills is explanatorily superfluous. It is obsolete for explaining why she did not get pregnant this month. So, H screens off B with regard to ~J (i.e. P(~J|H&B) = P(~J|M)), but not vice versa (i.e. P(~J|H&B) ≠

[32] The screening-off relation has been used by philosophers of science as one criterion of evaluating competing explanations. In this literature, it is generally accepted that a potential explanation that is screened off by another is, for that reason, defective. See, for example, Wesley C. Salmon, "Statistical Explanation", in *Statistical Explanation and Statistical Relevance*, by Wesley C. Salmon, Richard C. Jeffrey, and James G. Greeno (University of Pittsburgh Press, 1971); Wesley C. Salmon, *Four Decades of Scientific Explanation* (University of Pittsburgh Press, 1989); van Fraassen, *The Scientific Image*.

P(~J|B)). In this way, H renders B evidentially irrelevant for ~J because, given H, B and ~J are probabilistically independent.[33]

The screening-off relation is a limiting case. In response to the miraculous choice argument, the selectionist provides a rival explanation for the success of science that does not appeal to realism. So, anyone who believes this rival explanation does not need to explain the success of science by appealing to realism. What I want to do is recontextualize the selectionist response in light of the scientific-success argument. The strategy is to provide a statement, Q, such that Q (nearly) screens off metaphysical naturalism (N) with regard to the success of science in finding natural explanations for natural phenomena (S), but Q is not in turn (nearly) screened off by N with regard to S. In probabilistic terms, the following must be true:

(A) $P(S|N\&Q) \approx P(S|Q)$

(B) $P(S|N\&Q) \not\approx P(S|N)$

If we can find a statement, Q, such that (A) and (B) are true, the response is complete. Q would (nearly) screen off N with regard to S. Anyone who is justified in believing Q should not take the success of science as strong evidence for metaphysical naturalism.

VI. The Selectionist Response

Bas van Fraassen is often credited as the first to provide a selectionist explanation for the explanatory success of scientific theories.[34] He claims:

> The Darwinist says: Do not ask why the *mouse* runs from its enemy. Species which did not cope with their natural enemies no longer exist. That is why there are only ones who do. In just the same way, I claim that the success of current scientific theories is no miracle. It is not even surprising to the scientific (Darwinist) mind. For any scientific theory is born into a life of fierce competition, a jungle red in tooth and claw. Only the successful theories survive—the ones which *in fact* latched on to the actual regularities in nature.[35]

On van Fraassen's view, it is not surprising that we have explanatorily successful scientific theories. There is no miracle that requires an explanation. Wray, defending van Fraassen's analogy, argues that "the choice presented by the realist is not forced on us."[36] We do not have

[33] This is a slightly modified version of an example used in Salmon, *Four Decades of Scientific Explanation*.

[34] Though Wray is the first to use the term "selectionism." Wray, "A Selectionist Explanation for the Success and Failures of Science".

[35] van Fraassen, *The Scientific Image*, 39–40.

[36] Wray, "A Selectionist Explanation for the Success and Failures of Science," 85.

to choose between being a realist or believing that science's ability to find explanatory theories is a miracle.

Boyce provides the following helpful illustration for the selectionist response. Suppose a company, Psychics-R-Us, claims that they can find you a psychic. They ask you to give them a three-digit number. They then report to you that they have found a person, Clara, who correctly guessed your number. You would initially be impressed, and you might take this as evidence that Clara is, in fact, a psychic. But suppose you find out that Clara is one of a very large group of candidates, all of whom attempted to guess the number you've picked. Clara was chosen by Psychics-R-Us because she guessed the correct number. Upon learning about their strategy, you would be unimpressed. That Clara correctly guessed your number no longer seems to be strong evidence that she is a psychic.[37]

The structure of Boyce's analogy is obvious. That Psychics-R-Us found someone who correctly guessed your number corresponds to the production of explanatorily successful theories in science. That Clara is a real psychic corresponds to realism. We do not take Clara's correct guess as strong evidence that Psychics-R-Us is good at finding psychics or that Clara is a real psychic. At least not after learning about the process by which Psychics-R-Us chose Clara. If the analogy is apt, then we need not take the fact that science is good at finding explanatorily successful theories as evidence for realism. If we believe that our best scientific theories are "survivors of a winnowing process in which unsuccessful theories are rejected,"[38] we do not need a further explanation for their success.

So, let's define selectionism thus.

> Selectionism: there is a large pool of theories from which scientists reject non-explanatory theories and only accept explanatory theories.

According to the selectionist response, when a theory emerges in the scientific community, it is tested against natural phenomena. Theories that fail to explain natural phenomena are rejected and only those that explain natural phenomena are accepted.

[37] Boyce, "The Coincidentalist Reply to the No-Miracles Argument".
[38] Boyce, "The Coincidentalist Reply to the No-Miracles Argument," 929.

VII. Given Selectionism, Metaphysical Naturalism and the Success of Science are (Almost) Independent

In this section, I show how the selectionist response can be used, not just as a response to the miraculous choice argument, but also as a response to the scientific-success argument. First, let's note that the scientific-success argument and the miraculous choice argument cite the same piece of evidence, namely, that science is good at producing explanatorily successful theories.[39] Van Fraassen describes success in terms of a theory's ability to latch on to observable regularities.[40] Barnes points to the fact that scientific theories generate true observable consequences or are empirically successful.[41] Wray provides a more complex notion, on which the measure of explanatory success for scientific theories change throughout history.[42]

Fortunately, we don't need to agree on an analysis of explanatory success. We can simply adjust the selectionist response to fit the relevant notion of explanatory success at hand. We should note, however, that explanatory success must not entail truth. It must be possible for a theory to enjoy explanatory success without being true. To employ a notion of explanatory success that entails truth is to turn the miraculous choice argument into a deductive argument. Explanatory success would not be merely probabilistic evidence of truth—it would be conclusive evidence of truth.

A similar point applies to the scientific-success argument. We must assume that even in a world with supernatural entities, it is possible to produce an explanatory natural theory. Otherwise, the scientific-success argument will cease to be a probabilistic argument. As long as this assumption is granted, we can construct a variety of selectionist-style responses depending on the relevant notion of explanatory success used.

This takes us to the two claims mentioned in section four. First, given selectionism (Q), science's ability to find explanatorily successful theories (S) and metaphysical naturalism (N) are almost independent. Second, given metaphysical naturalism, the success of science and selectionism are not independent. These claims can be expressed in probabilistic terms in the following way:

$$(A)\ P(S|N\&Q) \approx P(S|Q)$$

[39] An anonymous reviewer convinced me that this point needs to be clarified.
[40] van Fraassen, *The Scientific Image*.
[41] Barnes, "The Miraculous Choice Argument for Realism".
[42] Wray, "A Selectionist Explanation for the Success and Failures of Science"; "Selection and Predictive Success".

(B) $P(S|N\&Q) \ncong P(S|N)$

These are the two claims we need to show to establish that Q (nearly) screens off metaphysical naturalism with regard to the success of science.

Let's start with (A). We will grant, as part of our background information, the claim that scientists adhere to methodological naturalism. That is, in constructing or discovering theories, they consider naturality a superempirical virtue. Given this claim and selectionism, the likelihood of science producing explanatorily successful theories is high. If it is *possible* to produce a scientific theory that explains phenomena and appeals only to natural entities, then science can select for that theory. Science can gather a pool of natural theories and select an explanatorily successful theory among the pool of candidates. All of this would be the case even in a world where there are supernatural entities. So long as, in such a world, science can continue to sift through non-explanatory natural theories until it finds an explanatory natural theory.

Now consider (B). Assume, for *reductio,* that (B) is false. That is, assume that given metaphysical naturalism, selectionism and the success of science are independent. In probabilistic terms, $P(S|N\&Q) = P(S|N)$. If this is the case, it follows, mathematically, that $P(S|N\&\sim Q) = P(S|N)$, and $P(S|N\&Q) = P(S|N\&\sim Q)$.[43] In other words, the likelihood of science's success is the same regardless of whether selectionism is true. But this seems discernibly false.

There are two ways selectionism can be false. The first is if there is no large pool of theories. But it seems clear that having only a small pool of theories harms science's chance of success. Even in a world where psychics exist, Psychics-R-Us can increase their chances of finding you a putative psychic by asking a large group of candidates to guess your three-digit number. If they only ask a small group of candidates to guess your number, they will harm their chances of finding you a putative psychic. Likewise, if we only have a small pool of theories, that will harm our chances of finding a successful natural theory, even in a world without supernatural entities.

Second, selectionism would be false if there is a large pool of theories but scientists don't reject the theories that fail to explain and accept only the explanatory ones. Again, this would

[43] Proof: $P(A) = P(A|B)P(B) + P(A|\sim B)P(\sim B)$. So, if $P(A|B) = P(A)$, then
$P(A) = P(A)P(B) + P(A|\sim B)P(\sim B)$,
$P(A) - P(A)P(B) = P(A|\sim B)P(\sim B)$,
$P(A)(1 - P(B)) = P(A|\sim B)(1 - P(B))$,
$P(A) = P(A|\sim B)$.

harm science's chance of success. In such a case, science will likely have an unimpressive track record that involves the acceptance of both explanatory and non-explanatory theories.

In either case, we see that P(S|N&Q) > P(S|N&~Q). Therefore, (B) is true. Even if we assume metaphysical naturalism, selectionism would make the success of science significantly more likely.

Since (A) and (B) are true, it follows that Q screens off N with regard to S. Given selectionism, the success of science fails to strongly support metaphysical naturalism.

For intuitive support, let's extend Boyce's Psychics-R-Us analogy for the scientific-success argument. Methodological naturalists claim that in attempting to find explanatory theories, scientists only look among those theories that do not postulate supernatural entities. Only if they cannot find an explanatory natural theory do they start looking for an explanatory supernatural theory. We can construe this as a means to limit the pool of candidates in Boyce's analogy. Suppose Psychics-R-Us claims that psychics lose their powers upon coming of age and seeks for putative psychics only among minors. Only if they cannot find a minor who correctly guessed a customer's number do they look for putative psychics among adults. When a customer enters his three-digit number, they ask 15,000 minors to guess the customer's number, and pairs one who correctly guessed the number with the customer.

In this scenario, the fact that fifteen-year-old Clara guessed your number is not strong evidence for her being a real psychic, nor would that be strong evidence for the claim that psychics lose their powers upon coming of age. Even if Psychics-R-Us develops an excellent track record for finding young putative psychics, we would not have strong evidence that psychics lose their powers upon coming of age. Given their selection process, there is nothing miraculous about Psychics-R-Us's ability to find putative psychics among minors even in a world where there are adult psychics.

Again, the structure of the analogy should be clear. The claim that psychics lose their powers upon coming of age corresponds to metaphysical naturalism. The strategy of looking for putative psychics among minors corresponds to methodological naturalism. Even if there are adult psychics, Psychics-R-Us's selection process enables them to consistently find putative young psychics. This corresponds to how, given selectionism, science can consistently find explanatory natural theories, even in a world with supernatural entities.

This analogy is also helpful to illustrate the screening-off relation. Given their strategy, the statement that Psychics-R-Us is reliable at finding putative young psychics and the hypothesis that all psychics are minors are nearly independent. On the other hand, given that all psychics are minors, the strategy that they employ would still make it more probable for them to be

successful in finding putative psychics. Thus, when we find out about Psychics-R-Us's strategy for finding putative psychics, the hypothesis that all psychics are minors becomes explanatorily superfluous. It is screened off by the fact that they employ a selectionist strategy in their project.

VIII. Potential Objections

We will now tackle several potential objections that may be raised against the selectionist response to the scientific-success argument.

VII.1 Selectionism is Not an Adequate Response to the No-Miracles Argument

Some philosophers argue that selectionism is only relevant to the miraculous choice argument but not to the other version of the no-miracles argument, namely, the miraculous theory argument. According to the miraculous theory argument, realism is the only view that doesn't make a miracle out of the explanatory success of the particular theories we have. Thus, according to this objection, selectionism explains how science manages to find explanatorily successful theories but it does not explain why the particular theories science accepts are explanatory.[44] Similarly, proponents of the scientific-success may argue that we have only explained how science manages to find natural theories that are explanatory. We have not explained why particular natural theories are explanatorily successful.

First, let's note that we will have made significant progress by distinguishing between the miraculous choice scientific-success argument and the miraculous theory scientific-success argument. But we can go even further. Selectionists have a response to the objection that selectionism is not an adequate response to the miraculous theory argument. Boyce argues that if selectionism is an adequate response to the miraculous choice argument, the antirealist is entitled to dismiss the miraculous theory argument.[45] Let's revisit the Psychics-R-Us analogy. Boyce claims that if you can explain how Psychics-R-Us manages to find a person who guessed your number, you have no obligation to explain how that particular person—Clara—correctly guessed your number. You are epistemically justified in believing that Clara correctly guessed your number by pure luck. Similarly, Boyce argues, if the antirealist can explain how science manages to find explanatory theories, she is under no further obligation to explain why the particular theories accepted by science are successful. Boyce calls this the "coincidentalist response."

[44] Philip Kitcher, *The Advancement of Science: Science without Legend, Objectivity without Illusions* (Oxford University Press, 1993); Jarrett Leplin, *A Novel Defense of Scientific Realism* (Oxford University Press, 1997).

[45] Boyce, "The Coincidentalist Reply to the No-Miracles Argument".

I'm inclined to think that Boyce is correct. If he is, then the supernaturalist may provide an analogous coincidentalist response to the miraculous theory scientific-success argument. The antirealist may believe that the explanatory success of particular theories is purely coincidental. In the same way, the supernaturalist may believe that the explanatory success of particular natural theories is purely coincidental and need not be explained by appealing to metaphysical naturalism.

VII.2 Richard Boyd: Selectionism Fails to Explain the Efficiency of Science

Richard Boyd provides another objection for selectionism.[46] He claims that van Fraassen's Darwinian analogy fails to capture scientific activity.[47] Van Fraassen has responded to Boyd's arguments[48], but it is worth briefly discussing one of Boyd's arguments here.

According to Boyd, "Darwin's antiteleological position would have been refuted if the data had shown that selection had been *too* efficient to be explained by any plausible materialist theory."[49] Applying this insight to the no-miracles argument, Boyd claims that science is *too* efficient at producing successful theories to be explained in selectionist terms. Similarly, proponents of the scientific-success argument may argue that selectionism fails to explain why science is so efficient at producing explanatory natural theories.

Here, I should reemphasize that my main project is to provide a selectionist-style response to the scientific-success argument. This Boyd-style objection, however, involves a new argument. Instead of citing science's ability to find explanatorily successful natural theories, it cites the high efficiency with which science finds explanatorily successful natural theories. So, if Boyd's objections to selectionism are well-founded, that will still be a significant lesson to learn for philosophers who discuss the scientific-success argument. Perhaps the mere fact that science finds explanatorily successful natural theories does not provide strong evidence for naturalism. Instead, it is the high rate at which science finds explanatorily successful natural theories that strongly confirms naturalism.

Ultimately, however, I don't think Boyd's objection is successful. For one, it is difficult to defend the claim that science efficiently produces explanatorily theories. Antirealists have, for the most part, conceded the claim that science produces explanatory theories. But I don't see

[46] A reviewer rightly notes that if I'm going to rely so heavily on selectionism, it would be helpful to discuss some of the objections raised against it.

[47] Richard Boyd, "Lex Orandi Est Lex Credendi", in *Images of Science: Essays on Realism and Empiricism with a Reply from Bas C. van Fraassen*, ed. Paul M. Churchland and Clifford A. Hooker (University of Chicago Press, 1985).

[48] Bas van Fraassen, "Empiricism in Philosophy of Science", in *Images of Science: Essays on Realism and Empiricism with a Reply from Bas C. van Fraassen*, ed. Paul M. Churchland and Clifford A. Hooker (University of Chicago Press, 1985).

[49] Boyd, "Lex Orandi Est Lex Credendi," 26.

why they would concede Boyd's claim that science is efficient in doing so, let alone the claim that it is more efficient than what van Fraassen's Darwinian explanation predicts. For example, Wray argues that there are failures in science, too; theories that were once accepted but eventually rejected. Wray also claims that van Fraassen's Darwinian explanation can account for cases where theories that were once explanatorily successful are eventually rejected. The realist, on the other hand, has nothing to say as she cannot claim that those theories were once true but eventually became false.[50] If Wray is right, then perhaps realism's predictions on the efficiency of science are too optimistic. If realism were true, we should expect science to be much more efficient than it currently is.

Furthermore, the antirealist can provide some account for the efficiency of science (if it is, in fact, efficient). Van Fraassen claims that "newly proposed theories are designed to have the same success in those areas where their progenitors were perceived as successful."[51] This may help science in terms of efficiency as scientists do not always start from zero when they are in the business of constructing new theories. Additionally, the antirealist may appeal to sociological factors. The current widespread availability of information and the amount of funding provided for scientific research contribute to science's efficiency. How much is still left unexplained after citing these factors? For these reasons, Boyd's objection doesn't seem to pose a serious threat to the selectionist response.

VII.3 Antirealism is too High a Cost for Resisting the Scientific-Success Argument

The metaphysical naturalist may object that you need to be an antirealist to resist the scientific-success argument. However, this is a costly commitment. It is better to be a realist and accept the scientific-success argument than to be an antirealist and resist the scientific-success argument.

Strictly speaking, this is false. When you endorse the selectionist response to the scientific-success argument, you also endorse the selectionist response to the no-miracles argument. This much is true. However, you are not thereby committed to antirealism. You can be a realist without endorsing the no-miracles argument.

VII.4 Given Selectionism, the Superempirical Virtues are Not Truth-Conducive

If naturality is to be considered a superempirical virtue, then the selectionist response to the scientific-success argument has unwelcome consequences. If the success of science does not strongly confirm the truth-conduciveness of methodological naturalism, then it would also fail to strongly confirm the truth-conduciveness of other superempirical virtue.

[50] Wray, "A Selectionist Explanation for the Success and Failures of Science".
[51] van Fraassen, "Empiricism in Philosophy of Science," 282.

This seems correct. There is nothing special about naturality compared to other superempirical virtues. So, if the success of science does not strongly confirm the truth-conduciveness of this virtue, neither should it strongly confirm the truth-conduciveness of other virtues. However, this is not a costly consequence. As mentioned above, you can be a realist and believe that some of the superempirical virtues are truth-conducive without endorsing the no-miracles argument. Some philosophers have argued for the truth-conduciveness of particular superempirical virtues without appealing to the success of science.[52] This also points to the fact that, again, one can be a realist without endorsing the no-miracles argument.[53]

VII.5 Natural Theories Cannot be Explanatorily Successful in a World with Supernatural Entities

The naturalist may argue that natural theories *cannot* be successful in a world with supernatural entities. Therefore, the success of a natural theory is conclusive evidence for naturalism.

Philosophers who defend a probabilistic version of the scientific-success argument claim that the likelihood of scientific success, in a world with supernatural entities, is low.[54] I don't know of anyone who claims that the likelihood is zero. This latter claim is much stronger and it is, I think, not one that many are willing to make. If it is impossible for science to succeed and adhere to methodological naturalism in a world with supernatural entities, we would not need a probabilistic formulation of the scientific-success argument. We have, effectively, a deductive argument for naturalism.

VII.6 Supernatural Theories are not Explanatorily Successful

A final objection worth considering involves taking an additional piece of evidence for the scientific-success argument: supernatural theories are not explanatory. Boudry et al. endorses this version of the scientific-success argument. They appeal to "the successful track record of natural explanations and the miserable track record of supernatural explanations."[55] If we take this second piece of evidence—that supernatural theories are not explanatory—metaphysical naturalism would not be screened off by selectionism.

To start, it should be noted that this objection would simply limit the scope of my criticism. My criticism would apply to the claim that the explanatory success of natural theories strongly

[52] Stathis Psillos, "On van Fraassen's Critique of Abductive Reasoning", *The Philosophical Quarterly* 46, no. 182 (1996); "The Fine Structure of Inference to the Best Explanation", *Philosophy and Phenomenological Research* 74, no. 2 (2007); Richard Swinburne, *Simplicity as Evidence for Truth* (Marquette University Press, 1997); Peter Lipton, *Inference to the Best Explanation* (Routledge, 2004).

[53] I thank an anonymous reviewer for this point.

[54] Forrest, "Methodological Naturalism and Philosophical Naturalism: Clarifying the Connection"; Draper, "God, Science, and Naturalism"; Boudry, Blancke, and Braeckman, "How Not to Attack Intelligent Design Creationism"; Sober, "Why Methodological Naturalism?"; Keeley, "Natural Mind".

[55] Boudry, Blancke, and Braeckman, "How Not to Attack Intelligent Design Creationism," 228.

supports metaphysical naturalism. It does not apply to the claim that the explanatory failure of supernatural theories strongly supports metaphysical naturalism. So, this objection is a red herring.

However, we can say more about this objection. The second piece of evidence—that supernatural theories are not explanatory—is difficult to defend. It is easy enough to find historical examples of non-explanatory supernatural theories (e.g. theories that appeal to Zeus, creationism, etc.). It is equally easy, however, to find historical examples of non-explanatory natural theories (e.g. theories that appeal to the *virtus dormitiva*). One needs more than a handful of non-explanatory supernatural theories to establish the claim that supernatural theories have a bad track record throughout history. Additionally, there are plenty of supernatural theories that enjoyed significant periods of success in science or, at least, would have been just as successful as their natural counterparts. If Aristotle's unmoved mover is a supernatural entity, then the centuries of success enjoyed by Aristotelian science presents a challenge for the claim that supernatural theories are not explanatory. Newton provides an account of gravitational attraction by appealing to a kind of divine occasionalism.[56] This stipulation is likely a response to the most common objection raised against Newtonianism—that gravity is an occult quality because it invokes action at a distance. Note that the occasionalist account of gravity would be just as successful as an account on which gravity is brute. The two accounts, after all, are empirically equivalent. Thus, this is a case where a supernatural theory would be just as successful as a natural theory.[57]

IX. Conclusion

There are telling similarities between the no-miracles argument and the scientific-success argument. Naturality can be construed as a superempirical virtue—a criterion of theory choice beyond empirical adequacy. So, the scientific-success argument starts by noting that science is successful and concludes that this strongly confirms the truth-conduciveness of a particular criterion of theory choice. If this is an apt description of the scientific-success argument, it is similar, in important ways, to the no-miracles argument. We should, therefore, be mindful of how considerations relevant to the no-miracles argument might also be relevant to the scientific-success argument.

[56] Isaac Newton, *Isaac Newton's Papers and Letters on Natural Philosophy* (Harvard University Press, 1978).

[57] For even more historical examples of successful scientific theories that appeal to supernatural entities, see Harrison, "Naturalism and the Success of Science".

References

Barnes, Emma C. 2002. “The Miraculous Choice Argument for Realism”. *Philosophical Studies* 111, no. 2: 97–120. https://doi.org/10.1023/A:1021204812809.

Boudry, Maarten, Stefaan Blancke, and Johan Braeckman. 2010. “How Not to Attack Intelligent Design Creationism”. *Foundations of Science* 15: 227–44. https://doi.org/10.1007/s10699-010-9178-7.

Boyce, Kenneth. 2018. “The Coincidentalist Reply to the No-Miracles Argument”. *Erkenntnis* 83: 929–46. https://doi.org/10.1007/s10670-017-9920-4.

Boyd, Richard. 1985. “Lex Orandi Est Lex Credendi”. In *Images of Science: Essays on Realism and Empiricism with a Reply from Bas C. van Fraassen*, edited by Paul M. Churchland and Clifford A. Hooker, 3–34. Chicago: University of Chicago Press.

Churchland, Paul M. 1985. “The Ontological Status of Unobservables: In Praise of the Superempirical Virtues”. In *Images of Science: Essays on Realism and Empiricism with a Reply from Bas C. van Fraassen*, edited by Paul M. Churchland and Clifford A. Hooker, 35–47. Chicago: University of Chicago Press.

de Andrade, Elaine M. P., Jean Faber, and Luiz Pinguelli Rosa. 2013. “A Spontaneous Physics Philosophy on the Concept of Ether throughout the History of Science: Birth, Death and Revival”. *Foundations of Science* 18: 559–77. https://doi.org/10.1007/s10699-013-9336-9.Descartes, Rene. 1724. *Les Principes de La Philosophie*. Kessinger Publishing LLC.

Draper, Paul. 2005. “God, Science, and Naturalism”. In *The Oxford Handbook of Philosophy of Religion*, edited by William J. Wainwright, 272–303. Oxford, U.K.: Oxford University Press. 10.1093/0195138090.003.0012.

Forrest, Barbara. 2000. “Methodological Naturalism and Philosophical Naturalism: Clarifying the Connection”. *Philo* 3: 7–29. https://doi.org/10.5840/philo20003213.

Halvorson, Hans. 2016. “Why Methodological Naturalism”. In *The Blackwell Companion to Naturalism*, edited by Kelly J. Clark, 1st ed., 136–49. Oxford: Blackwell.

Harrison, Peter. 2020. “Naturalism and the Success of Science”. *Religious Studies* 56: 274–91. https://doi.org/10.1017/s0034412518000574.

Keeley, Brian L. 2016. “Natural Mind”. In *The Blackwell Companion to Naturalism*, edited by Kelly J. Clark, 1st ed., 196–208. Oxford: Blackwell.

Kitcher, Philip. 1993. *The Advancement of Science: Science without Legend, Objectivity without Illusions*. New York: Oxford University Press.

Laudan, Larry. 1997. “Explaining the Success of Science: Beyond Epistemic Realism and Relativism”. In *Science and the Quest of Reality*, edited by Alfred I. Tauber, 137–61. Notre Dame: University of Notre Dame Press.

Leplin, Jarrett. 1997. *A Novel Defense of Scientific Realism*. New York: Oxford University Press.

Lipton, Peter. 2004. *Inference to the Best Explanation*. 2nd ed. London: Routledge.

Mahner, Martin. 2012. “The Role of Metaphysical Naturalism in Science”. *Science & Education* 21: 1437–59. https://doi.org/10.1007/s11191-011-9421-9.

Newton, Isaac. 1978. *Isaac Newton’s Papers and Letters on Natural Philosophy*. Edited by Bernard Cohen. 2nd ed. Cambridge, MA: Harvard University Press.

Papineau, David. 2020. “Naturalism”. Edited by Edward N. Zalta. *The Stanford Encyclopedia of Philosophy*. https://plato.stanford.edu/archives/sum2020/entries/naturalism/.

Plantinga, Alvin. 1997. “Methodological Naturalism?” *Perspectives on Science and Christian Faith* 49: 143–54.

Psillos, Stathis. 1996. “On van Fraassen’s Critique of Abductive Reasoning”. *The Philosophical Quarterly* 46, no. 182: 31–47. https://doi.org/10.2307/2956303.

———. 1999. *Scientific Realism: How Science Tracks Truth*. London: Routledge.

———. 2007. “The Fine Structure of Inference to the Best Explanation”. *Philosophy and Phenomenological Research* 74, no. 2: 441–48. https://doi.org/10.1111/j.1933-1592.2007.00030.x.

Putnam, Hilary. 1975. “What Is Mathematical Truth”. *Historia Mathematica* 2: 529–43.

Rea, Michael C. 2002. *World Without Design: The Ontological Consequences of Naturalism*. Oxford: Oxford University Press.

Rosenberg, Alexander. 2014. “Disenchanted Naturalism”. In *Contemporary Philosophical Naturalism and Its Implications*, edited by Bana Bashour and Hans D. Muller, 17–36. London: Routledge.

Ruse, Michael. 2005. “Methodological Naturalism under Attack”. *South African Journal of Philosophy* 24, no. 1: 44–60. https://doi.org/10.4314/sajpem.v24i1.31413.

Salmon, Wesley C. 1971. “Statistical Explanation”. In *Statistical Explanation and Statistical Relevance*, by Wesley C. Salmon, Richard C. Jeffrey, and James G. Greeno, 29–87. University of Pittsburgh Press.

———. 1989. *Four Decades of Scientific Explanation*. Pittsburgh: University of Pittsburgh Press.

Sober, Elliott. 2009. “Did Darwin Write the Origin Backwards?” *Proceedings of the National Academy of Sciences of the United States of America* 106: 10048–55.

———. 2011. “Why Methodological Naturalism?” In *Biological Evolution-Facts and Theories, A Critical Appraisal 150 Years After “The Origin of Species”*, edited by M. Leclerc, G. Aulette, and R. Martines, 359–78. Rome: Gregorian Biblical Press.

Swinburne, Richard. 1997. *Simplicity as Evidence for Truth*. Milwaukee: Marquette University Press.

Torrance, Andrew B. 2017. “Should a Christian Adopt Methodological Naturalism?” *Zygon* 52, no. 3: 691–725. https://doi.org/10.1111/zygo.12363.

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

———. 1985. “Empiricism in Philosophy of Science”. In *Images of Science: Essays on Realism and Empiricism with a Reply from Bas C. van Fraassen*, edited by Paul M. Churchland and Clifford A. Hooker, 245–308. Chicago: University of Chicago Press.

———. 2002. *The Empirical Stance*. New Haven: Yale University Press.

Wray, K. Brad. 2007. “A Selectionist Explanation for the Success and Failures of Science”. *Erkenntnis* 67: 81–89. https://doi.org/10.1007/s10670-007-9046-1.

———. 2010. “Selection and Predictive Success”. *Erkenntnis* 72: 365–77.