From the Pessimistic Induction to Semantic Antirealism

Greg Frost-Arnold[†‡]

The Pessimistic Induction (PI) states: most past scientific theories were radically mistaken; therefore, current theories are probably similarly mistaken. But mistaken in what way? On the usual understanding, such past theories are false. However, on widely held views about reference and presupposition, many theoretical claims of previous scientific theories are neither true nor false. And if substantial portions of past theories are truth-valueless, then the PI leads to semantic antirealism. But most current philosophers of science reject semantic antirealism. So PI proponents face a difficult choice: accept either semantic antirealism or an unorthodox position on reference and presupposition.

1. Introduction. The simplest version of the pessimistic induction (PI) is the following inductive argument:

> All (or 'most') of our past (fundamental) scientific theories are not approximately true—even the ones empirically successful in their time.
>
> Therefore, all (or 'most') of our current (fundamental) scientific theories are probably not approximately true—even the ones empirically successful now.

Realists have offered sophisticated replies this argument. Two leading responses are (i) the inductive base is not representative, so that current theories are relevantly dissimilar from previous ones (Hardin and Rosenberg 1982, 610ff.), and (ii) the parts of superseded theories responsible

†To contact the author, please write to: Philosophy Department, Hobart and William Smith Colleges, 300 Pulteney St., Geneva, NY 14456; e-mail: gfrost-arnold@hws.edu.

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for their empirical success were (approximately) true. For example, Kitcher differentiates a theory's 'working posits' from its 'idle wheels' (1993, 149); Psillos advocates a similar view (1999, 110). Such realists maintain that we are licensed to believe in those posits that generate empirical success but not the remainder of the theory (the 'idle wheels'). These realist maneuvers have generated antirealist responses. Stanford (2006, chaps. 6–7) argues that the distinctions in (i) and (ii) cannot be drawn in a way that simultaneously respects the historical record and saves the realist's core position. Chang (2003) also contests (ii), arguing that false assumptions about caloric served as essential 'working posits' in the derivation of empirically successful theories of heat.

I will not comment on these familiar debates over the PI. I shall bracket questions about how well the historical record, in whole or part, supports or undermines the conclusion of the PI. Rather, I will challenge a standard understanding of the PI, which holds that the fundamental claims of bygone scientific theories are false.[1] I suggest instead that, on views about the language-world relation that are common (although not universal), many of the fundamental hypotheses of discarded past theories are *truth-valueless*, that is, neither true nor false. Why? In the graveyard of superseded science, we find theories whose fundamental claims exhibit certain types of anomaly, such as reference failure, presupposition failure, or partially-defined predicates. On many leading semantic views, some or all of these anomalies lead to sentences that are neither true nor false. Thus, if one accepts these standard semantic views, and accepts (with the proponent of the PI) that present theories are relevantly similar to past ones, then one must accept that certain fundamental claims of our present theories probably lack truth-values too.

But, one might ask, why does it matter whether one thinks of past theories as false or truth-valueless? The PI proponent who considers past theories truth-valueless is committed to a type of scientific antirealism—*semantic antirealism*—that is extremely unpopular today.[2] Semantic antirealism contrasts with the most popular versions of recent scientific antirealism, which follow van Fraassen in adopting *semantic realism* about theoretical discourse and an *epistemological* antirealism. On this view, claims about unobservables have definite truth-values, but we limited beings do not know what those truth-values are. My aim is to argue that

1. For example, "while the history of science is a success story which is without parallel, it is in fact the history of good false theories which have been overthrown by better false theories" (Sankey 1991, 423; see also Stanford 2006, 7).

2. Semantic antirealism about theoretical science is distinct from the general semantic antirealism of Dummett and his followers, who propose that the meaning of any sentence is its conditions of proof or verification, instead of its truth conditions.

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the PI, when joined to currently dominant views about language, instead supports semantic antirealism about science.

Before delving into the details, let us consider two relatively simple and well-known illustrative examples, which motivate the suggestion that past theories contain truth-valueless claims. Within classical mechanics, sentences of the form 'Body b has absolute velocity v_0' are perfectly normal. For example, a Newtonian physicist could claim that the sun has a particular absolute velocity. Now, from a relativistic point of view, the claim

$$v_{\text{sun}} = 0 \tag{1}$$

involves some sort of mistake. In particular, we moderns say that there is no such thing as absolute velocity, so it is incorrect to attribute an absolute velocity of 0 to the sun. So sentence (1) is definitely not true. But now consider the negation of (1); namely,

$$v_{\text{sun}} \neq 0. \tag{2}$$

From the relativistic point of view, this also appears untrue since the sun does not have some other absolute velocity distinct from 0. Since neither (1) nor (2) appear to be true, the prima facie conclusion would be that they are both false.

However, taking both (1) and (2) to be false spells disaster, for then we have a pair of sentences of the form A and $\sim A$ that are both false. But the only way A and $\sim A$ can both be false is if A is both true and false; in short, declaring both (1) and (2) false leads to contradiction. And although Priest argues that there are true contradictions, even he holds that a sentence's being both true and false provides very strong (although defeasible) reason to reject it and that true contradictions appear only under quite rare and special circumstances, for example, the liar sentence (1998). So if we want to hold that neither (1) nor (2) is true, and avoid contradiction, then we can accomplish that by making both (1) and (2) truth-valueless.[3]

Consider another simple and familiar example: the concept of temporal precedence in prerelativistic space-time theories, viewed from a modern, relativistic viewpoint. Consider two events e_1 and e_2 that are spacelike related. Now imagine a Newtonian says that 'e_1 precedes e_2'. We relativists know that, for any two spacelike related events (given a convention for

3. I do not consider this an indisputable demonstration that (1) and (2) must be truth-valueless. For example, one could consistently hold that (1) is false and (2) is true; that is, this case should be understood within the framework of negative free logic, as advocated by Burge (1974) and Braun (1993). But embracing negative free logic is a substantive and contested semantic position, so my overall thesis (the PI proponent is either committed to semantic antirealism or to a substantive, contested semantic view) still holds (see the end of sec. 2).

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simultaneity), in some frames of reference one precedes the other, and in other frames the order is reversed. But for relativists, what is the truth-value of the prerelativist's claim? Intuitively, it is not straightforwardly true or false.[4] We could diagnose the reason for this truth-valuelessness in a number of ways: there is no absolute relation of temporal precedence, or the term 'precedes' is only partially-defined (its extension and antiextension do not exhaust the set of ordered pairs of space-time points), or the sentence incorrectly presupposes a global temporal ordering of space-time points independent of reference frames. The particular diagnosis is unimportant for the ultimate purpose of this article, so long as the Newtonian's sentence lacks a truth-value when e_1 and e_2 are spacelike separated.

Before proceeding, an objection should be addressed. One might agree that certain parts of discarded past theories (such as the two examples just considered) are truth-valueless, but maintain that past theories as wholes are false. This objector begins by noting that superseded theories' observational predictions falling outside the acceptable range of error are unequivocally false. I accept this. The objector continues: 'If theories are thought of as conjunctions of claims, and predictions are claims a theory makes, then the whole theory must be false, since a conjunction with one false conjunct is false'. First, for the theory as a whole to be false instead of truth-valueless, one must accept (an analogue of)[5] the strong Kleene scheme instead of the weak one;[6] thus, a justification for preferring the strong Kleene scheme is needed to justify considering the whole theory false. Second, and more important, regardless of which Kleene scheme one uses, some portions of the historical theories discussed in the realism debate make truth-valueless claims. That is, many individual conjuncts of a theory could still be truth-valueless, and thus, if one accepts the PI, many individual conjuncts of our present theories are likely truth-valueless—a conclusion that would still be very unwelcome. Section 2 argues that, on widely held semantic views, reference failure leads to truth-valueless sentences and that many errors of superseded scientific theories are instances of reference failure. Section 3 does the same for presupposition failure and partially-defined predicates.

4. Unless we assume that the word 'before' in a prerelativist's mouth should be understood as 'before relative to my frame of reference'. But this stretches credulity, given Newton's comments about absolute time in the *Principia*.

5. It is merely analogous because having no truth-value is different from having a third truth-value.

6. Suppose '. . .' is a false string of symbols, and '- - -' is a truth-valueless string of symbols. On the (analog of the) strong Kleene scheme, '. . . and - - -' is false, whereas it is truth-valueless on the weak one.

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2. Designation Failure. Various philosophers have suggested that several types of declarative sentences are neither true nor false; purportedly truth-valueless claims include inter alia future contingents, paradoxical sentences, and category mistakes. More important for present purposes, many claim that sentences containing certain noun phrases that fail to designate are also neither true nor false. This view comes in various flavors, which I shall outline soon, but first I will provide a brief account of how 'designation' is meant here. First, 'designation' covers the relationship between singular terms and the objects that bear them, as well as the relation between natural kind terms and natural kinds. For example, the terms 'Planet Vulcan' and 'caloric' both fail to designate.[7] Second, designation failure comes in two forms: underdesignation, when the term picks out no entity, and overdesignation, when the term picks out more than one entity. For example, 'Vulcan' and 'phlogiston' both underdesignate. Field (1973) introduced the following purported example of overdesignation to philosophers' attention: in special relativity, we can define 'mass' in two ways, either as total energy/c^2 (relativistic mass) or as nonkinetic energy/c^2 (proper or rest mass). Field suggests that the kind term 'mass' in Newtonian writings partially designates proper mass and partially designates relativistic mass.[8] Newton's 'mass' fails to designate, since it fails to pick out a single entity. Consider another less discussed example of overdesignation. The term 'prokaryote', introduced as a natural kind term applying to any organism that was not a eukaryote, actually designates two distinct natural kinds: eubacteria and archaebacteria. (Eubacteria and archaebacteria are at least as genetically distant from one another as each taxon is from the eukaryotes.) 'Prokaryote' fails to designate a single natural kind; it partially designates eubacteria and partially designates archaebacteria. In short, designation failure comes in different forms, for singular terms and natural kind terms, as well as for underdesignating and overdesignating terms.

Why hold that a sentence with nondesignating categorematic terms lacks a truth-value? This is a difficult and far-reaching question and cannot be fully addressed here. I will only provide a brief answer since our ultimate purposes lie elsewhere. We have already seen one motivation in the previous section: to avoid contradiction in the absolute-velocity example. To tackle the question somewhat more systematically, consider a simple case: an atomic sentence *Fa*, where *a* is a name and *F* is a predicate. Here is an intuitive account of the truth conditions for such sentences:

7. Treating names and natural kind terms as semantically similar is not entirely uncontentious, but it is the received view.

8. Earman and Fine (1977) doubt Newton's 'mass' is an example of a multiply denoting term, but since Field has made this example well known, I nonetheless use it.

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Fa is true if and only if the object picked out by *a* determinately has the property picked out by *F*, and *Fa* is false if and only if the object picked out by *a* determinately lacks the property picked out by *F*.[9] But what if either *a* or *F* fails to pick out anything (determinately)? Then neither the condition for truth nor the condition for falsity is met. For example, 'Vulcan orbits the sun' is definitely not true. Nonetheless, it does not meet the characterization of falsity given above; it is not what we might call a 'garden variety' falsehood. This is not meant as an irrefragable demonstration that atomic sentences containing nondesignating terms are neither true nor false; it is only an attempt to articulate and motivate a widespread view of truth and falsity.

A more principled justification for the claim that designation failure leads to truth-value gaps is available. The two leading theories of semantic content for designating expressions are the Direct Reference Theory (DRT) and Fregeanism.[10] Each of these prima facie entails that atomic sentences with nonreferring names or natural kind terms are truth-valueless. Thus, a PI proponent faces an unpleasant dilemma: reject leading semantic views or accept semantic antirealism. Let us consider these two semantic theories in turn.

Direct reference theory holds that:

> (**DRT: names**) The semantic content of a name (if any) is the object (if any) to which the name refers.
>
> (**DRT: kind terms**) The semantic content of a natural kind term (if any) is the property or kind (if any) to which the natural kind term refers.
>
> (**DRT: sentences**) The semantic content, if any, of a sentence containing a name (respectively, natural kind term) includes the object (respectively, natural kind), if any, to which that name (respectively, natural kind term) refers.

Accepting DRT pushes one to the view that certain sentences with nonreferring terms lack truth-value: a term that fails to refer expresses no semantic content. Thus, a sentence containing such a term will be 'infected', so to speak, and will also fail to express a complete proposition.

9. I include 'determinately' here to rule out vague predicates.

10. I set aside the other leading family of theories of semantic content, Inferential Role Semantics (IRS). Why? Fregeanism and DRT take as their central concepts *truth* and *reference* (or designation), whereas IRS theories try to do without these concepts or explain them in terms of conceptual role. But the question in the scientific realism debate is standardly couched as, 'Are scientific theories (approximately) true, and do their central theoretical terms refer?'

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Some advocates of DRT embrace the 'no proposition view': sentences with nondesignating categorematic terms express no proposition. Donnellan (1974) and Russell (1986, 207–8) hold this view. Others opt for the 'partial proposition view': a sentence with a nondesignating term expresses an incomplete proposition, and incomplete propositions lack a truth-value. Sentences with nondesignating terms are not nonsense, for they have some meaningful components combined appropriately, but those meaningful components nonetheless fail to generate something truth-valued upon combination. The view that partial propositions are truth-valueless is elaborated and defended in Taylor (2000), Reimer (2001), and Everett (2003), among others.

Frege claimed that empty names have sense but no reference. And because both sense and reference are compositional, sentences containing empty names can express senses yet have no reference, which for Frege is a truth-value. He writes: "The sentence 'Odysseus was set ashore at Ithaca while sound asleep' obviously has a sense. But since it is doubtful whether the name 'Odysseus', occurring therein, has a *Bedeutung*, it is also doubtful whether the whole sentence does" (1892/1997, 157). That is, 'Odysseus fell asleep on the beach' expresses a complete sense. However, this sentence nonetheless has no truth-value, in agreement with the partial- and no-proposition views. Thus, for Fregeans as well as direct reference theorists, if past scientific theories are replete with nondesignating terms, then prima facie such theories contain sentences that are neither true nor false (because they express either a complete sense without a reference, a partial proposition, or no proposition at all). Our earlier '$v_{\text{sun}} = 0$' is a clear example: there is no such kind as *absolute velocity*, and this designation failure leads to truth-valuelessness.

But absolute velocity is not an isolated instance. If we examine the launching point for modern discussions of the PI, Laudan's original list of empirically successful scientific theories that were ultimately incorrect, we find that he explicitly selects theories whose central terms apparently fail to designate (Laudan 1981, 33). For example, proponents of the theories on Laudan's list would accept 'Respiration and combustion are easier in airs without phlogiston'; 'Light waves propagate through the ether'; 'In any closed system, caloric is always conserved'; 'The entelechy of sea urchin embryos differs from that of water hydrae'; and 'Vulcan is between the sun and Mercury'. All these sentences contain nondesignating terms. None are true. On the most straightforward understanding of both DRT and Fregeanism, the two leading semantic views based on the notions of truth and reference, these sentences lack a truth-value.

Note 'the most straightforward understanding of DRT and Fregeanism'. Some proponents of these semantic theories are unhappy with the widespread truth-valuelessness their basic theory implies, and thus they

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introduce various theoretical maneuvers to eliminate truth-value gaps. There is a sizable literature on the subject, and the discussion has become multifaceted and subtle, so it cannot be explored here. It suffices to note that these attempts to eliminate truth-value gaps often involve either ad hoc elements introduced solely to 'save' partial propositions from being truth-valueless or counterintuitive consequences (e.g., if one holds that all atomic sentences with nonreferring names are false, then 'Vulcan = Vulcan' is false and 'Vulcan ≠ Vulcan' is true). But this is a rich and difficult debate, and it would be unfair to hold that none of these maneuvers could ultimately be successful. I only insist on one point: if the advocate of the PI holds that designation failure is common in the historical record but wants to avoid semantic antirealism, then she must make substantive, highly contested commitments in the philosophy of language.

3. Other Sources of Truth-Value Gaps. My main argument does not require that the semantically anomalous sentences found throughout the historical record involve designation failure; any mechanism that generates truth-value gaps will do. This section considers two other such mechanisms: presupposition failure and partially-defined predicates.

3.1. Presupposition Failure. Consider the following claim: 'Joe stopped smoking yesterday'. Intuitively, someone who utters this sentence takes for granted or *presupposes* that Joe has, at some past point in his life, been a smoker. Why? If this sentence is true, then Joe was a smoker up until yesterday; if it is false, then apparently either Joe is still smoking or Joe was a smoker up until a time earlier than yesterday. So if either it is true or it is false, then Joe was a smoker at some point in the past. If this description of the situation is correct, then we have an example of what is called a 'semantic presupposition': 'Joe stopped smoking yesterday' presupposes that Joe smoked at some earlier time. This analysis fits the following canonical account:

> S semantically presupposes $P \equiv$ if S is either true or false, then P is true.

In other words, if P is not true, then S is neither true nor false. This characterization is intended to capture a fair amount of 'intuitive' presuppositions.

Hopefully the similarity between 'Joe stopped smoking yesterday' and the examples from the historical graveyard of science is evident. For example, consider the claim 'Events e_1 and e_2 are simultaneous' in a Newtonian's mouth, where e_1 and e_2 are spacelike separated. This claim apparently presupposes that there is a unique global time order, for without

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such, there is no standard of simultaneity that the two events can determinately meet—or fail to meet. Similarly, '$v_{sun} = 0$' appears to presuppose that absolute velocity exists and that the sun has some absolute velocity. For '$v_{sun} = 0$' is not straightforwardly true or false, if there is no such thing as absolute velocity. For if I say that it is simply false, then I appear to be saying that the sun has some other absolute velocity distinct from zero. This example shows why reference failure is often thought of as a species of presupposition failure.[11] I have separated the two cases because people who have reservations about the semantic account of presupposition in general may nonetheless accept that reference failure in particular generates truth-value gaps.

Whether 'intuitive' or 'felt' presuppositions are best explained via the semantic account above is disputed, and there is an enormous amount of linguistic and philosophical literature on the topic (Horn 1985; Atlas 1989; Burton-Roberts 1999; Carston 1999). This debate has become sophisticated and esoteric, so I will refrain from advancing any substantive claims about the contentious issues here. However, although there is some suspicion about the coherence and applicability of the above semantic account of presupposition,[12] nonetheless many semanticists forge ahead with their research agendas, which accept and use a semantic account of presupposition (e.g., Heim and Kratzer 1998; von Fintel 2004; Lasersohn 2005).

However, suppose one grants that the semantic account of presupposition above is deficient for some reason. How do we then explain the felt difference between presuppositions and 'normal' entailments? The usual answer is that presupposition should be understood as a pragmatic matter, not a semantic one.[13] The pragmatic notion of presupposition is closer to the pretheoretical notion of a presupposition as something uncontroversially taken as recognized background knowledge in a communicative act.

How does pragmatic presupposition relate to the issue of truth-value gaps? According to some, certain utterances exhibiting pragmatic pre-

11. As Burton-Roberts says, "Much of the interest in presupposition centres precisely on the use of expressions that cannot be assigned a referent" (1999, 357).

12. For example, 'The present king of France is sitting next to me' (spoken by me now) seems false, not truth-valueless. Von Fintel (2004) defends the semantic account of presupposition from this difficulty and others.

13. Here is Stalnaker's canonical definition: "A proposition *P* is a pragmatic presupposition of a speaker in a given context just in case the speaker assumes or believes that *P*, assumes or believes that his addressee assumes or believes that *P*, and assumes or believes that his addressee recognizes that he is making these assumptions or has these beliefs" (1974, 200).

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supposition failure do not make genuine assertions at all—and thus such utterances would be neither true nor false, just like any other sounds emanating from a speaker's mouth that fail to express propositions. Atlas, a critic of semantic presupposition, holds this view (1989, 86). Glanzberg agrees that some cases of pragmatic presupposition failure result in a failure to express a proposition (2005). Thus, even those who deny that presupposition is best explained semantically can be committed to the view that utterances with failed presuppositions lack truth-values since those utterances may fail to express any proposition. Someone who holds such a pragmatic view of presupposition should be a semantic antirealist about many of the fundamental claims of past scientists.

3.2. Partially-Defined Predicates. Sources other than presupposition or reference failure could possibly make historical scientific claims truth-valueless. One such possibility is *partially-defined predicates*.[14] If a property or relation is undefined over certain objects, it is reasonable to hold that an atomic sentence is truth-valueless if it expresses that that property holds of those certain objects. This may be the best model for the previously discussed case of temporal predicates in the mouth of a Newtonian physicist. That is, 'e_1 precedes e_2' has a truth-value for certain values of space-time points e_1 and e_2—namely, for all causally related e_1, e_2. Every ordered pair of events $\langle e_1, e_2 \rangle$ such that e_2 lies in the future-directed light cone of e_1 is in the extension of 'e_1 precedes e_2', and every ordered pair $\langle e_1, e_2 \rangle$ such that e_2 lies in the past-directed light cone of e_1 is in the predicate's antiextension. However, any pair of events that cannot be connected by a causal signal is in neither the extension nor the antiextension of 'precedes'.

Some may think that partially-defined predicates are relatively scarce within the historical record. Then, even if we admit that predicates like 'precedes' generate truth-valueless sentences, such linguistic items are so rare that only a miniscule portion of theoretical scientific discourse would become truth-valueless. However, many philosophers of science hold that scientific terms exhibit *open texture*: there are cases in which it is not clear whether the term applies or not. Put otherwise, the term is *vague*: its conditions of application do not exhaust all grammatically permissible subjects of predication. And one appealing way to formally model vagueness or open texture is via partially-defined predicates. Vagueness, of course, has been the subject of intense and sustained study in Anglophone philosophy for the last 2 decades, and this attention has brought a welter of philosophical accounts of vagueness in its wake. For present purposes,

14. Some classify this as another type of presupposition failure (e.g., Soames 1989).

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however, only two points from the literature are important: first, on many accounts of vagueness, certain sentences involving vague predicates (sentences about 'borderline cases') are neither true nor false. Second, there appears to be good evidence that (from the point of view of our present linguistic practices) central terms of past scientific language are vague; LaPorte has forcefully argued for this point for terms such as 'species', 'mammal', and even 'water' (2004). If certain sentences involving vague terms are neither true nor false, and our past scientific discourse is shot through with vague terms, then it seems that truth-valuelessness due to vagueness may appear throughout the historical record. And if one accepts the supposition of the PI that present theories are relevantly similar to past ones, then this is a third way in which many of our theoretical claims today likely lack truth-values.

4. Conclusion. I have not argued for or against the PI. My claim is that if you accept that (i) present theories are relevantly similar to past ones; (ii) historical scientific claims exhibit significant designation failure, presupposition failure, or partially-defined predicates; and (iii) these three anomalies in (ii) lead to truth-valueless sentences, then you are saddled with a form of semantic antirealism. The PI advocate can avoid semantic antirealism, but only at a price. To avoid the conclusion of semantic antirealism, the PI proponent must make substantive, highly contested commitments in philosophy of language (thereby denying iii) or in the interpretation of the scientific record (denying ii).

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