The Identical Rivals Response to Underdetermination

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The underdetermination of theory by data obtains when, inescapably, evidence is insufficient to allow scientists to decide responsibly between rival theories. One response to would-be underdetermination is to deny that the rival theories are distinct theories at all, insisting instead that they are just different formulations of the same underlying theory; we call this the *identical rivals response*. An argument adapted from John Norton suggests that the response is presumptively always appropriate, while another from Larry Laudan and Jarrett Leplin suggests that the response is never appropriate. Arguments from Einstein for the special and general theories of relativity may fruitfully be seen as instances of the identical rivals response; since Einstein's arguments are generally accepted, the response is at least sometimes appropriate. But when is it appropriate? We attempt to steer a middle course between Norton's view and that of Laudan and Leplin: the identical rivals response is appropriate when there is good reason for adopting a parsimonious ontology. Although in simple cases the identical rivals response need not involve any ontological difference between the theories, in actual scientific cases it typically requires treating apparent posits of the various theories as mere verbal ornaments or computational conveniences. Since these would-be posits are not now detectable, there is no perfectly reliable way to decide whether we should eliminate them or not. As such, there is no rule for deciding whether the identical rivals response is appropriate or not. Nevertheless, there are considerations that suggest for and against the response; we conclude by suggesting two of them.

1 Responding to underdetermination

Consider a *prima facie* case of underdetermination: There seem to be two theories T_1 and T_2 such that standards of responsible theory choice preclude deciding between them. If we accept that the case is as it seems, then we must decide what to do about T_1 and T_2. A modest *agnostic* response is to suspend judgment. If our actions depend on the difference between them, then we muddle along in our uncertainty. A more bumptious response— call this *fideism*— is to believe one of the two theories anyway, as an article of faith.[1]

Of course, since this is only an *apparent* case of underdetermination, we might instead try to show that the choice is not really underdetermined at all. There are again two possibilities. We might deny that responsible choice between the two is impossible. If we tinker with the standards of theory choice, then there might be grounds to prefer one or the other. This is a standard gambit of realists, who add simplicity, novel prediction, or explanatory power to the

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[1]Regarding fideism, see Magnus (2005a) and also van Fraasen (2002).

standards that guide theory choice. To highlight the contrast with agnosticism, call this the *gnostic* response.

Alternately, we might deny that there really are two rival theories under consideration. This might seem as bumptious a response as fideism, but it need not be. Imagine, for example, that T_1 is a theory in French and that T_2 is its German translation; that T_1 is a theory expressed in the metric system and that the only difference in T_2 is that values are converted to imperial units; or that T_1 is formulated using Cartesian coördinates and that T_2 expresses equivalent claims using polar coördinates. Surely, standards of responsible theory choice will be insufficient to prefer one over the other with any of these three pairs. Within each pair, both of the options are the selfsame theory! One merits belief just if the other does. There really is no underdetermination at all. We might reply to any apparent case of underdetermination by insisting that the alleged rivals are really just different formulations of the same theory. Call this the *identical rivals* response.

These four responses form a matrix; see figure 1.[2]

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[2]Sklar (1974, ch 2) and Gardner (1976) offer a similar assessment of the options.

	We do not decide between T_1 and T_2.	We do decide between T_1 and T_2.
The case is judged to be underdetermined.	agnostic response	fideist response
The case is judged not to be underdetermined.	identical rivals response	gnostic response

fig. 1: Four responses to would-be underdetermination

For positivists, the identical rivals response is always the right one: Any two theories which cannot be distinguished on observational grounds have the same meaning and so are the same theory. Positivism runs into familiar difficulties— and there are probably no positivists among our readers, anyway— so we set that answer aside. What we want to know is, under what circumstances is the identical rivals response appropriate?

The obvious answer is: when the two theories *really are* identical. The difficult and interesting question is, rather, what counts as good evidence for the identity of two apparently inconsistent but observationally equivalent theories? Put otherwise, what sorts of considerations would lead one to view two such theories as identical? We propose to come at this difficult question in a roundabout way. In the next section, we consider famous Einsteinian arguments that make use of the identical rivals response (§2). These examples show that the response is appropriate in at least some cases. Moreover (as we discuss in §§3–4) they indicate that the identical rivals response goes naturally with a parsimonious ontology. We argue further: The identical rivals response is really only tenable in cases where a parsimonious ontology is tenable. In §5, we use this connection to provide some criteria for when the identical rivals response is appropriate.

2 Two examples from Einstein

Einstein employs what is recognizably the identical rivals response in formulating both the special and general theories of relativity. The same inferential pattern appears in his 1905 special relativity paper and reappears, applied to different subject matter, in his justification of the principle of equivalence, one of the essential steps on the intellectual road to general relativity.

Einstein (1905/1952) claims that Maxwell's electrodynamics suffers from certain faults. He presents these faults via the now-famous example of a magnet and a conductor moving relative to one another. If the magnet is regarded as moving and the conductor as being at rest, Maxwell's theory claims that an electric field with a certain energy will come into existence around the magnet, which produces an observable current in parts of the conductor. However, if the magnet is regarded as being at rest and the conductor as moving, then there is no electric field in the neighborhood of the magnet. Instead, an electromotive force is created in the conductor. This electromotive force gives rise to the very same current in the conductor as in the first case. If we move with the magnet, we say that an electrical field is produced around the magnet; if we move with the conductor, we say an electromotive force is produced in the conductor. In both cases, however, the current running though the conductor is the same; if we connected an ammeter to the conductor, we would measure the same value for the current in both cases. Einstein draws the following moral from these two cases: “Maxwell’s electrodynamics... when applied to moving bodies, leads to asymmetries which do not appear in the phenomena” (1905/1952, 37).

Let T_1 be the description according to which the magnet is in motion and the conductor is at rest; let T_2 be the description according to which the conductor is in motion and the magnet is at rest. T_1 and T_2 make the same predictions for all observable phenomena. We have a *prima facie* case of underdetermination.

In a similar case, Galileo counseled an agnostic response. In his famous discussion of a moving boat, Galileo concludes that the people below decks cannot tell whether they are in motion or not— it is ‘as if’ the people are at rest (1967, 116). Given two bodies in relative motion, Galileo would have said, there is a fact of the matter about whether one of them is at rest or not— even though no local appearances could allow us to determine which of the two is moving. In this case there is a genuine agnostic response to putative underdetermination; it is not merely a conceptual possibility marked out in figure 1.

Yet Einstein does not give Galileo’s agnostic response. Rather, he concludes that T_1 and T_2 are just different descriptions of the same situation. Although a orthodox physicist in 1905 would think that either the magnet or the conductor was in true motion, the supposed difference between two descriptions is illusory. In short, Einstein gives the identical rivals response.

Einstein deploys the identical rivals response when arguing for the general theory of relativity as well. His reasoning is especially clear in the first general relativity seminar he teaches, in the summer semester of 1919 in Berlin. Hans Reichenbach attended this seminar, and his notebook contains formulations of Einstein's that bring out the parallels to the 1905 paper. Early in the term, Einstein states that both classical mechanics and the special theory of relativity suffer from a certain "physical deficiency." Both rely on the natural law that gravitational mass equals inertial mass, which has been confirmed "with very great, astounding exactness" (1919, I.3). Nevertheless, classical mechanics must take the equality as a brute fact and consequently "there is no explanation for... [this] most important law of nature." As Einstein sees it, though, "we want the numerical equality reduced to an essential equality" (1919, I.4). Einstein accounts for this equality by the so-called *principle of equivalence*.[3]

Einstein considers two frames of reference. The first frame is inertial, i.e. it has zero acceleration in all three spatial dimensions, but has a homogeneous gravitational field of strength *g* directed along the

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[3]Einstein expresses this idea in print. He writes that "previous mechanics had indeed registered this important law, but had not interpreted it". An acceptable "interpretation" of this identity requires recognizing that one and "the same quality of a body expresses itself, according to circumstances, as 'inertia' or as 'weight' " (Einstein 1917/1997, 40). And elsewhere: "It is...clear that science is fully justified in assigning such a numerical equality only after this numerical equality is reduced to an equality of the real nature of the two concepts" (1922/2002, 56–7).

y-axis in the negative direction.[4] The second frame is non-inertial, for it accelerates in the *y*-direction at the rate γ, but has zero acceleration along the other axes. The equations of motion for an observer at rest with respect to the second frame "are the same equations that describe motion in the [homogenous] gravitational field. We can thus say: [the second frame of reference] is at rest, but a gravitational field is present. We need only set g=-γ. Through this conception, the essential difference between inertial and heavy mass is taken away" (1919, I.6).

How should one interpret the physical meaning of the equality g=-γ? In Reichenbach's notebook, there is a diagram of the two frames. Parallel to the *y*-axis in each, there is a drawing of a spring. Beneath the drawing, Reichenbach has written: "From the point of view of [the second frame of reference]: the tension of the spring arises through *gravitational* mass. From the point of view of [the first frame of reference], one judges: The tension of the spring arises through the inertial resistance of the body, through *inertial* mass. The same effect, in one case from inertial mass, in the other case from gravitational mass," (1919, I.6) but it is interpreted differently in different frames of reference.

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[4] A gravitational field (in a space) assigns to every point in the space a gravitational vector; this vector is interpreted physically as the instantaneous acceleration experienced by a test particle at that point in the space. A gravitational field is homogeneous if and only if the same vector is assigned to every point in the space; obviously, the gravitational fields in the vicinity of the sun, the earth, or any other body are not homogeneous.

The parallel with the 1905 inference is close to the surface. If the magnet is regarded as resting, then an electromotive force arises in the conductor; while if the conductor is regarded as resting, then an electrical field arises around the magnet. In either case, we observe the same value of the electrical current. Similarly, in the general relativistic case, if the system is considered to be in motion (constant acceleration) in a gravitation-free region, then the spring experiences inertial resistance; while if the system is considered to be at rest in a uniform gravitational field, then the spring experiences weight due to gravity. In both cases, a spring-based scale would measure the same force. Given the meter reading for the spring, we can explain this reading by positing an inertial force acting on it (the scale is accelerating in a gravitation-free region), or a gravitational force acting on it (the scale is at rest in a uniform gravitational field). One could accept this underdetermination at face value and respond with agnosticism, holding that one or the other description is correct even though we limited beings cannot say which. Einstein does not respond in this way. Rather, he concludes that the two forces are in fact 'essentially' the same, so that there is no real difference between an accelerated spring in a space free of gravitational forces and a spring at rest in a homogeneous gravitational field.

The difference between Einstein's two cases stems from the difference between the special theory, which maintains the notion of a privileged set of inertial frameworks, and the general theory, which attempts to do without such structures. The *constant velocity* of the 1905 paper is replaced by *constant acceleration* later. But both of these arguments pose would-be underdetermination scenarios between two descriptions, but defuse the underdetermination by way of the identical rivals response.

3 Ontology and the examples

The previous section illustrated two instances of the identical rivals response. They are sufficient to show that the identical rivals response is at least sometimes, if not always, appropriate—at least for philosophers of science who consider Einstein's arguments to be good.

Nevertheless, both go beyond the identical rivals response as we originally posed it. The trivial case was when we imagined the same theory in French and in German (or in metric and imperial units of measure, or in Cartesian and polar coördinates)— suppose, for the sake of concreteness, that we have contemporary biochemistry in two languages. The theories talk about a great many unobservable things, like amino acids, enzymes, and so on, as well as their many properties and relations. When we make the identical rivals response, we accept each of the theories. We accept that there really are amino acids and whatnot. For present purposes, it does not matter if this is the practical acceptance of a constructive empiricist or the belief of a realist. What matters is that the two theories are understood as positing a rich ontology of unobservable stuff. We accept the ontologies of the two theories at face value, and— as part of the identical rivals response— we insist that the two ontologies are the same.

The two non-trivial examples are importantly different than this. Consider Einstein's first argument. If we treat the two representations as making claims about absolute motion and absolute rest, then certainly they disagree. Moreover— since there is no absolute motion— neither description is true.[5] It is crucial that Einstein does not treat them in this way. He is only able to treat them as different descriptions of the same situation because he prunes their ontological commitments. There is no absolute motion, only relative motion. Einstein's second argument is similar. In employing the identical rivals response, he prunes any difference between constant acceleration and gravitation from his ontology. The distinctions drawn in the earlier theories are merely verbal distinctions without a difference.

So each extended example of the identical rivals response involves some ontological parsimony; that is, it involves eliminating some of the things that naïvely seem to be posited by the two theory formulations. Yet, as the trival examples are sufficient to show, the identical rivals response is not of necessity eliminativist. So is this just an accidental feature of the examples from Einstein that we've discussed? We argue that it is not. The identical rivals response, except in trivial cases (such as French-German and metric-imperial), requires ontological parsimony.

In the next section, we attempt to deliver on this claim.

4 General arguments

Our approach in this section begins with a sort of antinomy: An argument by John Norton purports to show that (to put it in our

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[5]One might say that they are false, or that they lack truth-values because of presupposition failure or some other semantic problems. But false and truth-valueless theories are both unacceptable, so this difference is unimportant here.

terminology) the identical rivals response is presumptively appropriate whenever we seem to be faced with empirically equivalent theories. At the other extreme, an argument by Larry Laudan and Jarrett Leplin purports to show that there could never be empirically equivalent theories. A consequence of the latter argument is that whenever we seem to be faced with empirically equivalent theories we must be mistaken; as such, the identical rivals response would never be appropriate. So these arguments seem to reach incompatible conclusions. This antinomy is resolved by explicitly acknowledging the rôle of ontological parsimony in applications of the identical rivals response. Before arguing for this, we should explain the two arguments.

THESIS: Anytime we are faced with apparent underdetermination, the identical rivals response is probably appropriate. To give the argument for the thesis briefly:

Suppose we have two theories which are demonstrated to have the same observational consequences.

Since the observational consequences can be reasoned about in this way, there must be some tractable description of them. If the observational consequences of a theory can be described compactly without recourse to the non-observable posits of the theory, then the posits are otiose. So we may presume this not to be possible. There are descriptions of the observational consequences of each theory that make essential use of the central theoretical terms of that theory.

There are three possibilities: Either the theoretical structures of the two theories are utterly distinct, one theory has surplus structure, or they are interconvertible without loss.

(1) The theoretical structure of each theory is what systematizes its observational consequences. As such, the demonstration that the theories have the same observational consequences must have exploited some similarity between the theoretical structures of the two theories. So we may conclude that the two theories do not have utterly different theoretical structures.

(2) If one theory has surplus structure, then— since the rival theory produces the same observational consequences without the surplus— the structure must be inessential for generating observational consequences. These are otiose. They are (as Norton says) "strong candidates for being superfluous, unphysical structures" (2008, 35).

(3) If the theoretical structures are interconvertible without loss, then we should think that the two theories are really just saying the same thing.

Since the third possibility is the most likely, we have a strong reason to think that the two are merely different formulations of the same theory.

Norton puts the conclusion of the argument this way: "[P]airs of theories that can be demonstrated to be observationally equivalent are very strong candidates for being variant formulations of the same theory" (2008, 35). As we would put the point: The identical rivals response is probably appropriate for any case in which the theories can be proven to have the same observational consequences.

Norton's formulation of the argument is somewhat weaker than what we have in mind. It "is specifically restricted to those [theories] whose observational equivalence can be demonstrated in the sort of compact argumentation that can appear in a paper in the philosophy of science literature" (2008, 33). And there may be be a gap between a case being a "very strong candidate" for the identical rivals response (as Norton says) and the response's being probably appropriate. Regardless, the same argument form can be re-deployed to yield the conclusion that the identical rivals response should be the presumptive reaction to empirically equivalent theories, and we will refer to this as 'Norton's argument' below.

Norton's argument raises several issues, but we wish to concentrate on his answer to the second possibility: one of the theories has surplus structure that is not essential for producing the theory's observational consequences. Toy examples of this kind are easy to produce. Let one theory be standard particle physics, and let another theory be standard particle physics plus the posit that there is an undetectable dragon in my garage. Of course the observational consequences of these two theories are the same, and one cannot argue on the basis of observation that there is no dragon. Yet it is tempting to treat the dragon not as an actual posit of the second theory, treating it instead as "superfluous" and "unphysical."

However, refusing to treat dragons as a serious posit of the second theory is not entirely innocent. Imagine that a century from now there is a technique for detecting previously undetectable dragons. Future scientists might come to the place where my garage once stood, turn on their dragonometers, and decide between these two theories. The invisible dragon would not be superfluous or unphysical after all. Returning to the more realistic cases of relativistic physics, it could turn out that future scientific generations will find good reasons to posit absolute velocities or to distinguish inertial effects from gravitational ones. For example, Bohm's interpretation of quantum mechanics requires absolute velocity. If Bohmian mechanics is eventually accepted, then what Einstein considered surplus structure in classical electrodynamics will once again play an important theoretical role. Similarly, if future technological developments allow for more precise versions of Eötvös's experiments to be carried out, then it is conceivable that inertial and gravitational forces will need to be pulled apart again, overturning Einstein's identification of them in the principle of equivalence; see, e.g., Einstein (1922/2002, 316.) The generality of the considerations raised in this paragraph suggest:

ANTITHESIS:*When faced with apparent underdetermination, the identical rivals response is never appropriate*. Laudan and Leplin (1991) argue that, in general, there cannot be logically distinct[6] but empirically equivalent theories. Their reasoning is similar to that of the previous paragraph. To summarize briefly:

The boundaries of the observable are historically variable; similarly, the auxiliary hypotheses that scientists employ in making predictions are historically variable. So take two theories that only disagree about matters that are *now* unobservable. We cannot rule out the possibility that at some time in the future we will develop a way to

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[6]Depending on how theories are individuated, this should perhaps be '...metaphysically distinct...' For the terms 'inertial mass' and 'gravitational mass' are not *logically* identical, even for Einstein—however, they are necessarily or 'essentially' identical for Einstein: a sentence of the form $\forall x(Px \equiv Qx)$ is not a logical truth, but it can be true in all possible worlds for certain values of P and Q.

observe the relevant differences; similarly, scientists might learn previously unknown auxiliary laws which connect the previously unobservable differences with observable consequences. As such, we cannot say of two such theories that they are empirically equivalent.

In the face of any putative underdetermination, we should deny that the rivals are empirically equivalent. This precludes employing the identical rivals response, because if they are the same theory then there cannot be any empirical difference between them.

If the supposition required at the outset of Norton's argument were timeless empirical equivalence with no logical possibility of observational discrimination, then Laudan and Leplin's argument would suffice to show the untenability of Norton's thesis: even though two theories may appear observationally equivalent given today's state of the art, tomorrow's unforeseeable new discoveries may overturn this apparent equivalence. However, Norton's argument need not suppose anything so strong. Distinct theories can have the same observational consequences, *given* background assumptions about observability.[7] For the purpose of Norton's argument, we can treat physics-*cum*-dragon and physics-*sans*-dragon as having the same observational consequences, because we presume as tacit background knowledge that nothing remotely like a dragonometer exists. Dragonometers, as a very remote possibility, can reasonably be set aside as science fiction. On a charitable interpretation, Norton's argument would take the actual physical posits of the two theories as *probably* identical. If the

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[7]Of course, as Laudan and Leplin note, such assumptions are linked to auxiliary hypotheses that are themselves historically variable.

‘dragons’ mentioned in on formulation are un-physical posits, then there is no possibility of their detection.

Refusing Norton’s suggestion and insisting that the dragons might one day be observable would require a literal reading of the dragon ontology, but parallel scruples would undo the Einsteinian examples (from §2.) Consider Einstein’s argument that opens the 1905 special relativity paper. Just as we can imagine dragonometers, we can imagine übergyroscopes that could tell the difference between real motion and absolute rest, and thereby decide which of the two empirically equivalent descriptions is the true one.[8] Or as mentioned above, Bohmian mechanics, which requires bodies to have absolute velocities, could eventually be accepted. If there were an ontological difference between moving the magnet and moving the conductor, then there might in principle be some way to distinguish between the two. If one accepts Laudan and Leplin’s argument, then the situation (in Einstein’s 1905 argument) in which the magnet is at rest would *not* be empirically equivalent to the situation in which the magnet is in motion— because imaginable devices and theories could tease them apart. However, the two competing claims are still underdetermined, in the sense that we cannot responsibly decide between them, since we have no übergyroscope.[9] Similar considerations apply to differentiating inertial

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[8]Indeed, responding to van Fraassen’s discussion of absolute space, Laudan and Leplin imagine discoveries that are tantamount to an übergyroscope (1991, 458).

[9]Although ‘underdetermination’ and ‘empirical equivalence’ are sometimes used interchangeably, this case would seem

mass and gravitational mass. If one follows Laudan and Leplin, then our inability to pull these apart would be merely a brute fact, an observed 'numerical equality,' as opposed to an 'essential equality.' They offer a version of what we earlier called the 'gnostic' response to apparent underdetermination— provided such fantastic devices, we could decide between the theories— but the two examples from Einstein show that the gnostic response is not always appropriate.

Bohmian mechanics and an übergyroscope both presuppose that there is an absolute difference between motion and rest; they take the ontologies of the two descriptions to be thoroughly physical, as opposed to 'unempirical' or 'superfluous.' The identical rivals response proposes instead that there is no such thing as absolute rest, so there is obviously no possible device for detecting it. Switching to Einstein's argument for the principle of equivalence, the identical rivals response is only appropriate because the "numerical equality" of gravitational and inertial mass is replaced with identity— what Einstein might have called 'essential equality.' The plausibility of Einstein's eliminativist ontology is the very reason that his identical rival responses are not undone by Laudan and Leplin's considerations. Because the alternatives describe the same situation, they are logically (or at least metaphysically) equivalent and so necessarily empirically equivalent. If the eliminativist ontology is correct, there is no possible future development that could make them yield different predictions.

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underdetermined even though the theories would not be empirically equivalent. For another such case, see Magnus (2005b).

Returning to Norton's argument, his answer to the second possibility is crucial. Ontological parsimony—refusing to take the excess structure as physical—rules out the possibility that the excess part will generate detectable differences as science advances. It is important to note that this eliminativist move is typically a crucial part of deploying the identical rivals response. We treat undetectable dragons as superfluous because the rest of science directs us to dismiss squamous phantoms. Yet we are fallibilists, and we recognize that we might be wrong; so we cannot banish dragons completely— dragons and absolute velocities remain (in a weak sense) epistemically possible. If scientists in a century develop dragonometers or übergyroscopes, our parsimonious ontology and identical rivals response will prove wrong in retrospect. Norton's argument only yields the conclusion that surplus structures are 'candidates' for occamizing; any two theories with the same observational consequences are candidates for the identical rivals response. Whether the identical rivals response should be elevated from mere candidacy to full adoption depends crucially on whether there is good evidence for ontological parsimony.

Here is another way of making the same basic point. Parties on both sides of the antinomy can accept the conditional 'If two theories are truly empirically equivalent, then they are identical simpliciter.' The thesis (Norton's conclusion) follows from accepting the antecedent and, by modus ponens, deriving identity. The antithesis (Laudan and Leplin's conclusion) follows from rejecting the consequent and, by modus tollens, deriving their empirical inequivalence. We have attempted to show in this section that both modus ponens and modus tollens, as uniform policies, would be rash when facing apparent cases of underdetermination. The success of Einstein's gambits shows that

Laudan and Leplin's modus tollens view is too strong, while Laudan and Leplin's plausible point concerning the variability of auxiliary hypotheses, and resultant variability of what is observable, shows that modus ponens would be too strong. An important reason why uniform modus ponens and uniform modus tollens are both too extreme is that the identical rivals response typically involves (in realistic cases) ontological eliminativism, and there is simply no rule to always eliminate or never eliminate—or even a default rule to eliminate or not. As philosophers should be well aware from debates over several specific eliminativist proposals, the evidential situation pro or contra elimination is usually rather subtle and complex.

5 Two conditions, but no rule

The discussion so far shows that the identical rivals response is sometimes appropriate but cannot necessarily be applied to all cases of apparent underdetermination. Applying it is not simply a matter of inspecting the meanings of the would-be rival theories. It is usually a matter of *deciding* how to understand them: treat the differences as substantive physical disagreement, or treat the differences as merely verbal. We strongly suspect that there is no determinate algorithm for this decision. We can never with absolute certainty rule out the possibility that future auxiliary theories might change the observable consequences of the theories, making today's superfluous content into tomorrow's well-confirmed posit. The point here is not just that such an outcome is logically possible. The Laudan-Leplin worries can always be formulated so long as the two rival theories are treated as genuinely distinct. As such, whether the would-be rivals are merely variant formulations of the same theory cannot be known with certainty. Despite the reasonable doubts raised by the Laudan-Leplin arguments, the two examples from Einstein are sufficient to show that the identical rivals response is sometimes appropriate.

Even though there is no algorithm, we want to suggest two kinds of considerations that are relevant to this decision.

5.1 The future discriminability condition

The identical rivals response is ultimately untenable if future developments will allow for scientists to observationally distinguish between the rival theories. If future technology can detect absolute motion, then it is a mistake even now to treat the disagreements about absolute motion as merely verbal differences. Conversely, the identical rivals response is tenable if such future developments will not occur. Call this the *future discriminability condition*, because it is not directly available to deliberation in the present moment. It is always a matter of whether future possibilities will be realized or not.

However, there can be directly available evidence for or against the future development of observable differences. Before the first neutrino detectors, it would have been rash to trim them presumptively from our ontology; scientists reasonably expected that it would eventually be possible to detect neutrinos, as technology advanced. In cases like these, it is inappropriate to apply the identical rivals response.[10] Such

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[10]This position does not beg the question of realism against the constructive empiricist. By ruling out the identical rivals response in such cases, we are only insisting that the theories should be understood to actually posit ultrasonic vibrations and neutrinos. The realist and the

cases contrast with e.g. absolute velocity, whose inaccessibility to our senses has nothing to do with its being too small for our visual system to detect. No matter how powerful our microscopes become, detecting absolute velocity will not become any easier. It would require an instrument that works in utterly novel ways, instead of simply extending our already-existing discriminatory powers. So the identical rivals response is more defensible here than in the case of neutrinos.

5.2 The heuristic utility condition

Independently, surplus structure may serve a useful heuristic rôle. Fundamental particles are often posited first only for systematic and theoretical reasons. They may be treated as genuine physical posits of the theory for some time before techniques are developed for actually observing them. Call this the *heuristic utility condition*: The identical rivals response is inappropriate when the peculiar posits of a theory are heuristically useful and guide scientists in developing the theory. Conversely, the response is appropriate when the posits serve no useful heuristic role.

A posit might be heuristically useful in this way even if it never makes an observable difference. Even if a particle theory is revised before techniques to observe the particle are developed, taking the posit seriously could be crucial for developing the theory; descendants of the theory may be ultimately confirmed.

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constructive empiricist agree on that much, and we leave them to argue over whether we should believe in the posits or merely accept as empirically adequate the theory that posits them.

In the remainder of the section, we consider two examples in which the internal condition plays a prominent rôle: quantum mechanics in 1926 and the indeterminacy of translation.

In the mid-1920s, Erwin Schrödinger's wave mechanics and Werner Heisenberg's matrix mechanics could have seemed like rival theories. In wave mechanics, the state of the system changed with time and the operators were time independent. In matrix mechanics, conversely, the state was time independent and the operators were time dependent. Nevertheless, any predictions of either would require both the state and an operator, and the predictions of each were (in general) time dependent. So it was natural to think that the disagreement is one about where to write the variable t, rather than a substantive disagreement about the world. Indeed, following papers by Schrödinger and Carl Eckart in 1926, physicists came to treat wave and matrix formulations of quantum mechanics as different formalisms for the same theory. As we would put it, they applied the identical rivals response.

Yet, as Muller (1997) has shown, Schrödinger's arguments were insufficient to show that the two were equivalent. Wave and matrix mechanics did not even have the same observational consequences at that time! So the two could not have been formulations of the same theory. Nevertheless, treating them as if they were was fruitful for physicists. What we are calling the internal condition— heuristic fruitfulness— vindicates the choice. Less than a decade later, von Neumann was able to represent the two approaches in terms of Hilbert spaces. Even though the theories were different in their details in 1926, *successors* of the two theories were just different expressions of a more general formalism.

In this case, as with the other cases we have considered, the identical rivals response involved ontological streamlining. Schrödinger's version of quantum mechanics described unobserved particles as fluctuating bits of jiggly matter; in Muller's phrase, "tiny jelly-like lumps of vibrating charged matter" (1997, 229). Treating wave mechanics as equivalent to the antimetaphyscial matrix mechanics meant treating these waves as unphysical.

Consider a different example: Quine's thesis of the indeterminacy of translation is a reaction to a putative underdetermination scenario.[11] Quine asks us to imagine two linguists working independently to translate the totally foreign Jungle language. Each creates a manual for translating between Jungle and English. The two might create manuals which prove equally serviceable in interactions between Jungle speakers and English speakers but which nevertheless disagree about which Jungle words correspond to which English words. "[T]he thesis of indeterminacy of translation" is that the two "manuals might be indistinguishable in terms of any native behavior that they gave reason to expect, and yet each manual might prescribe some translations that

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[11]Quine himself recognizes differences between the 'standard' underdetermination of theory by evidence in the sciences and his radical translation scenario. "The indeterminacy of translation is not just an instance of the empirically underdetermined character of physics" (1970, 180). We are not concerned here with the nitty-gritty of Quine exegesis.

the other translator would reject." (1987, 8). Considered as theories about the meanings of words in Jungle, the two translation manuals are empirically equivalent but incompatible theories.

This putative case of underdetermination might be met in any of the four general ways that we discussed in the introduction. If we took the agnostic route, we would infer that the existence of the two translation manuals shows that we English speakers cannot know which translation of a given utterance in Jungle provides the true meaning of that utterance.

Quine instead gives the identical rivals response: The existence of alternative translation manuals shows not that we should suspend judgment on which is the 'correct' or 'true' translation, but rather that neither is the one true or correct translation. As Quine says:

> The problem is not one of hidden facts. …The question whether …the foreigner *really* believes A [the translation according to the first manual] or believes rather B [the second manual's translation], is a question whose very significance I would put into doubt. (Quine 1970, pp.180-181)

Although the two manuals seem to disagree about the meaning of Jungle words and sentences, this appearance results only from thinking that the two manuals are theories about traditional (i.e. extra-behavioral) meanings of words or sentences. Quine defuses the would-be underdetermination by suggesting that there is no such thing as the traditional meaning of a sentence in isolation, just as Einstein concluded in 1905 that there is no such thing as absolute velocity. Different manuals are analogous to different inertial frames of reference.

If one is going to resist the Quinean deflation of meaning, it will not be by invoking the future discrimination condition. No one imagines that future linguists will be able to construct meaning-o-meters that determine which translation manual gives the true meanings of the words. Rather, it must be that there is some theoretical advantage to positing meanings. Katz (1967; 1997), for example, argues that such a theoretical advantage exists— that there is a systematic reason internal to linguistics or semantics for positing meanings.

This is a further illustration of the kind of consideration we have in mind with the heuristic utility condition: If there is no heuristic or theoretical advantage of one translation manual over the other, then there seems no ground left for resisting the identical rivals response.

6 Conclusion

We have argued for two general conclusions regarding the identical rivals response in actual scientific cases: First, it goes along with deflating the ontology of one or both theory formulations. The would-be rivals are made to agree because the points on which they could disagree are taken to be merely verbal differences. Second, the identical rivals response is never necessitated by the situation itself. It is, rather, a decision under uncertainty. It is a strategic choice about how to respond to apparent underdetermination.

In the previous section, we suggested two conditions which ought to influence this strategic choice. The future discriminability condition suggests that one should not apply the identical rivals response if there is evidence that future observations will allow you to detect effects of the posits about which the theories seem to disagree. The heuristic utility condition states: Don't apply the identical rivals response if the extra features of one formulation provide extra heuristic or theoretical resources for developing the theory. (Although this formulates the conditions as negative ones, we do not mean to suggest that they merely operate as roadblocks to the presumptive application of the identical rivals response. The conditions could be worded postively, in terms of when the response ought to be applied.)

Note that applying the external condition depends on our background knowledge. Note also that the internal condition depends on our present theoretical context; whether something is fruitful or heuristically useful depends on what else we have to work with. As such, both of these conditions depend on time and context.

Even acknowledging that Einstein was right to apply the identical rivals response and treat absolute velocity as an unphysical posit, it does not follow that the response would have been appropriate earlier. For Newton, absolute velocity played an important rôle. He could not see how mechanics could proceed without it,[12] so what we have called the future discriminability condition might have justified his rejecting Einstein's arguments (if, anachronistically, he had considered them). In the mid-nineteenth century, scientists might reasonably have hoped that the ether would provide a medium in which to measure the Earth's absolute velocity; the heuristic utility condition would have justified their rejecting Einstein's arguments (again, if they had

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[12] See especially Newton's unpublished manuscript *De Gravitatione et Aequipondio Fluidorum* (1962, II.1; in particular 129-131).

anachronistically considered them). It is hard to say when the time was right for Einstein's arguments, but certainly it had arrived by the time he proposed them.

This only seems shocking if we imagine that applying the identical rivals response is like intuiting a timeless essence. Yet it is not as if Einstein had peered into the Form of each state description and recognized them to be the same. Einstein made a scientific argument, situated in the scientific and evidential context of his time. Applying the identical rivals response was appropriate only given the background knowledge and theories of the time. And so it is in any case.

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