

A coherentist conception of ad hoc hypotheses

Abstract

What does it mean for a hypothesis to be ad hoc? One prominent epistemic account of ad hocness has it that ad hoc hypotheses have no independent empirical support. Other, non-epistemic, accounts view ad hoc judgements as subjective aesthetic judgements. Here I critically review both of these accounts and defend my own account, the *Coherentist Conception of Ad hocness* by working out its conceptual and descriptive attractions.

Keywords: ad hoc; confirmation; independent support; novel success; coherence

1 Introduction

It is widely agreed—amongst scientists and philosophers alike—that a good hypothesis ought not to be ad hoc. Consequently, a theory that requires ad hoc hypotheses in order to overcome empirical tests ought to be less acceptable for a rational agent than a theory that does without (or with fewer) ad hoc amendments. Presumably, theories amended with ad hoc hypotheses are less acceptable to rational agents because they *epistemically* deficient. Another way of expressing this would be to say that a theory amended with ad hypotheses will receive less confirmation from evidence which it thereby accommodates than a theory which does so without any ad hoc amendments.

Intuitively, a hypothesis is ‘ad hoc’, minimally, when it was introduced for the sole purpose of ‘saving’ a theory which faces observational anomalies. Whilst this definition may suffice for all practical purposes, it is not enough for anybody looking for an *epistemic* account, for the above intuitive definition gives us no answer to this question. It only tells us something about why ad hoc hypotheses are used; it tells us about *motivations*.

Philosophers of science were once very interested in specifying the epistemic meaning of ad hocness; mostly in the 1960-1980s. The philosopher with arguably the biggest impact outside the discipline, Karl Popper, was very much driven by the attempt to formulate conditions that would disqualify as

unscientific the ad hoc maneuvers of psychoanalysis and other alleged pseudo-sciences.¹ His student Imre Lakatos deemed research programmes degenerative when they kept making ad hoc modifications whilst ceasing to successfully predict new phenomena. According to Lakatos's student John Worrall ad hocness and novel success are just two sides of the same coin: "it is wrong to regard the downgrading of ad hoc explanations and the apparent upgrading of genuine predictions as two separate methodological phenomena—they are at root the same phenomena" (148). Curiously, although novel success plays a major role in the contemporary realism debate (e.g. Psillos 1999), there is little, if any engagement with the meaning of ad hocness.

The currently perhaps by far most popular epistemic account of ad hocness is the view that associates ad hocness with the lack of independent support. According to that view, a hypothesis is ad hoc when it has no empirical support other than the evidence it was invoked for. However, not everybody agrees that ad hocness is an epistemic concern in the first place. Instead, some have viewed judgements about a hypothesis being ad hoc as subjective aesthetic judgements with no relevance to theory confirmation.

In this paper I critically review the independent support account of ad hocness (Section 2) and subjectivist accounts of ad hocness (Section 3). I then advocate my own account of ad hocness by working out its conceptual and descriptive attractions (Section 4) and show that in further depth that Lorentz's attempt to render the contraction hypothesis, one of the most paradigmatic examples for an ad hoc hypothesis, non-ad hoc, lends further support to my account (Section 5). I conclude this paper in Section 6.

2 Ad hocness as lack of independent support

Popper believed that ad hoc hypotheses would decrease the falsifiability of the theory they were introduced to save (Popper 1959a 82f.) and that "degrees of ad hocness are related (inversely) to degrees of testability and significance" (Popper 1959b). If a hypothesis which is added to a theory entails only the evidence that is troublesome to this theory, then the falsifiability of the theory is

¹ See e.g. Popper (1959a 42). Lakatos (1978) once characterised Popper's falsificationism as "introducing new, non-justificationist criteria for appraising scientific theories based on anti-ad hocness." (39)

decreased: there is one state of affairs less that could threaten the theory in question. On the other hand, the falsifiability of the theory is increased when the added hypothesis makes new predictions. This is why Popper also claimed that ad hoc hypotheses “cannot be tested independently” (1974 986), i.e., they cannot be tested other than on the basis of the evidence they were introduced to account for. At least this is the idea. Barnes (2008 11) has, I think rightly, questioned Popper’s alleged connection between ad hoc hypotheses and decreased testability. For example, it is for example not plausible that the hypothesis “bread nourishes” when amended to “all bread nourishes except that grown in a particular region of France” after the relevant discovery, would result in a decrease in testability.

Independent testability also seems not the right way of thinking about one of the most emblematic ad hoc hypotheses. As Grünbaum (1959) pointed out, the Lorentz-FitzGerald contraction hypothesis (LFC), introduced to save the aether theory from refutation in the face of the famous Michelson and Morley aether drift null result, contra Popper, did indeed make an independently testable prediction: it entailed a positive aether drift result that was different from the positive result implied by the unmodified aether theory. There even was an experiment, the so-called Kennedy-Thorndyke experiment, which was apt to falsify this consequence of the LFC.² Still, there is strong evidence that contemporary scientists regarded the LFC as an ad hoc hypothesis. Einstein, for instance, wrote about LFC that “[t]his manner of theoretically trying to do justice to experiments with negative results through ad hoc contrived hypotheses is highly unsatisfactory” (Einstein in Warburg 1915 707). To Michelson, who was initially actually quite keen to explain away his null result in favor of the ether theory felt that “such a hypothesis seems rather artificial” (cited in Holton 1969 139). Even Lorentz, who had developed the LFC, admitted that it first appeared ‘far-fetched’ and that it depended on an assumption (namely that the same laws apply to intermolecular forces that apply to electrical ones) which ‘there is no reason to make’ (Lorentz 1895 in Einstein et al. 1952 6). In response to criticism by Poincare in 1900, Lorentz also

² The LFC had it that matter moving through the ether contracts in the direction of motion by the same laws governing the contraction of interference patterns. See for example (Janssen 2002b), footnote on p. 433, for the difference between the Michelson-Morley and the Kennedy-Thorndyke experiments and the respective ether theory predictions.

admitted that “[surely] this course of inventing special hypotheses for each new experimental result is somewhat artificial” (Lorentz 1904, *ibid.*, 12-13). Given that the LFC *was* independently testable, but nevertheless, clearly judged ad hoc even by those proposing it, there are thus good grounds for thinking that the lack of independent testability is not a mark of ad hoc hypotheses.³ The conclusion Grünbaum (1976) drew was this: an ad hoc hypothesis *can* have independent consequences, but when it does, these consequences have no support (because no relevant evidence has yet been gathered), or they have been shown to be false at the time of the hypothesis is judged ad hoc.

The idea that a hypothesis needs independent support for it to not be judged ad hoc is extremely popular amongst philosophers (e.g. Scerri and Worrall 2001, Sober 2008, Leplin 1975, Worrall 2002, Zahar 1973, Schaffner 1974, Lakatos 1978).⁴ However, there is again historical evidence which speaks against such a view. With regards to our example of the contraction hypothesis, the historian Holton remarks that the independent predictions of the LFC were “not of real interest in any case; they were not urged as tests that would decide on its acceptability” (Holton 1969 177).

Against the independent support idea of ad hocness, one may also appeal to an argument by Barnes (2005) made against Scerri and Worrall (2001) in the context of predictivism (the thesis that novel success counts more than accommodative success). Suppose with Worrall that creationists, when presented with fossils seemingly undermining the creationist doctrine, might respond with a ‘Gosse dodge’: fossils are just God’s playful writings in stone,

³ In response, Popper conceded that the LFC could not be disqualified as being not independently testable, but maintained that independent testability was the right way of thinking about ad hoc hypotheses. He then held that Einstein’s special theory of relativity was ad hoc to some degree too, but its degree of independent testability was much higher than the one of the LFC (Popper 1959b).

⁴ A very influential account of ad hocness is Leplin’s. Leplin not only embraces the independent support condition but also (amongst other things) requires that ad hoc hypotheses be ‘non-fundamental’. A detailed assessment of this idea is beyond the scope of the current paper. Lakatos (1978) distinguished between three senses of ad hoc hypotheses (added to a research programme): ad hoc₁ = the hypothesis makes no new predictions; ad hoc₂ = the predictions a made by a hypothesis are not confirmed; ad hoc₃ = the hypothesis does not is “not form an integral part of the positive heuristics” (fn 1 on p. 112). Ad hoc₃ for Lakatos was ‘synonymous’ with ‘empirical’ or ‘formal’ (fn 2 on p. 88). The first and the second sense are covered by my discussion in this section. A discussion of the third sense would lead us too far astray.

possibly testing our faith. Although one might think with Worrall that the Gosse dodge is ad hoc because it has no independent support, one might have doubts. Suppose we view the Gosse dodge as a general hypothesis about *all* fossils. Then the Gosse dodge *will* make predictions about *other* fossils in other parts of the world or about fossils yet to be discovered. Arguably, those other fossils would be independent support for the Gosse dodge. Yet the Gosse dodge is clearly ad hoc, regardless (807).

Proponents of the independent support view of ad hocness have repeatedly appealed to the discovery of the planet Neptune to make their case (Worrall 2002). In order to accommodate a discrepancy in the orbit of Uranus, Adams and LeVerrier, independently from each other, postulated another planet in the vicinity of Uranus in 1845-46. Neptune was subsequently discovered in 1846. Proponents of the independent support view of ad hocness have taken this to confirm their view (Worrall 2002): the Neptune hypothesis was introduced ad hoc in order to save Newtonian mechanics from refutation, but was rendered non-ad hoc when it received independent confirmation via the discovery of Neptune. However, as Leplin (1982) has pointed out, there is *no evidence whatsoever* that the scientific community at the time regarded the postulation of Neptune ad hoc, or somehow methodologically unsound.⁵ But if the postulation and discovery of Neptune really is no example for an ad hoc hypothesis, then it cannot lend credence to the independent support condition of ad hocness, or to *any* account of ad hocness for that matter.⁶ Moreover, it can then also not be the case that introducing a hypothesis to save a theory from refutation is sufficient for that hypothesis to be ad hoc. Something else is needed.

The independent support view of ad hocness is very persistent. In the most recent contribution on the topic of ad hocness, Friederich et al. (2014) discuss several judgments by physicists (and some philosophers) about the Higgs mechanism (HM) of the standard model in particle physics being ad hoc.

⁵ See for example Grant (1852 164-201) and Grosser (1962). Bamford (1996), similarly, notes that “[t]here was no theoretical objection, however, to a planet located at some intermediate distance beyond Uranus” (216).

⁶ Incidentally, it is interesting to note with Leplin (1975 314, fn. 17) that Lorentz appears to have regarded the question of whether or not the LFC was ad hoc independently of the question of whether or not there ever could be (positive) experimental tests for it (Lorentz 1885 in Einstein et al. 1952 6). We shall return to this point later in the paper (Section 5.1).

Friederich et al. list the following features of the HM that arguably underlie physicists' ad hoc judgments: (i) the HM leads to a large number of free parameters for the particle masses that are not determined in a principled fashion but need to be put in 'by hand' on the basis of experimental results, (ii) there are no known fundamental scalar particles in physics apart from the Higgs boson, (iii) the symmetry breaking of the HM, *contrary to all other known cases of symmetry breaking*, is implemented not dynamically but by fiat,⁷ and (iv) the fact that the bare mass of the Higgs particle is 'fine-tuned' to its interaction mass (by 34 orders of magnitude) is "unexplained".⁸ This is known as the 'fine tuning' or 'naturalness' problem and, according to Friederich et al, "is widely regarded as the most severe" argument against the "fundamental scalar character" of the Higgs field.⁹ In other words, the HM has a number of arbitrary features. Interestingly this is also what Weinberg, in his original paper, expressed when he conceded that "[...] our model has too many arbitrary features for these predictions [regarding the electroweak "mixing angle"]¹⁰ to be taken very seriously" (Weinberg 1967 1265-66). It is *this* aspect of arbitrariness that appears to underlie physicists' judgment that HM is ad hoc.

Friederich et al. conclude their analysis by announcing "the end of the ad hoc character of the [HM]¹¹ due to the recent discovery [of the Higgs particle]" (3914). More specifically, they argue that the Higgs mechanism is no longer to

⁷ Symmetry breaking normally is due to composite rather than fundamental fields. Only in the former case can it be dynamical.

⁸ In quantum field theory any experimentally determined particle mass is understood as the sum of the 'bare' mass and the 'interaction mass', due to the interaction of the particle with vacuum fluctuations.

⁹ Friederich et al. mention two further points: that a non-zero Higgs field in a vacuum is conceptually problematic and 'triviality'. The first of these points, Friederich et al. argue, makes a false presupposition: the Higgs field in the vacuum actually *is* zero. The second concerns the position of the so-called "Landau pole", basically a limit of the standard model to certain energy scales. The Landau pole for the standard model depends on the observed Higgs mass. For the currently observed Higgs mass, the Landau pole turns out to be entirely absent. This result, Friederich et al. point out, can be generated only "if the self-coupling of the Higgs boson is assumed to be vanishing, i.e. trivial, while this self-coupling must be non-vanishing for the HM to generate non-vanishing particle masses". For reasons of simplicity, I will leave out those points in my discussion.

¹⁰ The mixing angle of the Weinberg model, which also became known as Weinberg angle, indicates the relative strengths of the neutral and charged weak interactions and the masses of the Z and W bosons.

¹¹ Instead of HM, Friederich et al. use the abbreviation SMHM for Standard Model Higgs Mechanism.

be considered an ad hoc hypothesis because “the most crucial characteristic of an ad hoc hypothesis [namely the *condition of independent support*] [...] is no longer obeyed” (p. 3913). As evidence for this claim Friederich et al. do not adduce any evidence apart from citing the fact that “many physicists [...] now seem to be ready to accept the [HM] as part of physical reality” (ibid.). However, the mere acceptance of the reality of the HM by physicists does not entail that its status *thereby* changed from ad hoc to non-ad hoc. On the contrary, as Friederich et al. astutely point out themselves, *none* of the aforementioned issues, which physicists cited as reasons for deeming the HM ad hoc, has been resolved by the recent discovery of the Higgs particle (3913). But if the grounds for deeming HM ad hoc prior to the discovery of the Higgs particle were good ones (and Friederich et al. do not doubt this), then why should we think that those same grounds are no longer good ones after the discovery, unless we are given reason to think that those reasons are no longer valid ones? Indeed, Friederich et al. also report that “most of them [i.e., most physicists] seem to be not ready to conclude that the criticisms of the [HM] were unfounded” (ibid.). It therefore looks as though the HM, as theoretical construct, still exhibits all the features that make it ad hoc, and therefore is to be considered ad hoc, despite the fact that Higgs particle, as predicted by the HM, exists. Friederich et al.’s discussion can therefore lend no support to the independent support view of ad hocness, according to which a hypothesis ceases to be ad hoc when its independent predictions are confirmed.

Overall, then, there appears to be little evidence from scientific practice in favour of the view that ad hoc hypotheses are those hypotheses which have no independent support. Given the prominence of these examples in the discussion (in particular the LFC and the Neptune example), the defender of the independent support account should indeed be worried. But of course, this does not mean that the account is *therefore* incorrect. It might well be that there is something to be said for it on the basis of other examples than the ones mentioned here. Will have to leave it at that though and will now proceed to subjectivist accounts of ad hocness.

3 Subjectivist accounts of ad hocness

In a remarkable paper discussing the role of the Michelson-Morley experiment, the historian Holton noted that scientists’ judgments about a hypothesis being

ad hoc are often accompanied by aesthetic terms such as ‘artificial’, ‘contrived’, ‘strange’, ‘surprising’, and the like (Holton 1973 327).¹² Holton also claims that ad hoc judgments are highly context-dependent, and vary inter- and even intra-subjectively. That is, what might be regarded as ad hoc by some may be seen as non-ad hoc by others, and what might be at regarded as ad hoc one point in time, according to these authors, might be regarded as methodologically sound at a later point in time, even by a single person (Holton 1973 176-183). In conclusion, Holton urged that philosophical analysis “must be supplemented by an understanding of matters of scientific taste and feeling” (183). Recently Hunt (2012) reaffirms that “scientists’ aesthetic sense or ‘feeling’ governs their judgments in this matter [of ad hocness]” and that the answer to the question of whether a hypothesis is ad hoc is “largely in the eye of the beholder” (13). On the subjectivist account, whether a hypothesis is deemed ad hoc or not (by anyone) has no epistemic bearing. Hunt accordingly concludes that “at the end of the day there seem to be no ad hoc hypotheses and no non-ad hoc hypotheses, only hypotheses—full stop” (Hunt 2012 13).

I think it is highly questionable that the subjectivist account accurately represents scientists’ views of the matter. Contrary to Holton and Hunt I think it is quite obvious that scientists do indeed care about whether or not their hypotheses are ad hoc and that they do view ad hoc hypotheses as epistemically deficient (see e.g. our discussion of the LFC above). Furthermore, if ad hoc hypotheses would be just as good as any other non-ad hoc hypotheses then there would be very little constraint on theorizing other than saving the phenomena. Any theory facing anomalies could be patched up at will without that being objectionable. Since any theory can save any phenomena when amended ad hoc, how could scientists then rationally deliberate about which theory to adopt?

Contrary to how the subjectivists would have it, the inter-subjective and intra-subjective variance of ad hoc judgements, if it is real, does not entail the conclusion that the subjectivists try to establish. Scientists make mistakes. Thus, when scientists disagree as to whether a hypothesis is ad hoc or not, some

¹² Holton even claims that an ad hoc judgment need not be pejorative and that there are “acceptable ad hoc hypotheses”. Holton provides no evidence for this claim other than *stating* that scientists sometimes describe them positively (Holton 1973 327).

might scientists might simply be wrong. And scientists might change their minds about the ad hoc status of a hypothesis for *all the wrong reasons*. This is of course not to say that none of the reported variance should be taken seriously. On the contrary. What I will argue, though, is that we don't have to go all the way subjectivist and relativist to accommodate such judgments.

4 A coherentist conception of ad hocness

Let us start out with another example. The Ptolemaic system of our planetary system famously used the theoretical device of epicycles: the planets were envisaged to move on circles whose centre in turn moved along the circumference of other circles around the central body, believed to be Earth. Although epicycles have become proverbial for ad hoc devices, it was not those to which Copernicus objected when criticizing the Ptolemaic system in his *De revolutionibus*. In fact, Copernicus himself made heavy use of them (Kuhn 1957).¹³ Instead, what appears to have taken central stage in Copernicus's objections to the Ptolemaic system were concerns about coherence:

[Ptolemaic astronomers have not] been able [...] to discern or deduce the principal thing - namely the shape of the universe and the unchangeable symmetry of its parts. With them it is as though an artist were to gather the hands, feet, head and other members for his images from diverse models, each part excellently drawn, but not related to a single body, and since they in no way match each other, the result would be a monster rather than a man. (Copernicus cited in Kuhn 1957 137-8)

I will specify what underlies Copernicus's criticism further in a moment, but I take this to be *prima facie* evidence for what I call the Coherentist Conception of Ad Hocness (CAH), according to which a hypothesis H is ad hoc, iff theory T and H do not cohere *or* H does not cohere with the accepted background theories B.¹⁴ More precisely,

Definition of ad hocness: A hypothesis H, when introduced to save a theory T from empirical refutation by data E, is ad hoc, iff (i) E is evidence for H and (ii) H appears *arbitrary* in that H coheres neither with theory T nor with background theories B, i.e., neither T nor B provide *good reason* to believe

¹³ Gingerich (1975) raises doubt that the numbers of epicycles can be determined unequivocally on any of the two systems.

¹⁴ McMullin (1993 133-4) was perhaps the first to link ad hocness with the lack of coherence. Yet McMullin's account remains sketchy.

that H (possibly specifying a particular value of a variable), rather than non-H (or some value other than the one specified by H).

Condition (i) is trivially true for any ad hoc hypothesis, for ad hoc hypotheses get introduced to accommodate the data, which T cannot, in the first place. Condition (ii) prominently features coherence relations. Coherence has been described as a measure for “how well things hang together” (BonJour 1985). There is no agreement about what exactly coherence amounts to, but I will assume that if H coheres with T or B, T or B will give one *good reasons to believe* that H, rather than non-H. These reasons, by virtue of being provided by T or B, will be *theoretical* reasons. How are theoretical reasons to believe H to be understood?

For T or B to provide theoretical reasons to believe that H (rather than non-H), T or B must of course be logically consistent with H. But consistency is not sufficient for T or B to provide theoretical reasons to believe that H (rather than non-H), much as consistency is not sufficient for coherence.¹⁵ For T or B to provide theoretical reasons to believe that H, further conditions must be satisfied. In the most straightforward case, T or B provide theoretical reasons to believe that H when H can be deduced from T or B. Yet again, also deduction is neither a necessary nor sufficient condition for T or B to provide a theoretical reason to believe that H. It is not sufficient because any arbitrary disjunct X (such as “God exists”) can be deduced from any set of assumptions. But clearly such arbitrary disjuncts should not count as good theoretical reason to believe that H in our context. Deduction is not necessary for providing theoretical reason that H either, because, I take it, there are other, non-deductive ways of theoretically justifying H. For example, a theoretical reason to believe that H might consist in an explanation for *why* H should be the case, by the lights of T or B. Such an explanation, in turn, could be causal, or it could consist of a subsumption of H under a regularity. T or B might also provide reasons to believe that H simply in virtue of ruling out scenarios inconsistent with H (as we shall see in a moment). In other words, I believe it is advisable to adopt a pluralist attitude towards the kinds of permissible theoretical reasons to believe

¹⁵ In the following, I will, for the sake of simplicity, not write out the contrastive part of “reasons to believe H, *rather than non-H*”. Whenever I do use the simplified phrase, I nevertheless do want it to be understood in its complete version. The contrastive part ensures that the reasons provided by T or B are *relevant* reasons to believe that H.

that H, which T or B can provide, just as one might want to be pluralist about the nature of coherence relations. However, so long the theoretical reasons to believe that H ought to be good ones, we will demand that the theories in question have empirical support. Otherwise, any arbitrarily cooked-up theory could be used to render an ad hoc hypothesis non ad hoc. At the same time, it should be emphasized that, by the lights of CCAH, good reasons to believe that H can never be *just* empirical reasons alone, for they must be provided by T or B, and thereby be theoretical reasons.

Let us return to Copernicus's criticism of the Ptolemaic system. Copernicus explicated the aforementioned analogy by discussing a number of observations which, on the Ptolemaic system, had to be simply assumed, but for which the Copernican system gave good reasons to believe.¹⁶ Some of these observations were the maximum elongation of the inferior planets, i.e., the observational fact that Mars and Venus are never observed beyond a certain angle from the apparent trajectory of the sun on the celestial sphere, i.e., the so-called ecliptic (28° and 47° , respectively). In order to account for this fact, it was decreed in the Ptolemaic system that the centre of the epicycle on which an inner planet would move had to be fixed on a line connecting Sun and Earth. In the Copernican system, in contrast, the inner planets cannot possibly move away from the sun beyond a certain angle, because the inner planets' orbits are encompassed by the Earth's orbit around the sun (see Fig. 1).¹⁷

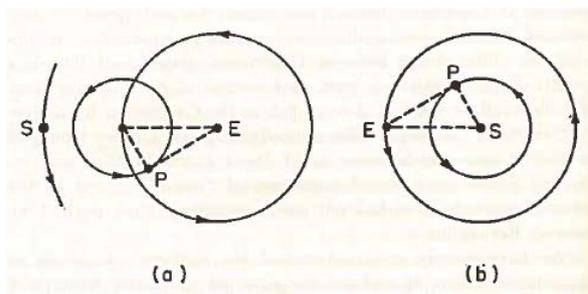


Fig. 1: The phenomenon of maximum elongation of the inner planets as explained in the Ptolemaic system (left) and the Copernican system (right). From (Kuhn 1957).

¹⁶ Another point that was important to Copernicus was that the Ptolemaists had, with the deployment of eccentrics, departed from the Aristotelian principle of uniform motion. For a highly interesting discussion see (Miller 2014).

¹⁷ For a detailed discussion see also (Janssen 2002a).

The way in which the Ptolemaic system accommodates the phenomenon (E) of maximum elongation is clearly ad hoc, because neither the Ptolemaic system itself, nor the background theories at the time provided any good reasons to believe the hypothesis H that the centre of the inner planets' epicycles must remain fixed on a line connecting the sun and Earth. H was arbitrary, since theoretically unmotivated. In contrast, in the Copernican system it is *impossible* for the inner planets to move beyond a certain angle away from the sun (as observed from the Earth), as it was surmised (H*) that the inner planets' orbits are located inside Earth's. The Copernican system thus provides excellent theoretical reasons to believe that H*, as H* follows straightforwardly from the Copernican system.

Before illustrating CCAH with further examples, let us clarify and compare CCAH to other accounts of ad hocness.

4.1 Clarifications and comparison with other accounts

Let us first note that, contrary to a not too uncommon misconception, condition (i) of the CCAH is not sufficient for a hypothesis to be ad hoc. Consider again the stipulation of Neptune after the detection of irregularities in the orbit of Uranus (cf. Section 2). Again, contrary to folklore, there is no evidence that the hypothesis of Neptune was considered ad hoc before Neptune was discovered, even though it was introduced to save Newtonian mechanics. On the CCAH, the Neptune hypothesis was never ad hoc, because Newtonian mechanics *did* provide good reasons to believe that there was another planet in the vicinity of Uranus, given the irregularities of its orbit.

My coherentist account of ad hocness is an objectivist account. When a hypothesis does not cohere either with T or B, H will be ad hoc. Contrapositively, when H coheres with T or B, it won't be ad hoc. Yet, the account does allow for a subjective element in ad hoc *judgements*: some scientists might judge some connections of H to T or B to be more important than others. I'm therefore proposing an analogue to Kuhn's model of theory-choice where individuals weigh objective theory properties according to their own (subjective) preferences (Kuhn 1977). Analogously, scientists can legitimately differ about which coherence relations they consider to be more important. But that has no bearing on whether or not coherence relations obtain

between H and T or B. Accordingly, judgements about some hypothesis H being ad hoc when as a matter of actual fact H does cohere with T or B are *false* judgements. Subjectivist accounts of ad hocness (Section 3) have no such restrictions. My account thus sets clear limits to the legitimacy of ad hoc judgements.

Relatedly, as we saw, proponents of a subjectivist account of ad hocness have cited degrees of ad hocness as evidence for ad hoc judgements being entirely aesthetic (Section 3). Yet, once again, one can admit the former without drawing the latter (radical) conclusion. Also CCAH allows for *degrees* of ad hocness: the stronger the coherence between H and T or B, the less ad hoc H. The strength of coherence may perhaps be gauged both in terms of number of relations and quality of relations. It is also worth noticing that degrees of ad hocness allow us to say one theory ought to be preferred over another, regarding ad hocness, even if neither theory manages entirely without ad hoc hypotheses: one theory might just invoke fewer ad hoc hypotheses than the other. In fact, I think one might question whether there is any prominent scientific theory which does entirely without ad hoc assumptions.

Take again the Copernican system: it did not manage to do entirely without ad hoc assumptions. For example, it is a consequence of the Copernican system that one should be able to observe a parallax shift, namely an apparent shift in the position of stars, due to the observer's changing positions on Earth moving around the sun. Yet, the effect could not be observed up until the early 19th century due to technological limitations (telescopes were not advanced enough at the time). Copernicus thus had to invoke the idea that the stars were in fact much further away from us than generally thought at the time. However, this hypothesis was incoherent with the accepted background theories of the time and therefore ad hoc. This was just one of the reasons why it took decades before the Copernican system gained wider acceptance (Copernicus also lacked a workable physics for a moving Earth). Regardless, the Copernican system was much less ad hoc, as compared to the Ptolemaic system, when it came to accounting for observations regarding the planets, the sun, and the moon (it, for example, explained in a non-ad hoc fashion the fact that only the planets, but not the sun and the moon, retrogress, and why the frequency of planetary retrogressions decreases from Saturn, Jupiter, and Mars, and increases from Venus to Mercury, and that the superior planets are the brightest in their

opposition (Copernicus 1543/1992 26-7)). Thus, we can say that the Copernican system, when it was first proposed, constituted an improvement with regards to the number of ad hoc assumptions it had to invoke in accounting for many planetary observations, which made it preferable over the Ptolemaic system. At the same time, the Copernican system too had to make do with a number of ad hoc assumptions before it was eventually developed into a system coherent with accepted physics. Thus, the CCAH account, although allowing the basis of comparative theory-choice on the basis of degrees of ad hocness, does not suggest simplified algorithms that do not adequately mirror the complexity of history.

Of course there are other important considerations in theory choice than ad hocness. Most importantly, a theory needs to be empirically adequate. And if we do not find a theory that is empirically adequate *and* non-ad hoc, clearly, we should stick to it in any case if it is empirically adequate. For example, Planck famously introduced the concept of quantization of energy into physics in an ad hoc fashion in order to account for black body radiation. He himself was not very happy about that and physicists worked for decades to devise a theory that gives us good reasons for the quantization of energy (Kuhn 1987). Thus, although undesirable, ad hoc hypotheses can drive progress not only by way of helping scientists to save the phenomena but also by way of giving incentives to develop theories which render those very same hypotheses non-ad hoc (by providing good reasons for believing in them).

Let us turn to the example of the Higgs mechanism discussed by Friedrich et al. (2014) and recall that they report the following grounds on which it has been deemed ad hoc by physicists: (i) it possesses a large number of free parameters, (ii) there are no other fundamental scalar particles other than the Higgs boson, (iii) the symmetry breaking of the Higgs mechanism is different from all other known cases of symmetry breaking, and (iv) the Higgs particle is 'fine tuned' to its interaction mass and unexplained. As we saw earlier, the independent support of the Higgs mechanism in the form of the discovery of the Higgs boson does little to alleviate those issues. The independent support account thus seems unsuited as a correct characterization of ad hoc judgements in this particular (important) part of physics. In contrast, CCAH accommodates these observations in the following way: (i) and (ii) fall under the heading of "T provides no reason for believing that H", and (iii) and

(iii) are instances where “B provides no reason for believing that H”, as our background theories give us no reason why there ought to be only one fundamental scalar particle and why symmetry breaking may proceed differently only in the Higgs mechanism.

Coherence and unifiedness, at least intuitively, are closely related. But although several writers have gestured at a lack of unifiedness when discussing ad hoc features of theories, a precise account of what this would amount to is as of yet wanting.¹⁸ Suppose the rough idea that an explanation is unified if it explains a set of phenomena with a small amount of basic assumptions or principles and say that we possessed a particular unified explanation / theory of a certain set of phenomena (Kitcher 1981). Would that mean that *none* of the phenomena in that set could be ad hoc with regard to that theory? Or would it mean only that at least *some* of the phenomena could not be ad hoc with regard to that theory? The former is implausibly restrictive: many highly unifying theories make ad hoc assumptions (see e.g. the standard model and our discussion of the Higgs mechanism in this paper). But if it’s only some phenomena, what is it in the unification account that determines which phenomena are not ad hoc with regard to a unifying theory? In other words, the unification account of ad hocness has an *unspecificity* problem, which is absent on the CCAH. In fact, unification and CCAH are nicely complementary: a unified theory can be coherent to one or another degree, and vice versa, a coherent theory can be unified or not (or maybe unified to one or the other degree).¹⁹ At the same time, a unified theory will never lack *potential* coherence, as it presumably will give reasons for believing in at least some of the lower level hypotheses about the phenomena which it unifies (for actual coherence to obtain those reasons must of course be good reasons).

There is another problem. Suppose we have a theory A which accounts for the phenomena in a unified way and a theory B which needs to invoke further hypotheses accounting for further evidence. Can we then dismiss B on the basis

¹⁸ I think Leplin’s non-fundamentality assumption implicitly appeals to the idea that ad hoc hypotheses are those that are not unified with the theory in question (Leplin 1975). More recently, Boudry and Leuridan (2011), in their criticism of (Sober 2008), seem to be sympathetic to this idea.

¹⁹ It has in fact be argued that unification accounts subscribe to a “the winner take all” conception of explanation according to which an explanation either is or is not explanatory, without allowing for degrees of explanation (Woodward 2014).

of the number of assumptions it is making? Not necessarily. As we know from Duhem, any empirical test requires a host of auxiliary assumptions. Thus, in our example, not only does B requires further assumptions, but also A does. However, whether we end up with more assumptions on B than on A is an entirely open question and there is nothing in the situation that would allow us to even make us an educated guess. Lastly, the unification account, contrary to CCAH, cannot accommodate the fact that background knowledge seems to play a role in ad hoc judgements, as in the case of the Higgs mechanism (see above).

As mentioned at the very beginning of this essay, some philosophers view ad hocness as the converse of novel success (Worrall 2002). So, one may ask, how does the CCAH account relate to novelty, and in particular the thesis that novel success is better evidence for a theory than accommodative success? On CCAH, there is no asymmetry between evidence that is predicted and evidence that is accommodated. In both cases, CCAH requires good reasons for the hypothesis invoked to predict or accommodate E. So for example, when Einstein, in 1915, was able to derive from the theory of general relativity (T) that light would bend around massive objects such as stars (H), the theory provided reasons for believing in the existence of star light bending, which motivated Eddington and others to go out and collect observational evidence (E) for H. In contrast, the Ptolemaic system, which we briefly considered above, can for example predict that the inner planets will not be observed beyond a certain angle from the sun, but it give no good reasons for believing in this prediction (because its stipulation of coordination of the position of the sun, Earth, and the centre of an inner planet's epicycle cohere neither with the theory itself or the background knowledge). Thus, although the Ptolemaic system is able to make predictions regarding maximum elongation, the basis on which it does is objectionable. Prediction therefore does not secure against ad hocness.

Finally, one might perhaps be worried that the CCAH could commit one to a coherentist epistemology for science with all its well-known and highly problematic implications. But that is not the case. Coherentism is the view that a belief is justified *if and only if* it coheres with other beliefs. Nothing in the CCAH would imply that much. On the contrary, I believe that theories and hypotheses in science are justified when they are supported by the relevant evidence, just as foundationalism has it. Nevertheless those support relations, on CCAH, will be stronger or weaker depending on the amount of coherence between the

hypothesis and the theory in question. In other words, the coherence relations *modify* the support relations. The epistemology to be associated with the CCAH may therefore be referred to as weak foundationalism (Olsson 2012).

5 The Lorentz-FitzGerald contraction hypothesis revisited

According to the CCAH, theoretical reasons for belief are crucial for determining whether a hypothesis is ad hoc nor not. In this section I will argue that Lorentz sought to render the contraction hypothesis, a paradigmatic example for an ad hoc hypothesis, non-ad hoc by providing theoretical reasons for belief for it. I take this to confirm the CCAH.

In the analysis of the LFC, one must distinguish between an early and a later, mature, version. The early version was proposed in cursory form by Lorentz in 1895 (and by FitzGerald around the same time) in a short section in the final chapter of a 139-page strong book, the mature version in 1904. Many philosophers of science, for various reasons, believe that the ad hoc charge applies only to the early, but not to the mature version of the LFC (Zahar 1973, Acuña 2014, Janssen 2002b, Grünbaum 1976). And that is consistent with us possessing evidence for scientists such as Einstein deeming the early, but not necessarily the later version of LFC, ad hoc (Holton 1969 169).

Let us briefly recall that, in the early version of LFC, Lorentz simply assumed that (i) “molecular forces are also transmitted through the ether, like the electric and magnetic forces of which we are able at the present time to make this assertion definitely”, that (ii) the ‘attraction and repulsion’ of molecular forces for a body at rest would be in equilibrium, and that (iii) the Lorentz transformations would apply not only to electrostatic forces, but also to the ‘molecular forces’ holding together matter (Lorentz 1875 in Einstein et al. 1952 6). As Lorentz readily admitted himself, “there is no reason” in his theory for making the latter assumption in particular. And assumption (ii) is highly implausible (cf. Janssen 2002b 437).

Some commentators have emphasized that Lorentz’s remarks were specifically catered to the Michelson-Morley experiment and that Lorentz articulated the LFC in more general terms only in the later 1904 publication, where he also managed to derive the second order effects he needed to account

for the Michelson-Morley experiment (Janssen 2002b, Schaffner 1974).²⁰ The mature formulation of the LFC entailed consequences which the early version didn't (or at least not explicitly), such as the velocity-dependence of mass (Janssen 2002b 425). That consequence was of course testable. It is also for this reason that some philosophers have claimed that the mature LFC was not ad hoc (e.g. Acuña 2014).

But even with the mature LFC, it has been argued, there is something wrong. According to Janssen (2002b):

In Lorentz's theory, there is a strict separation of ether and matter [...] Lorentz decreed a number of important exceptions to the Galilean-invariant Newtonian laws that are supposed to govern matter, so that the laws effectively governing matter are Lorentz invariant. Why, one can legitimately ask, would the laws governing matter have the property of Lorentz invariance, which so far appeared to be nothing but a peculiar property of Maxwell's equations? [...] In the final analysis, it is thus left an *unexplained coincidence* in Lorentz's theory that both matter and fields are governed by laws that are Lorentz invariant [whereas in Einstein's theory of special relativity, it isn't]. (p. 423 and 426, added emphasis)

Janssen (2002a) cites for approval Poincaré's dismissal of the LFC in his introduction of *Sur la dynamique de l'électron* (1906):

We cannot content ourselves with simply juxtaposing formulas that would agree only by some happy coincidence; the formulas should, so to say, penetrate each other.

And indeed, also in the mature theory Lorentz was merely *assuming* that the Lorentz transformations would apply to 'molecular forces', holding together matter, in the same way they applied to electrostatic forces (Lorentz 1904 in Einstein et al. 1952 22).

Janssen does not link this perceived deficit of Lorentz's theory to judgments about LFC being ad hoc. Indeed he concludes that "a solid case can be made for the claim that [Lorentz's mature] theory is not ad hoc by any of the criteria considered here" (ibid., 437). Instead he regards the above shortcoming

²⁰ For Janssen (2002b 425) the "generalised" LFC is the following: "a matter configuration producing a certain field configuration in a frame at rest in the ether will, when the system is set in motion, change into the matter configuration producing the corresponding state of that field configuration in the frame moving with the system."

as a *different* reason for why Lorentz's theory was inferior to Einstein's.²¹ Yet I don't see why one ought to keep those reasons separate. After all, already in the publication of the early LFC version, as we mentioned before, Lorentz admitted that "there is no reason" to suppose (as he did) that the Lorentz transformations should apply also to matter. But if that's so, then it's not too implausible to suppose that *this* is also what Einstein and others objected to when deeming the (early) LFC ad hoc.

It is also interesting to note that Lorentz, in a letter to Einstein in 1915, i.e., 10 years after proposing his mature theory, stated his belief that the LFC was rendered non-ad hoc by him offering an explanation for it in terms of molecular forces:

[...] I had added that one can arrive at this hypothesis [i.e., the LFC], if one extrapolates from what one was able to say about the influence of translation on electrostatic forces to other forces. *Had I stressed it more, the hypothesis would have made less of an impression of having been devised ad hoc*" (Lorentz 1915 in Schulmann et al. 1998 71-2).²²

What Lorentz had said in 1875, again, was

that [the LFC] is by no means far-fetched, as soon as we assume that *molecular forces are also transmitted through the ether*, like electric and magnetic forces of which we are able at present time to make this assertion definitely [...] *From the theoretical side*, therefore, there would be no objection to this hypothesis (Lorentz in Einstein et al. 1952 6, added emphasis).

So what Lorentz appeared to have thought was that the LFC lost its ad hoc character at the moment when he was able to lend to it some *theoretical* plausibility. And that Lorentz thought, despite the fact that he at the same time admitted that he had devised the molecular forces explanation only *after* he had come up with the LFC (Lorentz 1915 in Schulmann et al. 1998 74). Although we don't know what Einstein made of that suggestion,²³ Lorentz doesn't seem to be alone with this judgement. Leplin (1975 fn. 18 p. 314-5) points out, for example, that two later textbooks (one from 1924 and one from 1969) seem to suggest that

²¹ See Acuña (2014) for a detailed criticism of Janssen's account.

²² This is my own translation of the original German text.

²³ In his reply to Lorentz, Einstein did not mention the issue (Schulmann et al. 1998).

“Lorentz’s representation of contraction as a condition of molecular equilibrium mitigated its ad hoc character”.²⁴

5.1.1 Assessment

From the point of view of CCAH, what Lorentz appeared to have sought to do in order to diminish the ad hoc status of the LFC was to establish a coherence relation between the LFC and the rest of the ether theory.²⁵ That he achieved only to a limited degree. Although there perhaps was *some* plausibility in assuming that the molecular forces that Lorentz postulated for matter would behave not unlike the electromagnetic forces “since both types of force are states of the same substratum”, as (Zahar 1973 116) put it, it remained highly curious how this was to be achieved. As mentioned above, the ‘molecular forces’ hypothesis required that there be an electrostatic equilibrium when a body is at rest. But there is no such thing as electrostatic equilibrium (cf. Janssen 2002b). Thus, although Lorentz was able to provide *some* reasons to believe that LFC, he wasn’t able to provide *good* reasons. His attempted explanation of the LFC in terms of molecular forces did not establish coherence with either the ether theory nor with the background theories.

6 Conclusion

The historical cases discussed in this paper support a new conception of ad hocness, namely the coherentist conception of ad hocness, which has several conceptual and descriptive advantages over its competitors.

Getting the concept of ad hocness right could have a number of ramifications for philosophical debates. Theories of confirmation, arguably, should take into consideration whether or not a theory is ad hoc. But how should these accounts be amended to take accommodate the results of the

²⁴ Zahar (1973) suggests it is for this reason that the LFC is not to be regarded ad hoc. Zahar claims that Lorentz was able to ‘derive’ the LFC from the molecular force hypothesis. But that’s not the case. Lorentz offered only a ‘plausibility’ argument, no derivation (Janssen 2002b 436-7). In his mature theory, the length contraction he derived from what Janssen calls the *generalised* LFC (see fn. 20, above).

²⁵ One might be tempted to interpret Lorentz’s molecular forces hypothesis as an attempt to produce an explanation that would engender novel predictions and that it was for the latter reason, not for the former, that Lorentz thought the LFC was rendered non-ad hoc. But, as we already noted in Section 2.1 with Holton, independent predictions of the LFC “were not urged as tests that would decide on its acceptability” (Holton 1969 177).

current study? The scientific realism debate, too, might be affected: realists might want to explore the possibility of arguing for their position by exploiting the idea that theories which are less ad hoc are better confirmed than theories that possess more ad hoc elements. All this, however, goes way beyond the limits of this paper.

References

- Acuña, Pablo. 2014. "On the empirical equivalence between special relativity and Lorentz's ether theory." *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 46:283-302.
- Bamford, Greg. 1996. "Popper and his Commentators on the Discovery of Neptune: A Close Shave for the Law of Gravitation?" *Studies in History and Philosophy of Science Part A* 27 (2):207-232.
- Barnes, Eric C. 2005. "On Mendeleev's predictions: comment on Scerri and Worrall." *Studies in History and Philosophy of Science Part A* 36 (4):801-812.
- Barnes, Eric C. 2008. *The paradox of predictivism*. Cambridge: Cambridge University Press.
- BonJour, Laurence. 1985. *The structure of empirical knowledge*: Cambridge University Press.
- Boudry, Maarten, and Bert Leuridan. 2011. "Where the Design Argument Goes Wrong: Auxiliary Assumptions and Unification." *Philosophy of Science* 78 (4):558-578.
- Copernicus, N. 1543/1992. *On the Revolutions (with a commentary by E. Rosen)*. Baltimore: Johns Hopkins University Press.
- Einstein, Albert, HA Lorentz, H Weyl, and H Minkowski. 1952. *The principle of relativity*. New York: Dover.
- Friederich, Simon, Robert V Harlander, and Koray Karaca. 2014. "Philosophical perspectives on ad hoc hypotheses and the Higgs mechanism." *Synthese* 191 (16):3897-3917.
- Gingerich, Owen. 1975. "'Crisis' versus aesthetic in the Copernican revolution." *Vistas in astronomy* 17:85-95.
- Grant, Robert. 1852. *History of physical astronomy*. London: Henry G. Bohn.
- Grosser, Morton. 1962. *The Discovery of Neptune*. Cambridge: Harvard University Press.
- Grünbaum, Adolf. 1959. "The falsifiability of the Lorentz-Fitzgerald contraction hypothesis." *The British journal for the philosophy of science* 10 (37):48-50.
- Grünbaum, Adolf. 1976. "Ad hoc auxiliary hypotheses and falsificationism." *The British Journal for the Philosophy of Science* 27 (4):329-362.
- Holton, Gerald James. 1969. "Einstein, Michelson, and the "crucial" experiment." *Isis*:133-197.
- Holton, Gerald James. 1973. *Thematic origins of scientific thought: Kepler to Einstein*: Harvard University Press.
- Hunt, J. Christopher. 2012. "On Ad Hoc Hypotheses." *Philosophy of Science* 79 (1):1-14.

- Janssen, Michel. 2002a. "COI stories: Explanation and evidence in the history of science." *Perspectives on Science* 10 (4):457-522.
- Janssen, Michel. 2002b. "Reconsidering a scientific revolution: The case of Einstein versus Lorentz." *Physics in Perspective* 4 (4):421-446.
- Kitcher, Philip. 1981. "Explanatory unification." *Philosophy of science*:507-531.
- Kuhn, Thomas S. 1987. *Black-body theory and the quantum discontinuity, 1894-1912*: University of Chicago Press.
- Kuhn, Thomas S. 1957. *The Copernican revolution: planetary astronomy in the development of western thought*. Harvard: Harvard University Press.
- Kuhn, Thomas S. 1977. "Objetivity, Value Judgment, and Theory Choice." In *The Essential Tension*, 320-333. Chicago: University of Chicago Press.
- Lakatos, Imre. 1978. *The Methodology of Scientific Research Programmes: Volume 1: Philosophical Papers*. Edited by J. Worrall and G. Currie. Cambridge: Cambridge University Press.
- Leplin, Jarrett. 1975. "The concept of an ad hoc hypothesis." *Studies In History and Philosophy of Science Part A* 5 (4):309-345.
- Leplin, Jarrett. 1982. "The assessment of auxiliary hypotheses." *The British Journal for the Philosophy of Science* 33 (3):235-249.
- McMullin, Ernan. 1993. "Rationality and paradigm change in science." In *World changes: Thomas Kuhn and the nature of science*, edited by Paul Horwich, 55-78. Cambridge: MIT Press.
- Miller, David. 2014. *Representing Space in the Scientific Revolution*. Cambridge: Cambridge University Press.
- Olsson, Erik. 2012. Coherentist theories of epistemic justification. In *The Stanford Encyclopedia of Philosophy (Spring 2013 Edition)*, edited by Edward N. Zalta.
- Popper, Karl R. 1959a. *The logic of scientific discovery*. London: Routledge.
- Popper, Karl R. 1959b. "Testability and 'ad-hocness' of the contraction hypothesis." *British Journal for the Philosophy of Science* X (37):50.
- Popper, Karl R., and Philip A. Schilpp. 1974. *The Philosophy of Karl Popper*: Open Court.
- Psillos, Stathis. 1999. *Scientific realism: How science tracks truth*. London: Routledge.
- Scerri, Eric R., and John Worrall. 2001. "Prediction and the periodic table." *Studies in History and Philosophy of Science Part A* 32 (3):407-452.
- Schaffner, Kenneth F. 1974. "Einstein versus Lorentz: research programmes and the logic of comparative theory evaluation." *The British Journal for the Philosophy of Science* 25 (1):45-78.
- Schulmann, Robert, Anne J Kox, Michel Janssen, and József Illy, eds. 1998. *The collected papers of Albert Einstein. Vol. 8: The Berlin years: Correspondence 1914-1918*. Princeton: Princeton University Press.
- Sober, Elliott. 2008. *Evidence and evolution: the logic behind the science*. Cambridge: Cambridge University Press.
- Warburg, E. 1915. *Die Physik: Die Kultur der Gegenwart*. Leipzig: Teubner.
- Weinberg, Steven. 1967. "A model of leptons." *Physical Review Letters* 19 (21):1264.
- Woodward, James. 2014. Scientific Explanation. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta.

Worrall, John. 2002. "New evidence for old." In *In the Scope of Logic, Methodology and Philosophy of Science*, edited by Peter Gardenfors, 191-209. Dordrecht: Kluwer

Zahar, Elie. 1973. "Why did Einstein's Programme supersede Lorentz's?(I)." *The British Journal for the Philosophy of Science* 24 (2):95-123.