

ISSA Proceedings 2002 - Retransmittability And Empirical Propositions



1. Introduction

The standard dictionary definition of a formally valid argument in classical, bivalent, deductive logic proceeds as follows: An argument is valid if it is impossible for all its premises to be true and its conclusion to be false. A valid argument, unlike a sound one, can have false premises or

it can have a mixture of true and false premises, but if all of its premises are true, then its conclusion must be true as well. This can also be expressed by saying that truth is transmitted from all of the premises of a valid argument to its conclusion and that falsity is retransmitted from the conclusion of a valid argument to at least one of its premises. The terminology of transmittability and retransmittability has its origins in the work of Popper and Lakatos. That truth is transmitted and that falsity is retransmitted are both mentioned in (Popper, 1974, 64), though Popper sees these as being properties of valid rules of inference rather than of arguments. Lakatos, in the course of developing his mathematical methodology of proofs and refutations, formulates a principle of the retransmission of falsity which states 'that global counterexamples be also local: falsehood should be retransmitted from the naive conjecture to the lemmas, from the consequent of the theorem to its antecedent' (Lakatos, 1976, 47).

Two interesting questions to ask of valid arguments are whether anything other than truth is transmittable and whether anything other than falsity is retransmittable. Concerning transmittability, some unusual contenders have been proposed. For example, in (Gjertsen, 1989, 127) it is suggested that if the premises of a valid argument are ambiguous, obscure, uncertain or bland, then so must be its conclusion! In this paper I am interested in the questions whether the property of being an empirical proposition is transmittable and, especially, whether this property is retransmittable. I show that a valid deductive argument with consistent premises, all of which are empirical, can have a non-empirical conclusion which is not logically true. I also show that it is possible for a valid deductive argument with consistent premises to have an empirical conclusion and

yet to have no empirical premises. (Note that in this paper I do not, as some philosophers do, distinguish between propositions and statements. These terms are used interchangeably.) My interest in problems relating to transmittability and retransmittability arose out of my interest in what is sometimes known as anti-justificationism. This term applies to a family of approaches to philosophical problems inspired by the work of Popper. (Popper's clearest statement of his rejection of justificationism can be found in (Popper, 1983, 18-34).) Although anti-justificationists disagree about many things, they all agree in rejecting the traditional conception of knowledge. In this knowledge is defined to be justified true belief. A claim to knowledge is justified if it follows logically from other propositions which themselves have already been justified. As the chain of justifications cannot be indefinitely extended it must terminate in propositions which are not justified by other propositions but in some other way. In empiricism, for example, the ultimate authority is sense experience and a proposition which is to count as genuine knowledge must be derivable from basic or atomic propositions whose truth is guaranteed by sense experience. Anti-justificationists, by contrast, do not attempt to give a precise and exact definition of knowledge. Unlike justificationists, they do not attach great importance to definitions of philosophical terms. They see knowledge as consisting of a collection of conjectural and tentative theories that may well be replaced by better theories as these come along in the future. Scientific knowledge consists of those theories that have not yet been falsified, but which have withstood serious attempts to test and criticise them. Criticism is very important in anti-justificationism and a variety of forms of criticism are employed. In order to test a theory anti-justificationists ask various questions about it and then evaluate the answers that are given to those questions. These questions include, but are not restricted to, the following: Is this theory consistent? Is this theory better than its rivals? Does this theory successfully solve the problem it was put forward to solve? Is this theory in conflict with some scientific theory that is well established? Is this theory in conflict with some element of the dominant cultural worldview? If the theory is empirical, we can also ask if it is consistent with observed facts. According to (Bartley, 1984, 114), however, in justificationism criticism and justification are fused. That means that theories are criticised by showing that they cannot be derived from the ultimate epistemological authority. Thus, in empiricism, any theories that cannot be derived from or justified by basic statements whose truth is guaranteed by sense experience are excluded from science. In extreme cases, such as that of logical positivism, they are deemed to

be meaningless.

According to (Bartley, 1984, 261) one of the assumptions legitimating the fusion of criticism and justification is the view that the derivatives of a statement inherit all the properties of intellectual value or merit possessed by that statement. (Any proposition that follows logically from a given proposition or set of propositions is said to be a *derivate* of that proposition or set of propositions.) He calls this the *transmissibility assumption* and states it as the view that '*all properties, measures, and tokens of intellectual value or merit are transmitted from premises to conclusion, in the same manner as truth, through the relationship of logical derivability or deducibility*' (Bartley, 1984, 261). (In this context I prefer the spelling 'transmittability' to 'transmissibility' as the latter spelling of the word is used in epistemic logic. Transmissibility assumptions there refer to the conditions under which, concerning some proposition, when a person only knows that another person knows that proposition, he himself can legitimately be said to know it (Hendricks, 2001, 268).)

Bartley is particularly interested in criticising various theories of confirmation which are important in many versions of empiricism. One of the key components in many theories of confirmation is known as the *consequence condition*. According to (Goodman, 1983, 68) this states that 'whatever confirms a given statement confirms also whatever follows from that statement' (In (Hempel, 1965, 31) this is called the *special consequence condition*). Some philosophers, such as Carnap, have given numerical values to empirical theories which measure how well they have been confirmed. This value is known as the *degree of confirmation* of the theory and it obeys the laws of the probability calculus (Carnap, 1950). As probability is transmitted from the premises of an argument to its conclusion, in the sense that the probability of the conclusion is greater than or equal to the probability of the conjunction of the premises, degree of confirmation is also transmitted in this way. (Popper's notion of the degree of corroboration of a theory, by contrast, does not satisfy the laws of the probability calculus (Popper, 1983, 223-227). It is, rather, a measure of the degree to which a theory has stood up to tests and to attempts to falsify it (Popper, 1983, 228).)

Bartley mentions that the property of being an empirical proposition is not transmittable, although it is assumed to be by many empiricists. He adds that this gives rise to counter-intuitive results in that non-empirical conclusions can inherit the probability and degree of confirmation of the empirical premises from which

they follow. Bartley, however, uses the obvious notion of transmittability, to which it is easy to find counterexamples, and he does not even ask if the property of being an empirical proposition is retransmittable.

My plan for the remainder of this paper is, firstly, to mention the counterexamples to the claim that the property of being an empirical proposition is transmittable using the obvious definition of transmittability and then to show that counterexamples can still be devised to this claim even if we strengthen the notion of transmittability involved. I also show that these counterexamples make use of very weak assumptions. In fact, counterexamples can be devised which only use patterns of argumentation that are valid in minimal logic. After that I turn my attention to the topic of retransmittability and my discussion of that topic mirrors my discussion of transmittability.

I demonstrate that the property of being an empirical proposition is not retransmittable using the obvious notion of retransmittability and also that it is not retransmittable using a strengthened notion of retransmittability. These arguments employ very weak assumptions. In fact, as in the case of transmittability, counterexamples can be constructed which only use patterns of argumentation that are valid in minimal logic.

2. Transmittability

A considerable number of empiricists think that the property of being an empirical proposition is transmittable. For example, in (Ayer, 1946, 33) we find the claim, 'Surely from empirical premises nothing whatsoever concerning the properties, or even the existence, of anything super-empirical can legitimately be inferred.' Such a statement presupposes the view that the property of being an empirical proposition is transmittable or, at the very least, that the conclusion of a valid argument with empirical premises is either empirical or a logical truth. Another example occurs in Dancy's exposition of Kripke's views on necessity. Dancy argues that the proposition that a table is necessarily not made of ice is empirical 'because it is derived by inference from our empirical knowledge that' it is wooden (Dancy, 1991, 220).

Such a comment presupposes that the property of being an empirical proposition is transmittable, at least in arguments with a single premise. The most obvious way of formulating the claim that the property of being an empirical proposition is transmittable is given in principle (T1):

(T1) If all the premises of a valid deductive argument are empirical, then the

conclusion must be as well.

However, because of the way in which validity is defined, counterexamples to (T1) are easy to come by. It follows from the definition of validity that all arguments whose premises form an inconsistent set are valid and all arguments with logically true conclusions are valid. Thus, the following two arguments are both counterexamples to (T1):

1. The speed of light in a vacuum is greater than 300 million metres per second.
The speed of light in a vacuum is less than 200 million metres per second.
Therefore, God created the universe.
2. The speed of light in a vacuum is greater than 300 million metres per second.
Therefore, either snow is white or snow is not white.

The premises of argument (1) are both empirical, but, as they form an inconsistent set, they allow the derivation of a non-empirical, metaphysical conclusion. The premise of argument (2) is empirical, but its conclusion is a tautology. Thus, both (1) and (2) show that principle (T1) is false. However, I do not think that someone who believes in the principle that the property of being an empirical proposition is transmittable would be unduly concerned by such counterexamples. Therefore, it is necessary to devise counterexamples to a stronger version of this principle. This stronger version is captured in principle (T2):

(T2) A valid deductive argument all of whose premises are empirical and whose set of premises is consistent and whose conclusion is not logically true must have an empirical conclusion.

Both (T1) and (T2) can be thought of as capturing the idea that the property of being an empirical proposition is transmittable, but the sense in which it is transmittable is not identical in these two principles. To distinguish them I will say that (T1) states that the property of being an empirical proposition is *weakly* transmittable whereas (T2) states that the property of being an empirical proposition is *strongly* transmittable.

A counterexample to (T2) can be obtained from (Popper, 1974, 258n):

3. There is now a sea-serpent on view in the entrance hall of the British Museum.
Therefore, there exists a sea-serpent.

According to Popper this has an empirical premise and a metaphysical conclusion. However, to see (3) as a counterexample to (T2) involves accepting Popper's

particular definition of what a metaphysical statement is. For him a statement is metaphysical if it cannot be falsified. The premise of argument (3) can be falsified by actually going to the entrance hall of the British Museum and carefully checking whether or not a sea-serpent is displayed there. Because it can be so falsified, the premise of (3) is an empirical proposition for Popper. The fact that this procedure might result in the premise of (3) being verified is irrelevant to Popper in deciding whether or not it is empirical. The conclusion of (3), by contrast, cannot be falsified, though it could be verified. It cannot be falsified because this would require the entire universe being checked for the presence of sea-serpents. This task could never be completed. That the conclusion of (3) could be verified, by actually encountering a sea-serpent, is irrelevant to Popper in deciding whether or not it is empirical.

Many people have found Popper's account of what constitutes a metaphysical proposition counter-intuitive and it is not universally accepted. It is possible, however, to devise counterexamples to (T2) which do not depend upon Popper's understanding of what constitutes a metaphysical statement. Consider the following two arguments:

4. The speed of light in a vacuum is less than 200 million metres per second. Therefore, either the speed of light in a vacuum is less than 200 million metres per second or God created the universe.
5. Either the speed of light in a vacuum is less than 200 million metres per second or God created the universe. The speed of light in a vacuum is not less than 200 million metres per second. Therefore, God created the universe.

If the disjunction of an empirical proposition with a non-empirical, metaphysical one is taken to be non-empirical and metaphysical, then (4) is a counterexample to (T2). However, if such a disjunction is taken to be empirical, then (5) is a counterexample to (T2). Whether the disjunction of an empirical proposition with a non-empirical one is taken to be either empirical or non-empirical, we have a counter-example to (T2). The conclusion that the property of being an empirical proposition is not transmittable follows by the simple constructive dilemma. It should be noted that the truth or falsity of the premises that occur in arguments (4) and (5) is not at issue here. All that I am concerned to show is that there exists a *valid* argument with consistent premises, all of which are empirical, whose conclusion is neither empirical nor a logical truth.

The argument used to show that the property of being an empirical proposition is

not strongly transmittable makes use of very weak assumptions. It assumes the validity of three patterns of argumentation, namely disjunction introduction, the disjunctive syllogism and the simple constructive dilemma. (Disjunction introduction is needed to establish the validity of (4) and the disjunctive syllogism is needed to establish the validity of (5).) These three argument-patterns are all pretty weak. They are, for example, all valid in intuitionistic logic. In fact, both disjunction introduction and the simple constructive dilemma are also valid in minimal logic, though the disjunctive syllogism is not. Few people, except a small number of extreme intuitionistic mathematicians, regard minimal logic as being an accurate formalisation of everyday and scientific reasoning, but counterexamples to (T2) can even be devised that only make use of patterns of inference that are valid in minimal logic. The heart of the argument showing that (T2) is false is the claim that a disjunctive proposition is either empirical or non-empirical, even if one of its disjuncts is non-empirical. Similarly, a conditional statement must be either empirical or non-empirical even if its antecedent is non-empirical. Consider the following two arguments:

6. The speed of light in a vacuum is greater than 300 million metres per second. Therefore, if God created the universe, then the speed of light in a vacuum is greater than 300 million metres per second.

7. If God created the universe, then the speed of light in a vacuum is greater than 300 million metres per second. The speed of light in a vacuum is not greater than 300 million metres per second. Therefore, God did not create the universe.

If, on the one hand, we take a conditional with a metaphysical, non-empirical antecedent to be non-empirical, then (6) is a counterexample to (T2). On the other hand, if we take such a conditional to be empirical, then (7) is a counterexample to (T2). Argument (6) is valid because it is an instance of the rule known as implication introduction and argument (7) is valid because it is an instance of *modus tollendo tollens* and both of these are valid in minimal logic.

The only other assumption that was made in the two arguments presented above (that were used to show that the property of being an empirical proposition is not strongly transmittable) is the assumption that every proposition is either empirical or non-empirical. This is an instance of the law of the excluded middle and in recent years this law has been severely criticised (Dummett, 1993). However, this instance of the law is not problematic since it is easy to decide whether or not a statement is empirical. Dummett's view is that the law of the

excluded middle is in doubt only in those cases when it is impossible to effectively decide the truth or falsity of the component disjuncts. That is not the case here.

3. Retransmittability

At first sight it appears as if the failure of the property of being an empirical proposition to be transmittable creates grave problems for empiricism. One of the motivations of empiricists like Ayer is to exclude metaphysics from science. If the property of being an empirical proposition were transmittable, then every statement following logically from basic statements whose empirical character is beyond doubt would also be empirical. This means that nothing metaphysical could be part of science. However, the fact that the property of being an empirical proposition is not transmittable means that various sorts of non-empirical material may well enter science. Thus, it looks as if the non-transmittability of the property of being an empirical proposition would radically undermine the empirical purity of science. This, however, need not be the case. To appreciate this we first need to note that Ayer, for example, appears to overlook the role of mathematics in science. Although sometimes scientists make use of arguments all of whose premises are empirical, much of the time the arguments they use also contain mathematical premises. Although the following argument is unlikely to appear in any textbook of physics, it illustrates my point, 'The speed of light in a vacuum is less than 350 million metres per second. A speed of 350 million metres per second is less than one of 400 million metres per second. Therefore, the speed of light in a vacuum is less than 400 million metres per second.' Somebody who is attracted by the view that the property of being an empirical proposition is transmittable would also want to allow such arguments in science. Because of this, I think that critics of empiricism, such as Bartley, are wrong to attach so much importance to the failure of the transmittability of the property of being an empirical proposition. The failure of this principle is not a fatal weakness of empiricism. The retransmittability of the property of being an empirical proposition would achieve much of what empiricists need in order to exclude metaphysics from science. If the property of being an empirical proposition were retransmittable, then an empirical conclusion could not be validly inferred from a set of metaphysical premises.

It is interesting that Frege, one of the fathers of the modern version of empiricism known as analytical philosophy, attached far more importance to the retransmittability of the property of being an empirical proposition than to its

transmittability. Frege was greatly influenced by Kant and accepted Kant's distinction between a priori and a posteriori (or empirical) statements and also his distinction between analytic and synthetic statements. Frege also thought that there were synthetic a priori statements. (An example of such a statement is 'Every event has a cause.') Thus, Frege did not think that every non-empirical statement is analytic. According to (Frege, 1953, 3) the 'distinctions between a priori and a posteriori, synthetic and analytic, concern, as I see it, not the content of the judgement, but the justification for making the judgement.' He goes on to say (Frege, 1953, 4), 'The problem [of how to categorise a judgement] becomes, in fact, that of finding the proof of the proposition, and of following it up right back to the primitive truths.' In the specific case of trying to decide whether a proposition is empirical he lays down the following requirement (Frege, 1953, 4), 'For a truth to be a posteriori, it must be impossible to construct a proof of it without including an appeal to facts, i.e., to truths which cannot be proved and are not general, since they contain assertions about particular objects. But if, on the contrary, its proof can be derived exclusively from general laws, which themselves neither need nor admit of proof, then the truth is a priori.' In these passages Frege is making distinctions between *true* propositions. He does not explicitly consider how we would decide whether or not a *false* proposition was empirical. Frege's requirement for a proposition to be a true, empirical one involves constructing a sound argument with that proposition as its conclusion and not merely a valid one. (A sound argument is one which is valid and all of whose premises are true.) In making the distinctions between a priori and empirical statements and also between analytic and synthetic ones only for true statements Frege is committing the fallacy that Anscombe has dubbed the fallacy of being guided by the truth. (This fallacy is mentioned, for example, in (Geach, 1976, 8).) A correct account of these two distinctions would encompass all statements and not just true ones. In the case of deciding whether or not a statement is empirical I do not think that it is difficult to extend Frege's account to cover both true and false statements.

The definition of a sound argument makes use of the notion of a valid argument. Therefore, I think it is reasonable to suggest that Frege implicitly assumes that the property of being an empirical proposition is retransmittable. His characterisation of a true, empirical statement can then be split into two parts. First, we characterise an empirical statement, irrespective of truth or falsity, and then we characterise its truth. A characterisation of an empirical statement in the

spirit of Frege's definition would then go as follows: For a proposition to be a posteriori it must be impossible to construct a valid argument which has that proposition as its conclusion without including at least one a posteriori premise or one premise which is not general because it mentions particular objects. (The reason for the disjunction in this definition is to accommodate the fact that it might be necessary to construct a chain of valid arguments in order to decide whether a proposition is empirical. Ultimately, the chain will end in basic propositions. The correctness of Frege's characterisation of these as being not general because they mention particular objects is not important here.) To complete the characterisation of a *true* empirical statement all we have to add is that there must exist a *sound* argument with this statement as its conclusion.

The most obvious way of formulating the claim that the property of being an empirical proposition is retransmittable is given in principle (R1):

(R1) If the conclusion of a valid deductive argument is empirical, then at least one of its premises must be as well.

However, because of the way in which validity is defined, counterexamples to (R1) are easy to come by. It follows from the definition of validity that all arguments whose premises form an inconsistent set are valid and all arguments with logically true conclusions are valid. If a proposition is empirical, then it cannot also be logically true. Therefore, to devise a counterexample to (R1) all we need to do is to form an argument with non-empirical premises such that the set of these is inconsistent. As a proposition cannot simultaneously be both empirical and mathematical a suitable counterexample is:

8. The number 7 is prime. The number 7 is not prime. Therefore, the speed of light in a vacuum is greater than 300 million metres per second.

I do not think that anyone attracted to the idea that the property of being an empirical proposition is retransmittable would be unduly concerned by this sort of counterexample. Therefore, it makes sense to strengthen (R1). This is done in principle (R2):

(R2) A valid deductive argument whose set of premises is consistent and whose conclusion is empirical must have at least one empirical premise.

Both (R1) and (R2) can be thought of as capturing the idea that the property of being an empirical proposition is retransmittable, but the sense in which it is retransmittable is not identical in these two principles. To distinguish them I will

say that (R1) states that the property of being an empirical proposition is *weakly* retransmittable whereas (R2) states that the property of being an empirical proposition is *strongly* retransmittable. To devise a counterexample to (R2) consider the following two arguments:

9. God created the universe. Therefore, either God created the universe or the speed of light in a vacuum is greater than 300 million metres per second.

10. Either God created the universe or the speed of light in a vacuum is greater than 300 million metres per second. God did not create the universe. Therefore, the speed of light in a vacuum is greater than 300 million metres per second.

Here, the statement that God created the universe and its negation are both taken to be examples of non-empirical, metaphysical statements. If the disjunction of an empirical proposition with a non-empirical one is taken to be empirical, then (9) is a counterexample to (R2). However, if such a disjunction is taken to be non-empirical, then (10) is a counterexample to (R2). As the disjunction of an empirical and a non-empirical proposition must be either empirical or non-empirical, the falseness of (R2) follows by the simple constructive dilemma.

The argument used to show that the property of being an empirical proposition is not retransmittable makes use of very weak assumptions. In fact, it makes use of the same assumptions as the first argument used above to show the falsity of (T2), that is to say, the argument which hinges on the fact that a disjunction of an empirical and a non-empirical proposition must be either empirical or non-empirical. It assumes the validity of disjunction introduction, the disjunctive syllogism and the simple constructive dilemma and it also assumes that every proposition is either empirical or non-empirical. The discussion of these assumptions that occurs above is, therefore, also relevant here. It is also possible to devise counterexamples to (R2) that make use of conditional propositions rather than disjunctive ones, but I omit the details as nothing new would be added to the discussion by including them. Thus, it is possible to show that (R2) is false using only patterns of argumentation that are valid in minimal logic.

As far as I know no one else has explicitly shown that the property of being an empirical proposition is not retransmittable in either the weak or strong meaning of retransmittability. Nor has anyone else made explicit the assumptions on which these results depend. Discussions of retransmittability are usually to be found in discussions about imperative and deontic logic. For example, in (Hare, 1952, 28) it is stated, '*No imperative conclusion can be validly drawn from a set of*

premisses which does not contain at least one imperative.' In other words, if a valid argument in imperative logic has an imperative conclusion, then it must have at least one imperative premise. That is to say, the property of being an imperative is retransmitted from the conclusion of a valid argument in imperative logic to at least one of its premises. In several articles Geach has presented a number of counterexamples to Hare's claim. (See, for example, (Geach, 1972). (Borowski, 1980) cites other relevant articles by Geach and evaluates them critically.) According to (Prior, 1976, 91) it was T. H. Mott who first used an argument similar to the one that I used above (to show that the property of being an empirical proposition is not strongly retransmittable). However, he used it in the context of deontic logic to show the falsity of the maxim, 'Ethical conclusions never follow from *consistent* premises all of which are non-ethical' (Prior, 1976, 90). Neither Prior nor Mott, however, make explicit what assumptions Mott's argument makes. (Surprisingly, discussions of transmittability are much rarer than discussions of retransmittability in imperative and deontic logic.)

4. Conclusion

Bartley was the first philosopher to make explicit the difference between justificationist and anti-justificationist approaches to epistemology. He stated the transmissibility assumption that is implicit in justificationism. He was particularly critical of empiricism and showed, for example, that various counter-intuitive consequences follow from the fact that, although degree of confirmation is transmittable, the property of being an empirical proposition is not. He, however, understood transmittability in a weak sense. Furthermore, he did not even ask if the property of being an empirical proposition is retransmittable, which is all that some justificationists, like Frege, think that is necessary in order to preserve the justificationist account of empirical knowledge. In this paper I have distinguished between weak and strong senses of transmissibility and retransmissibility and I have shown that the property of being an empirical proposition is neither transmittable nor retransmittable in either the weak or the strong sense of these terms. Furthermore, I have clearly stated the assumptions underlying the counterexamples to principles (T2) and (R2) and shown that they are extremely weak as they are valid in intuitionistic logic. I have also shown that counterexamples to (T2) and (R2) can be devised which only make use of patterns of argumentation that are valid in minimal logic. Hopefully, by explicitly stating these two principles and by showing that they are false I will encourage philosophers who hold them to think some more about the nature of deduction

and how deduction interacts with the property of being an empirical proposition. I do not think that empiricism will be destroyed just because I have shown that both (T2) and (R2) are false, but the falsity of these two principles makes it clear that it is no easy matter to exclude metaphysics from science by insisting that we can only start from empirical and, maybe, mathematical premises.

REFERENCES

- Ayer, A. J. (1946). *Language, Truth and Logic*. Second edition. London: Gollancz.
- Bartley, III, W. W. (1984). *The Retreat to Commitment*. Second edition. London: Open Court.
- Borowski, E. J. (1980). Moral autonomy fights back. *Philosophy*, 55, 95–100.
- Carnap, R. (1950). *Logical Foundations of Probability*. Chicago: University of Chicago Press.
- Dancy, J. (1991). *Introduction to Contemporary Epistemology*. Oxford: Blackwell.
- Dummett, M. (1993). *The Seas of Language*. Oxford: Oxford University Press.
- Frege, G. (1953). *The Foundations of Arithmetic: A Logico-Mathematical Enquiry into the Concept of Number* Oxford: Blackwell.
- Geach, P. T. (1972). Imperatives and practical reasoning. In P. T. Geach, *Logic Matters* (pp. 270–288). Oxford: Blackwell.
- Geach, P. T. (1976). Morally significant theses. *Open Mind*, number 4, 5–12.
- Gjertsen, D. (1989). *Science and Philosophy: Past and Present*. Harmondsworth: Penguin.
- Goodman, N. (1983). *Fact, Fiction and Forecast*. Fourth edition. London: Harvard University Press.
- Hare, R. M. (1952). *The Language of Morals*. Oxford: Clarendon Press.
- Hempel, C. G. (1965). *Aspects of Scientific Explanation and Other Essays in the Philosophy of Science*. London: Collier-Macmillan.
- Hendricks, V. F. (2001). *The Convergence of Scientific Knowledge: A View from the Limit*. London: Kluwer.
- Lakatos, I. (1976). *Proofs and Refutations: The Logic of Mathematical Discovery*. Cambridge: Cambridge University Press.
- Popper, K. R. (1974). *Conjectures and Refutations: The Growth of Scientific Knowledge*. Fifth edition. London: Routledge and Kegan Paul.
- Popper, K. R. (1983). *Realism and the Aim of Science*. London: Routledge.
- Prior, A. N. (1976). The autonomy of ethics. In A. N. Prior, *Papers in Logic and Ethics* (pp. 88–96). London: Duckworth.