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The Magic of Ad Hoc Solutions

ABSTRACT: *When a theory is confronted with a problem such as a paradox, an empirical anomaly, or a vicious regress, one may change part of the theory to solve that problem. Sometimes the proposed solution is considered ad hoc. This paper gives a new definition of 'ad hoc solution' as used in both philosophy and science. I argue that a solution is ad hoc if it fails to live up to the explanatory requirements of a theory because the solution is not backed by an explanation or because it does not diagnose the problem. Ad hoc solutions are thus magical: they solve a problem without providing insight. This definition helps to explain both why ad hoc solutions are bad and why there may be disagreement about cases.*

KEYWORDS: ad hoc solution, explanation, Lorentz-FitzGerald contraction hypothesis, liar paradox, Church-Fitch paradox.

Introduction

From the late 1950s until the 1980s ad hoc hypotheses were all the rage. Not that science was in a particularly bad state at that time; but due to Popper, philosophers of science were obsessed with ad hoccery. If science progresses via falsification, as Popper thought, we should ensure that theorists do not immunize their pet theories by devising additional hypotheses whenever experimental data contradicts their theory. But the history of science shows that additional hypotheses do sometimes constitute fruitful developments of a theory. For Popper and his school, the problem of determining which hypotheses are degenerative rather than progressive is the problem of determining which hypotheses are ad hoc. (The term 'ad hoc' has a pejorative and nonpejorative meaning. Here I am only interested in its pejorative sense.)

Despite the benefit of hindsight, the falsificationists were unable to give a definition of 'ad hoc hypothesis' that conformed to the usage of scientists in the examples they discussed. The main problem was that they considered empirical testability a cornerstone of science, and (thence?) ad hoccery should be some lack of testability. But nothing in the scientific literature suggests that scientists consider a hypothesis ad hoc if it lacks testable consequences. Worse, some hypotheses

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were considered ad hoc even though they did have independently testable consequences. Jarrett Leplin mockingly observes that what followed were 'distinctions and refinements [that] constitute something like a degenerating research program, many of whose entries are patently *ad hoc*' (1975: 314 fn.16).

Leplin's comment illustrates that philosophers are not immune to giving ad hoc solutions. But although there is a large body of philosophical literature about ad hoc hypotheses in science, there is little work on ad hoccery more generally. Worse, many definitions of ad hoccery only apply to solutions suggested when faced with an empirical anomaly, thus excluding most parts of philosophy. But there is nothing to suggest that when a physicist claims some solution is 'ad hoc', they mean something quite different from when a philosopher makes a similar claim. On the contrary, it is likely that 'ad hoc solution' means roughly the same thing in different fields. There are differences between specific fields: physics uses different methods than (say) history. But at a very general level, in all fields of rational inquiry one develops theories based on evidence with the aim of explaining certain aspects of the world. Such theories may run into problems for which solutions are then proposed. Some of these solutions are called 'ad hoc'. Other semitechnical terms in the vicinity of 'ad hoc solution'—'begging the question', 'special pleading', and 'moving the goalposts'—mean the same thing whether used by physicists, historians, or philosophers. This is one reason to think 'ad hoc solution' is not polysemous.

A second reason is that 'ad hoc solution' fails three standard tests for polysemy. The first is conjunction reduction. For example, 'credit' can mean praise as well as a type of loan from a bank. Conjoining sentences that use these different senses results in ambiguity. For example, 'Jane and Anna got credit from the bank for their work' is ambiguous, while 'Jane got credit from the bank' and 'Anna got credit for her work' are unambiguous. However, 'Jane gave an ad hoc solution to a paradox' and 'Anna gave an ad hoc solution to an experimental anomaly' can be conjoined unambiguously into 'Jane and Anne gave ad hoc solutions to a paradox and an experimental anomaly'.

Another test is ellipsis: unless a polysemous term is used univocally, it is inappropriate to ellipse it. Thus, if Jane wants to participate as a runner in a marathon, while Anna wants to organize that marathon, one cannot express this as 'Jane tried to run the marathon and Anna did too'. However, 'Lorentz once proposed an ad hoc solution and so did Tarski' is perfectly all right. Finally, polysemous terms can avoid contradictory readings. Since Jane wants to participate in, but not organize, the marathon, one can say without contradiction that Jane wanted to run the marathon, but she did not want to run the marathon. It is an awkward formulation, but contradiction is avoided because of polysemy. No such noncontradictory reading seems available for 'Lorentz's contraction hypothesis was an ad hoc solution, but it was not an ad hoc solution'.

Thus, *pace* Lakatos (1970), 'ad hoc' does not have multiple senses and unless we find good evidence that 'ad hoc solution' means something different in the context of one field than it does in another, we better have a definition of 'ad hoc solution' that applies across the board. But currently there is not even any attempt made at such a definition.

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This paper aims to fill that lacuna by giving a definition of 'ad hoc solution' that applies to science and also to philosophy. I argue in particular that once we add the concept of explanation, we gain an adequate understanding of ad hoccery. This more general definition also gives insight into why ad hoc solutions are bad, and it helps explain why some may disagree whether a solution is indeed ad hoc.

Before giving my definition, I discuss the most common associations people have with ad hoccery in section 1 and show how those fail to provide necessary or sufficient conditions for ad hoccery. In section 2 I define 'ad hoc solution' in terms of explanatory failure, and in section 3 I apply this definition to the discussion about the Church-Fitch paradox of knowability, the discussion about the axioms of Zermelo-Fraenkel (ZF) set theory, and the Lorentz-FitzGerald contraction hypothesis. I conclude with some remarks about the relation between ad hoccery and our theories of explanation.

1. Some Stubborn Associations

The Latin phrase 'ad hoc' translates 'to this', and the adjective 'ad hoc' is commonly defined as 'created for a specific purpose'. The many definitions given in the philosophy of science literature may suggest that 'ad hoc' is not used for a specific purpose but is rather a highly polysemous term. To restore order, we should rid ourselves of some stubborn associations by showing that none of these are necessary or sufficient for something to count as ad hoc.

The first of these associations is that ad hoc hypotheses lack testability or empirical content. Popper made this the cornerstone of his notion of ad hoccery (1959: 83; 1965: 241). But scientists *do* consider some testable hypotheses ad hoc—even when the hypothesis makes predictions beyond the specific experiment that brought about the problem for the original theory. The endlessly discussed Lorentz-FitzGerald contraction hypothesis (LFC), which Popper (1959: 83) considered a paradigmatic example of an ad hoc hypothesis, did have (novel) testable consequences: the result of the Kennedy-Thorndike experiment in 1931 constituted an empirical refutation of it (Grünbaum 1959: 49ff.).

Neither is lack of testability sufficient for ad hoccery unless virtually all hypotheses in fields such as philosophy, mathematics, or history count as ad hoc. Hypotheses in these fields are commonly not experimentally testable. Popper and others in this tradition usually limit their definition to the use of 'ad hoc' in the sciences and in particular physics, thus implicitly holding that 'ad hoc' is polysemous. Worse, it is not obvious that hypotheses in physics that lack testable consequences are ad hoc. String theory is currently untestable, and the multiverse hypothesis seems untestable in principle. But to the best of my knowledge, no one currently complains that they therefore are ad hoc: testability thus does not seem sufficient for ad hoccery. Better to abandon this 'strange fixation on testability' (Leplin 1975: 345). (For more arguments against lack of testability as a cornerstone for ad hoccery, see *inter alia*: Bamford 1993, Grünbaum 1976: 342ff., and Hunt 2012: 3ff.)

A second association is with circular explanations. Popper takes ad hoc explanations to be 'almost circular' (1972: 192), and David Miller gives 'it is the

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dormitive virtue of opium that induces sleep' as an example of an ad hoc hypothesis that is 'supposedly explanatory' (1981: 6–7). Since 'dormitive virtue' just means 'the ability to induce sleep', this is a circular explanation. But it is unclear what is ad hoc about it—unless, of course, all explanatory failures are ad hoc. Conversely, there are paradigmatic cases of ad hoccery, such as the LFC, that are clearly not circular explanations. If the LFC were a circular explanation, then the phenomena it explained should provide (part of) its explanation. The phenomena it explained did not provide the explanation for the LFC but were (part of) the *justification* for the LFC. But justification and explanation are distinct notions. My justification for believing that it is raining is that I see the rain, but (me seeing) the rain does not explain why it is raining. (Although it does help explain why I *believe* it is raining. But the target of explanation is the fact that it rains, not the fact that I believe that it is raining.) It thus seems that two fallacies are here combined by a fallacy of association. (For more on why circular explanations are different from ad hoc explanations, see Bamford 1993: 336ff.)

A third, related association is that ad hoc solutions lack independent evidence or independent reasons (Schaffner 1974: 68; Zahar 1973: 101ff.). Roughly, the idea is that a solution is ad hoc if the problem it solves is the only evidence or reason that can be given for it. Of course, it is a good thing when your hypothesis is corroborated by various pieces of independent evidence. But the history of science suggests that a lack of independent evidence is not sufficient to consider a hypothesis ad hoc. The only empirical evidence for the postulation of Neptune was an anomaly in the expected movement of Uranus; yet, there is no evidence that scientists considered it ad hoc (Leplin 1982: 237). Similarly, the redshift of a galaxy's characteristic spectrum is explained by the velocity of the galaxy although there is little evidence for the velocity of a galaxy beyond its redshift (Lipton 2001: 45).

Conversely, no scientist at the time seemed to think that additional (experimental) evidence for the LFC would make it less ad hoc (Holton 1969: 177). And, as a more extreme example, a parapsychologist who holds that psychic phenomena are disturbed by the presence of inquisitive or skeptical observers can point to a wide range of corroborating cases where psychic phenomena were different from their expectations (Boudry 2013: 249). Still, the parapsychologist's hypothesis is ad hoc. In sum, there is little evidence for the idea that a hypothesis is ad hoc if and only if it lacks independent evidence.

A lack of generality or a failure to unify is a fourth association (Lange 2001; Leplin 1975: 336ff.). The idea is that non-ad hoc solutions solve similar problems and therefore unify these problems. Unfortunately, some solutions are ad hoc even if they take care of various related problems. I solve Russell's paradox by holding that every predicate specifies a set except in those cases where this would result in paradox. Moreover, my solution is general and unified: all these paradoxes have in common that supposing the existence of some set leads to a paradox. Still, the solution is blatantly ad hoc (Hand and Kvanvig 1999: 426). (Another example would be the parapsychologist's hypothesis mentioned in the previous paragraph.)

Conversely, not every exception to a general rule is ad hoc. Many sweeping scientific generalizations are, in the face of new data, restricted, and this is often considered progress. Bamford (1993) illustrates this by Hooke's law, which states

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that the extension of a spring is proportional to the force exerted on the spring. Springs do not always behave in accordance with Hooke's law; the point at which they stop behaving in that way is their elastic limit. Knowledge of the elastic limit of a material and how this limit changes due to fatigue is indeed crucial for designing bridges (Bamford 1993: 305ff.). But all these exceptions to Hooke's law do not make the theory of springs ad hoc. (At least to my knowledge no one ever made that complaint.)

Some accounts of ad hoccery combine some of these associations. For example, Leplin's (1975: 337) detailed analysis of ad hoccery states, among other things, that if a hypothesis is ad hoc, then (i) there is no other evidence for it other than the experiment for which the hypothesis was formulated, (ii) the hypothesis has no applications outside of that experiment, and (iii) it has no independent theoretical support. But as we just saw, neither lack of independent evidence nor lack of generalizability is necessary for ad hoccery. Moreover, Leplin thinks ad hoccery is a global affair. He states that if a hypothesis is ad hoc, there are problems other than the specific experimental anomaly that triggered the hypothesis. These other problems indicate that the theory is 'non-fundamental': that the problems cannot be solved unless the non-fundamentality is removed, and that 'a satisfactory solution to any of these problems . . . must contribute to the solution of the others' (1975: 337). I do not see why ad hoccery cannot be local. Below I discuss two examples (a theory of bread and the Church-Fitch paradox) that are local: there are no obvious other problems that need to be dealt with too.

This ends our association game. Time to look at the problem of ad hoccery with fresh eyes.

2. Ad Hoc Solutions

Let us start with the classic toy example of the nourishment of bread. Suppose our basic bread theory states that all bread nourishes. This helps explain various bread-related facts, but it also faces a challenge. In August 1951 at least five people from the French village Pont Saint-Esprit died after eating bread. Not all bread nourishes, it seems, and our basic bread theory needs changing. A straightforward solution is to restrict the general statement of our theory: all bread nourishes, *except* the bread in Pont Saint-Esprit in August 1951. Now the tragedy of Pont Saint-Esprit no longer contradicts our theory. This is a good thing. At the same time, the solution is fishy and a paradigm of ad hoccery. Why?

It is important to note that the exception is true. The bread in Pont Saint-Esprit did not nourish while bread normally does. Every solution should thus state that the bread in Pont Saint-Esprit was not nourishing or at least be compatible with this claim; otherwise the resulting theory is simply false. The restriction itself can thus not be what is ad hoc: all solutions should exclude the bread from Pont Saint-Esprit from the nourishing bread. But not all solutions are considered ad hoc. We can understand why some are ad hoc if we focus on explanation. The simple exclusion solution gives no clue as to *why* the bread from Pont Saint-Esprit did not nourish while any satisfactory solution should explain this fact. Its explanatory failure, I submit, is what makes the simple exclusion solution ad hoc.

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Contrast the simple exclusion with the ergot solution that states that all bread nourishes except bread that contains ergot and that the bread from Pont Saint-Esprit contained ergot. Neither solution is contradicted by the tragedy of Pont Saint-Esprit so they are equal in that respect. But the ergot solution has more explanatory depth: it can answer the question why the bread of Pont Saint-Esprit did not nourish. While the simple exclusion solution takes this as an unexplained fact, the ergot solution explains it: the bread contained ergot, and bread containing ergot does not nourish. The ergot solution thus explains or, as I prefer to put it, *diagnoses* the problem by pointing to a feature of the bread in Pont Saint-Esprit that is responsible for its failure to nourish. By 'diagnosing a problem' I thus mean an explanation for why the problem arose. (Note that this need not be an explanation for why the problem is indeed a problem. In our example we want an explanation for why the bread in Pont Saint-Esprit did not nourish. We are not interested in explaining why it is a problem for the original theory that the bread in Pont Saint-Esprit did not nourish. One should explain why theories should be empirically adequate to meet this latter explanatory demand. A diagnosis merely explains how the problem arose and takes it for granted that the problem is indeed a problem.)

The ergot solution as it stands may still be somewhat wanting. It solves the problem of the bread in Pont Saint-Esprit using an entity that (apparently) counters bread's capacity to nourish. But why does bread containing ergot fail to nourish? And what exactly is ergot? Some might say this solution is still not free of ad hoccery. Compare it with the poison solution, which holds that the bread in Pont Saint-Esprit contained a poison and that all bread nourishes except when it contains a poison. While the ergot solution triggers the question 'why does bread containing ergot fail to nourish?', the poison solution triggers no analogous question. In many contexts it is considered obvious that bread containing a poison fails to nourish. Poisons are bad for human beings, and therefore bread containing them will have a bad effect on human beings eating that bread. The poison solution is thus *backed by* a sufficient explanation.

Despite this, the poison solution may not be overall better than the ergot solution, because the first provides a less specific diagnosis than the latter. The diagnosis of the poison solution is that the bread in Pont Saint-Esprit contained a poison. But this is arguably too general. There are many poisons, and the poison solution does not single out a particular one that the bread in Pont Saint-Esprit was supposed to contain. It raises the question which poison was in the bread exactly? Ideally, we would thus want a theory that provides both a specific diagnosis and is backed by an explanation. Of course, in our example this is achieved by combining the last two solutions, that is, the ergot-poisoning solution, which states that (a) all bread nourishes except when it contains a poison; (b) ergot is a poison; and (c) the bread in Pont Saint-Esprit contained ergot. In many contexts claim (a) is not in need of any further explanation. The diagnosis (c) is now backed by (a) and (b) because these latter two answer the question why bread containing ergot fails to nourish. The resulting theory thus provides a non-ad hoc solution to the problem of the bread of Pont Saint-Esprit because it diagnoses the problem, and the diagnosis is backed by an explanation. The simple exclusion solution, on the other hand, provides an ad hoc solution because it fails to diagnose the problem, and, trivially, its diagnosis is not backed by an explanation.

More generally, I claim that 'ad hoc' is used in philosophy and science for solutions that are non-explanatory, thus:

(Ad Hoc) A solution to a problem is *ad hoc* if and only if

(i) the solution is nonexplanatory, that is,
(a) the solution does not diagnose the problem, or [Diagnosis]
(b) the solution is not backed by a good explanation; and [Explanation]
(ii) it is reasonable to demand a solution that diagnoses the problem and is backed by a good explanation. [Reasonable]

An ad hoc solution is thus mysterious either because it does not diagnose the problem or because it is not backed by a good explanation. And this mystery is problematic because a non-mysterious solution is reasonably demanded. I have defined ad hoccery for solutions rather than for hypotheses because ad hoccery mostly comes up in the context of problems: empirical anomalies, paradoxes, vicious regresses, and so on. (Many definitions of 'ad hoc hypothesis' therefore state that the hypothesis is proposed as a solution to some empirical anomaly.) It may help to go over the conditions in (Ad Hoc) in some more detail.

The first condition states that the solution is not explanatory because (a) it fails to diagnose the problem or (b) it is not backed by an explanation. To diagnose a problem is to explain how it arose in the first place. In the above example both the ergot solution and the ergot-poison solution diagnosed the problem as arising from ergot in the bread. The diagnosis in this case thus introduces an object that is held responsible, but a diagnosis may instead delete rather than introduce an object. The problems of phlogiston theory may, for example, be diagnosed as arising from the mistaken assumption that phlogiston exists. (Diagnosing is easier with the benefit of hindsight.) And some diagnoses are orthogonal to matters of existence: a diagnosis of the Grelling-Nelson paradox ('Is "heterological" a heterological word?') would not point to an object that is responsible for the paradox but may point out a property of natural languages (that they are semantically closed, for example).

A solution is backed by an explanation when it is explained how the solution solves the problem. In the bread example, the simple exclusion solution was not backed by an explanation because there was no answer to the question why the bread in Pont Saint-Esprit did not nourish. But neither was the ergot solution backed by an explanation because (to most people) it would be unclear why the presence of ergot in the bread ensures that it no longer nourishes. The poison solution was backed by an explanation: something that is nutritious in normal circumstances is no longer nutritious when it contains a poison. And the final solution we discussed partly used this same explanatory backing: ergot is a poison, and something that is nutritious in normal circumstances is no longer nutritious when it contains a poison; *therefore*, bread containing ergot fails to nourish.

In the bread example we saw also that more general diagnoses, which may apply to more cases than the case at hand, are not necessarily better. Blaming poison whenever a nourishing substance fails to nourish is a general solution, but we often want to know specifics. On the other hand, a good diagnosis can often be generalized—other products made from grain and containing ergot will also fail to nourish. Generality is thus a bad predictor for the quality of a diagnosis: good diagnoses can often be generalized, but a general diagnosis may be too general to be informative. Clearly, it may be debatable whether a diagnosis is good, which explains why we may disagree about ad hoccery.

I should stress that the distinction between diagnoses and explanations is artificial: a diagnosis is a kind of explanation. But the bread example shows that not every diagnosis is backed by an explanation, and therefore I have chosen the term 'diagnosis' for that which explains how the problem arose so that 'explanation' can be unambiguously used for that which backs the solution. I take the term 'diagnosis' from Stephen Read who argues that Buridan's solution to the liar and revenge paradoxes is 'an *ad hoc* device designed solely, and without any real diagnosis, to block the paradoxes' (2002: 202). (Indeed, not everyone agrees with Read's claim, see Benétreau-Dupin 2015; Hughes 1984: 20; and Klima 2008.)

In the context of theories of truth, there is another good example of a solution that does *not* diagnose a problem. Deflationists hold that there is not much to truth; it is completely characterized by (T): 'p' is true if and only if p. Like many other theories of truth, deflationism faces a problem with the liar sentence: 'this sentence is not true'. By applying (T) to the liar and using some basic logic, we get a contradiction. One way out for deflationists is to restrict (T) so it does not apply to those propositions that lead to a paradox. This solves the problem but without diagnosing it because it does not tell us *why* applying (T) to some sentences leads to a contradiction.

Contrast this with a solution that bans all self-referential sentences from (T). This solution diagnoses the problem as due to self-referentiality; the liar results in paradox *because* it is self-referential. This response might still be ad hoc, though, for it seems to meet condition (i) (b): the solution is not backed by an explanation. The claim that self-referentiality is problematic needs to be backed by an explanation if only because not all self-referential sentences seem problematic. 'This sentence contains five words' is a perfectly consistent self-referential sentence. Hence, unless backed by an explanation, the self-referentiality response may be ad hoc although for a slightly different reason than the previous solution. (Of course, the self-referentiality response might just be bad because it is false. Or maybe it is both false and ad hoc: ad hoccery offers no protection against other vices.)

To avoid satisfying condition (i) of (Ad Hoc) a solution should both diagnose the problem and, unless the solution is not in need of an explanation, be backed by an explanation. This link between ad hoccery and explanatory failure can also be found in Read's assessment of Paul Horwich's deflationist solution to the liar:

> The fact that he [Horwich] excludes the paradoxical cases of (T) from the account of truth shows, first, the ad hoc and unsatisfactory nature of his account of the paradoxes—after all, he has no further account of truth to which he can appeal to explain the exclusion. (Read 2002: 214)

A similar sentiment is expressed by J.C. Beall and Bradley Armour-Garb:

> Nothing in deflationism itself yields a principled explanation of why such sentences should not be within the range of (T)'s variables (as it were). This leaves open the possibility that deflationists may none the less resort to *ad hoc* restrictions. (Beall and Armour-Garb 2003: 313)

It may of course happen that a solution lacks both a diagnosis and an explanatory backing. For example, Read seems to think that 'to explain the exclusion' Horwich should provide both a diagnosis of the paradox and an explanatory backing for the exclusion of the problematic sentences.

I will add one small aside about Samuel Schindler's (2018: 59) analysis of ad hoccery because it resembles (Ad Hoc) in some sense. Schindler holds that a hypothesis is non-ad hoc if it coheres with the theory at hand or the relevant background theories, and a hypothesis coheres with the (background) theory just in case the theory provides theoretical reasons for believing the hypothesis. If the hypothesis can be deduced from the (background) theory, then, for Schindler, this constitutes a theoretical reason to believe the hypothesis. Another theoretical reason for believing a hypothesis is if the (background) theory *explains* why the hypothesis is true. This latter idea is somewhat similar to condition (i) (b) of (Ad Hoc). But note that coherence plays no role in (Ad Hoc) and that mere deduction of a solution is, under (Ad Hoc), insufficient to save it from ad hoccery. Moreover, Schindler's definition of 'ad hoc hypothesis' only covers hypotheses that are 'are introduced to save a theory . . . from empirical refutation' (2018: 59) and is thus inapplicable in most philosophical contexts.

Just as there may be disagreement about the quality of a diagnosis or about the quality of the explanation backing the diagnosis, there may be disagreement about whether the diagnosis needs an explanation. In the bread example, someone might demand a further explanation for why ergot is poisonous. This demand is reasonable in the context of chemistry and biology where we seek to explain why some substances are poisonous. But the demand may be unreasonable in the context of history.

Which brings us to the second condition: just because you can cook up a why-question that the solution does not answer, does not mean that the solution is ad hoc. Some demands for explanation are unreasonable, and condition (ii) ensures that failing to live up to an unreasonable demand does not make a solution ad hoc. Again, there may be disagreement about whether demanding an explanation is reasonable and thus disagreement about whether a solution is ad hoc. I have no theory to offer on when an explanation is reasonably demanded, and it is beyond of the scope of this paper to construct one. (But see Bromberger 1992 for an illuminating discussion.)

Conditions (i) and (ii) show that a solution may become non-ad hoc if it becomes possible to diagnose the problem, if a reasonably demanded explanation starts backing it, or if it becomes unreasonable to demand an explanation for it. In the next section I show that philosophers and scientists use 'ad hoc' in accordance with (Ad Hoc).

3. (Ad Hoc) Applications

Philosophers often complain that something is ad hoc. Within the philosophy of language, 'many philosophers regard [Tarski's solution to the liar] as ad hoc' (Sher and Bo 2019: 38). (For example, Fox 1989: 177 and Priest 2000: 309.) In the philosophy of mathematics, the axioms of ZF set theory are often considered to provide an ad hoc solution to the set-theoretical paradoxes (Cook and Hellman 2018: 53; Menzel 1986: 37–39; Putnam 2000: 24). And in metaphysics it has been argued that universals and tropes are pieces of ad hoc ontology (Rodriguez-Pereyra 2002: 210ff.) and that postulating a primitive non-mereological form of composition for facts is an ad hoc solution to the unity problem (Betti 2015: ch. 2).

In science the complaint of ad hoccery seems to be less often made than in philosophy. Examples of alleged ad hoc hypotheses that are often discussed by philosophers of science are Ptolemy's epicycles, the LFC, and the neutrino hypothesis. Of these three, the LFC is arguably the strongest example because even Lorentz himself thought it was ad hoc.

Since I lack the space to discuss all cases where the complaint of ad hoccery is made, I will only discuss the use of 'ad hoc' in the debate about the Church-Fitch paradox of knowability, in the discussion about the axioms of ZF set theory, and in the evaluation of the LFC. In each case I show that the use of 'ad hoc' corresponds to (Ad Hoc).

3.1 An Unknown Truth

The Church-Fitch paradox shows that all truths are known if all truths can be known. (For a general introduction to this paradox, see Brogaard and Salerno 2019.) Some antirealists are committed to the claim that all truths can be known, and the paradox threatens their position because it seems absurd to hold that all truths are known. Besides the rules of elementary logic, the paradox assumes that knowledge is factive and distributes over conjunctions and that absurd propositions are impossible. Here is a sketch of the problem. Suppose that all truths can be known (TCK), that is,

(TCK) For all propositions p, if p is true then it is possible to know p.

Suppose, for contradiction, that there is a truth, q, that is not known. By (TCK) it is possible to know the following conjunction: q is true and q is not known. Suppose this conjunction is known. Then it follows from knowledge's distribution over conjunctions that q is known and that it is known that q is not known; from this, by the factivity of knowledge, it follows that it is known and not known that q—contradiction. Hence, if all truths are knowable, all truths are known.

Neil Tennant (1997) offers a solution to the paradox based on distinguishing Cartesian from anti-Cartesian propositions and restricting (TCK) to Cartesian propositions. A proposition p is anti-Cartesian if and only if we can derive a contradiction from the assumption that p is known. Tennant distinguishes three ways in which a proposition might be anti-Cartesian. First, the proposition itself may be inconsistent, in which case a contradiction can be derived from the

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assumption that we know it. Second, a proposition such as 'No thinking thing exists' may be consistent but false whenever it is the object of a propositional attitude. Finally, there are claims of the forms '*p* and it is not known that *p*' from which we can derive a contradiction if we assume that knowledge distributes over conjunctions. By restricting (TCK) to Cartesian propositions, paradox is avoided because '*q* and it is not known that *q*' is an anti-Cartesian proposition. Tennant's diagnosis of the Church-Fitch paradox is thus that anti-Cartesian propositions are wrongly taken to be within the scope of (TCK).

Not everyone likes Tennant's solution. Michael Hand and Jonathan Kvanvig (1999) argue that it is ad hoc. A non-ad hoc solution to the paradox must not merely exclude those propositions that lead to a problem, but

> one must go beyond such arbitrary approaches. Realists do this by observing that truth is 'radically nonepistemic', thereby giving themselves a *reason* based on their conception of truth for denying [(TCK)]. Tennant must do something comparable. We should expect him to find some feature of truth, antirealistically conceived, that disarms the paradox by allowing some truths to be unknowable. (Hand and Kvanvig 1999: 423, my italics)

Hand and Kvanvig demand some theory of truth that provides a reason or explanation for restricting (TCK). Note that Hand and Kvanvig do not deny that Tennant's solution is general. They simply think that generality is no defeater for ad hoccery. As a toy example they mention the claim that any grammatically predicative expression defines a set, except when this assumption leads to a contradiction. This solution to Russell's paradox is quite general but 'clearly ad hoc' (Hand and Kvanvig 1999: 426).

Hand and Kvanvig grant that Tennant has given *a* diagnosis of the problem: the problem arises for (TCK) because it uses an anti-Cartesian proposition. But they seem to think that the diagnosis is wrong or lacks an explanatory backing. For example, they argue that Tennant's solution works for (TCK) but not for its necessitation; it should also work for this modalized cousin because the antirealist holds that it is essential to truth that it is knowable. This suggests that Tennant's diagnosis is incorrect by not going to the heart of the matter. After considering some ways to deal with the stronger version, Hand and Kvanvig claim these are all ad hoc because they do 'do not cite some feature of truth that calls for the restriction in question' (1999: 425). They thus want the diagnosis to be backed by an explanation: some feature of truth should explain the restriction.

In his response to Hand and Kvanvig, Tennant operates with a different conception of ad hoc, for he stresses the generality of his approach and compares it favorably to other general solutions to various problems. For example, he considers the following restriction to (T) to avoid the liar paradox: For all propositions *p*, '*p*' is true if and only if *p*, *except* for those propositions from which we can derive a contradiction. This restricted schema 'is substantive, informative and important. The objection that the restriction invoked is *ad hoc* is groundless' (Tennant 2001: 110).

I beg to differ. This recipe for restricting general principles is a get-out-of-jail-free card that immunizes principles like (T) and (TCK) against defeat. It also leaves it completely mysterious why some propositions are excluded. This is as (Ad Hoc) prescribes: restricting a general principle by simply excluding the instances that lead to problems fails to diagnose the problem because it does not even try to explain how the problem came about. This makes such solutions unsatisfactory and triggers the reproach of ad hoccery. I am not alone in thinking this: Igor Douven (2005: 50–51) makes the same point before offering a more principled case for Tennant's solution.

Douven's account of what it takes to be non-ad hoc is quite similar to that of Hand and Kvanvig although Douven rightly objects to the idea that one's solution to the Church-Fitch paradox should be based on one's theory of truth. Why, Douven asks, 'could it not be something about one's conception of, for instance, knowledge that explains what is wrong with [(TCK)]?' (2005: 49). Douven provides the following criterion:

> In order to qualify as principled or non-*ad hoc*, it is necessary and sufficient that a proposal for restricting [(TCK)] in a particular way be accompanied by a reason for adopting it other than its capability to solve the paradox, and that reason must be related, in an informative or explanatory way, to one or more of the concepts that are either implicitly or explicitly involved in [(TCK)]. (2005: 50)

Douven thus thinks that the restriction imposed on (TCK) is not ad hoc only if it is backed up by some explanatory or informative reason. Douven is thus appealing to (i) (b) of (Ad Hoc). He then provides such a reason for Tennant's (anti-)Cartesian solution based on the idea that anti-Cartesian propositions cannot be consistently believed. He takes this to be both independently motivated (because it also helps to solve a version of Moore's paradox) and an explanation for why there are unknowable truths (there are unknowable truths because there are propositions that cannot be consistently believed; Douven 2005: 57–58). This last point illustrates that although Douven does not explicitly mention the need for a diagnosis in his conditions for non-ad hoccery, he does provide such a diagnosis.

I do not wish to pass judgement on Douven's solution but only want to note the strategy. Although he ends up with a more general restriction of (TCK) than Tennant, Douven nowhere suggests that this is part of the reason his solution is not ad hoc. Instead Douven attempts to explain the restriction, and this explanation also diagnoses the paradox: exactly as (Ad Hoc) prescribes.

3.2 An Iteration

To illustrate the adequacy of (Ad Hoc) further I apply it to the philosophical debate about the axioms of ZF set theory. Any student of set theory knows that naive set theory leads to problems such as Russell's paradox and the Burali-Forti paradox. The main suspect is the axiom schema of (naive) comprehension whose instances ensure that any grammatically predicative expression defines a set. In ZF set

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theory one replaces this schema either with the axiom schema of replacement (together with an axiom stating the existence of the empty set) or with the axiom schema of separation. This avoids the known set theoretic paradoxes—but not to everyone's satisfaction.

> Zermelo's approach, however, offers no *justification* of the restrictions imposed upon *P* [i.e., the naive comprehension principle] other than the fact that the paradoxes are avoided. But that is ad hoc. What we would like is some sort of explanation of *why* there is no Russell set or no set of all ordinals, or why, at least, we shouldn't be able to prove there are such sets from our axioms. (Menzel 1986: 39, italics in the original)

In line with (Ad Hoc) Menzel wants a solution that offers a diagnosis: why do the paradoxical sets not exist? Menzel is not alone in finding the solution ad hoc: 'the "resolution" offered by first-order ZFC is a paradigm of the ad hoc' (Cook and Hellman 2018: 53). (And although Putnam [2000: 24] does not use the term 'ad hoc', I agree with Douven [2005: 51] that Putnam is best understood as saying that ZF is ad hoc.)

These critics of ZF demand an explanation for the selection of axioms as well as a diagnosis of the paradoxes of naive set theory, preferably in one sweep. This may be provided by the iterative conception of sets: the idea that sets are 'constructed' in stages and that each stage contains all previously constructed sets plus all subsets that can be constructed out of them. Boolos (1971) popularized this conception among philosophers, and it diagnoses Russell's paradox as a problem of trying to construct a set consisting both of elements one previously constructed and of an element one has not yet constructed. But at each stage one can only use previously constructed sets. (Of course, all this talk of 'constructing' should not be taken literally.) Moreover, Boolos takes the iterative conception of a set to explain the axioms of ZF such that they are 'not at all ad hoc' (1971: 218).

Interestingly, Boolos notes that the axiom schema of replacement does not 'follow from the iterative conception' (1971: 228) but has 'many desirable consequences and (apparently) no undesirable ones' (229). This provides at best an abductive argument for replacement but may fall short of the kind of explanation that someone like Putnam demands. This illustrates that disagreement about ad hoccery can be due to disagreement about whether a solution is (sufficiently) backed by an explanation.

Instead of trying to meet the demand for a satisfactory explanation, Penelope Maddy (2011) defends contemporary set theory against the charge of ad hoccery by holding that such an explanation is unreasonable, effectively saying that condition (ii) of (Ad Hoc) is not met. (To be sure, Maddy does not frame her argument in terms of ad hoccery.) Maddy argues that the axioms of a mathematical theory need no explanation or 'intrinsic justification', that is, justification coming from some pretheoretic notion of a set. Rather, the axioms are extrinsically justified: they are as simple and powerful as possible while (for all we know) avoiding contradiction. According to Maddy, it thus is unreasonable to demand an explanation; hence none of the axioms of set theory are ad hoc because condition (ii) of (Ad Hoc) is not satisfied.

3.3 LFC Revisited

The LFC hypothesis was one of Popper's main examples of an ad hoc hypothesis (1959: 83), and it is now a litmus test for any definition of 'ad hoc solution'. The LFC states that an object contracts in its direction of travel. It was proposed by FitzGerald and, independently, by Lorentz after the famous null results of the Michelson-Morley experiments. These experiments used an interferometer designed to detect the ether on the basis of its effect on the speed of light. A light beam was first split into two beams traveling in perpendicular directions, and both beams were then sent back to a single screen. The light beam that would travel parallel to the direction of the earth relative to the ether should take longer than the light beam that travelled perpendicular to the earth's direction of travel. However, the two light beams always arrived at (virtually) the same time, no matter when the experiment was conducted or which direction the interferometer was facing. Thus, either the speed of light was constant, which was hard to square with the idea that light travelled through the ether, or—as the LFC states—objects contract in their direction of travel, which explains why the 'slower' light beam arrives at the same time as the 'faster' one. Current physics holds that, in a sense, both are true. The speed of light is constant and, stated in relativistic terms, the length of a moving object is shorter than its proper length, which is its length as measured in its own rest frame. Note that this does not mean a moving object is physically deformed—its proper length does not change—but 'merely' that the measured length of an object depends on whether the object is in motion relative to the observer. Crucially, the LFC was not originally stated in relativistic terms, and it was clear to everyone that the hypothesis was fishy.

The LFC is a rather good litmus test for any theory of ad hoccery because physicists at the time, including Lorentz, were dissatisfied with it (Holton 1969: 139). But it should be noted that because this is a much-discussed case study, there are a few myths surrounding the Michelson-Morley experiments and the LFC. One is that the experiments played a key role in Einstein's formulation of special relativity. Instead, it is unclear whether Einstein was even aware of these experiments when writing his 1905 paper. Einstein (1905) suggests he arrived at his theory mainly via his dissatisfaction with the asymmetries in Maxwell's theory of electrodynamics. Another myth is that the LFC had no new testable consequences. It did, and these consequences were refuted by the Kennedy-Thorndike experiments. (For detailed myth busting, see Grünbaum 1959 and Holton 1960, 1969.)

In this subsection I show that Lorentz considered the LFC an ad hoc solution in the sense of (Ad Hoc). I argue that Lorentz thought the LFC provided a diagnosis but was not backed by a good explanation. Thus, the problem with the LFC was that no reasonable explanation could be given for *why* objects contracted in their direction of travel. The explanatory backing Lorentz ended up giving was not fully satisfactory—not even to himself—because it depended on assumptions for which he could at most give analogical arguments. Accordingly, the LFC was ad hoc because it satisfied conditions (i) (b) and (ii) of (Ad Hoc).

In a letter to Einstein dated 23 January 1915, Lorentz writes that, like Einstein, he also thought that the LFC was ad hoc and that he had said so in print (Kox 2008:

410; Lorentz seems to refer to his 1904a.) Lorentz also states that in the absence of a general theory one should be content with explaining a single fact, 'as long as the explanation is not artificial' ('*wenn diese Erklärung nur nicht erkünstelt ist*', Kox 2008: 410). He thought that the LFC was not artificial, but rather the only possible explanation ('*die einzig mögliche*') and one that would have seemed less ad hoc and even quite natural when one assumes that the transformation properties of electromagnetic forces also hold for other forces, in particular molecular forces (Kox 2008: 411). Lorentz thus assumed an analogy: molecular forces are affected in a moving body similar to the way electromagnetic forces change around a moving body. (Note, incidentally, that this assumption is both unifying and, in principle, testable.)

This assumption provides a crucial part of Lorentz's attempt to give a satisfactory explanatory backing of the LFC. Because this, together with other assumptions, allowed him to derive the LFC from the Maxwell equations. But as Lorentz admitted elsewhere, the assumption that molecular forces are affected in a moving body in a way similar to the way electromagnetic forces change around a moving body was by no means unquestionable. He called it 'bold' (Dutch: '*gewaagd*', 1892: 78), admitted that 'we really have no reason' to suppose it ('*wozu freilich kein Grund vorliegt*', 1895: §92), and thought it 'cannot in itself be pronounced to be either plausible or inadmissible', 1904b: 825).

In *The Theory of Electrons* (1915) Lorentz seems very much aware that this assumption is on shaky grounds:

> We can understand the possibility of the assumed change of dimensions, if we keep in mind that the form of a solid body depends on the forces between its molecules, and that, in all probability, these forces are propagated by the intervening ether in a way more or less resembling that in which electromagnetic actions are transmitted through this medium. From this point of view, it is natural to suppose that, just like the electromagnetic forces the molecular attractions and repulsions are somewhat modified by a translation imparted to the body, and this may very well result in a change of its dimensions. (1915: 201–2)

Notice how cautious Lorentz expresses himself: 'in all probability', 'more or less resembling', 'it is natural to suppose', and 'may very well'. Moreover, the assumption that molecular forces behave similarly to electromagnetic forces is not the only assumption Lorentz makes to derive the LFC. According to one count, Lorentz's explanatory backing of the LFC contains at least eleven additional hypotheses. For a paper dealing with fundamental physics 'it is veritably obsessed with making hypotheses' (Holton 1960: 630).

It is fair to say that Lorentz was not completely convinced by his own solution. In the concluding remarks of *The Theory of Electrons* (1915) he contrasts his overall solution with Einstein's theory of relativity: 'Einstein simply postulates what we have deduced, with some difficulty and *not altogether satisfactorily*, from the fundamental equations of the electromagnetic field' (1915: 230, my italics).

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The LFC provided a diagnosis of the null result of Michelson and Morley, but it lacked a satisfactory explanatory backing. Lorentz tried to provide such a backing by deriving the LFC from the Maxwell equations using certain assumptions about the electron. But the backing that Lorentz gave depended on at least one assumption for which there was at best an analogical argument: the idea that molecular forces are affected in a moving body similar to the way electromagnetic forces change around a moving body. Moreover, everyone in the scientific community, including Lorentz, demanded a solution that diagnosed the problem *and* was backed by a satisfactory explanation. The best explanation that Lorentz was able to give was, however, not fully satisfactory. Hence, the LFC was an ad hoc solution in the sense defined by (Ad Hoc).

4. Concluding Remarks

When an otherwise successful theory is confronted with an empirical anomaly, a paradox, a vicious infinite regress, or some other defect, one may always change the theory to solve the problem. But not every solution is an improvement, and degenerative solutions are often called 'ad hoc'. A good definition of 'ad hoc solution' should help explain why, despite solving more problems than the original theory, the new theory is no improvement. I have argued that the answer lies in its explanatory failure: ad hoc solutions do not diagnose the problem or are not backed up by an explanation. Since a theory should not merely list facts or solve problems but also provide explanations, ad hoc solutions go against the *raison d'être* of a theory. We thus eschew ad hoc solutions for more than merely aesthetic reasons (*pace* Hunt 2012).

My analysis of ad hoc solution applies to all fields of rational inquiry insofar as these fields aim to provide explanations. This is an advantage over other accounts of ad hoccery, which all focus on ad hoc hypotheses that answer to empirical anomalies. Still, other definitions of ad hoccery can supplement (Ad Hoc). (Thanks to a reviewer for this journal for suggesting this to me.) (Ad Hoc) does not detail when a diagnosis or explanation is not good enough. Here Leplin's (1975) discussion about ad hoccery might be useful: it may be that the explanation is no good because it fails to be fundamental or because it cannot be generalized. Or one might agree with Schindler (2018) that a good explanation must cohere with relevant background theories to be satisfactory.

This also shows that (Ad Hoc) can explain why there are so many different definitions of 'ad hoc hypothesis' in the philosophy of science: because there are competing notions of what a good scientific explanation looks like. For example, Popper famously held that a good scientific explanation is falsifiable. It is no wonder, then, that he considered lack of testability—that is, nonfalsifiability—a cornerstone of ad hoccery. Similarly, those who think good explanations are generalizable will likely consider ungeneralizable solutions ad hoc.

Because explanation is what distinguishes ad hoc solutions from genuine solutions, we should thus investigate explanations to gain a better understanding of ad hoccery. Given the current interest in explanation—both in the philosophy of science (Lange 2016; Lipton 2004; Reutlinger and Saatsi 2018; Woodward 2003) and in metaphysics (Correia and Schnieder 2012; Kment 2014; Ruben 2012)—our understanding of ad hoccery is bound to grow in the foreseeable future.

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