Absolutism vs Comparativism About Quantity

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We naturally think that material bodies have *weights*, *sizes*, *masses*, *densities*, *volumes*, and *charges*; that there are *spatial distances* between them *temporal durations* between events involving them. These are all features of material bodies that fall under the category of *quantity*.

In this paper I discuss a question that arises for all quantities but which is best illustrated by the case of mass. The property of having mass is a determinable, but it appears to have two kinds of determinates. On the one hand, we naturally think that something with mass has a determinate *intrinsic* property, a property it has independently of its relationships with other material bodies. But we also think that things with mass stand in various determinate *mass relationships* with one another, such as x being more massive than y or x being twice as massive as y. My question is: of the intrinsic masses and the mass relationships, which are the more fundamental? According to a view I will call *absolutism*, it is the intrinsic masses. The absolutist does not deny that things with mass stand in determinate mass relationships, she just insists that those relationships hold in virtue of the particular intrinsic mass possessed by each body. Thus, if my laptop is twice as massive as my cup, the absolutist thinks that this is in virtue of the intrinsic mass that they each possess. In contrast, *comparativism* is the view that the fundamental facts about mass concern how material bodies are related in mass, and all other facts about mass hold in virtue of them.

I will describe both these views more precisely in Section 1, and as we will see an analogous issue arises for all quantities. Given the central role that quantities play in our understanding of the natural world, it is surprising that neither the physics nor the philosophy literature contains much discussion of the issue. In this paper I motivate and defend comparativism, but I am less interested in pressing that particular view as I am in broadly surveying what I take to be the more important lines of argument for each position, and as a result I will at times sacrifice depth

for the sake of breadth. Moreover, my discussion will mostly be limited to the case of mass, but I try to focus on arguments that stand a good chance of generalizing to other quantities.

The main consideration in favor of comparativism is developed at the end of the paper in Section 8 and is based on the idea that we can only ever observe mass relationships. More fully, the idea is that even if material bodies possessed the intrinsic masses posited by the absolutist, those intrinsic masses would be *undetectable* in the strong sense that the structure of the physical laws governing our world guarantee that they could never have an effect on our senses. Now, absolute velocity and absolute simultaneity are undetectable in the very same sense, and for this reason most contemporary metaphysicians and physicists call them 'redundant' or 'superfluous' and dispense with them on Occamist grounds. My thought is that exactly the same grounds should convince us to dispense with the intrinsic masses posited by the absolutist. More precisely, the Occamist principle I appeal to is that positing undetectable structure is a vice, in the sense that if one theory of the material world posits undetectable structure that another does not then all else being equal we should prefer the latter. All else being equal, then, we should prefer comparativism. Now, whether all else is indeed equal depends on whether there are stronger considerations in absolutism's favor. So in sections 2–7, the bulk of the paper, I consider a number of potential arguments for absolutism and argue that none are convincing; hence my preference for comparativism.

Although I intend the discussion to generalize to all quantities, I will not discuss how the category of quantity itself is to be defined. I will also bracket the largely empirical question of which particular quantities are instantiated around us. Relativistic physics teaches us that at rock bottom there are no temporal or spatial distances but rather a unified space-time interval, and other physical theories might talk of even more weird and wonderful quantities. But here I focus on the case of mass for simplicity.

1 More on Absolutism and Comparativism

The absolutism vs comparativism issue *per se* has not received much discussion. To be sure, views that count as absolutist have been defended by Armstrong [2] and [3], Mundy [19], and Lewis [17]; and views that count as comparativist have been defended by Ellis [10], Bigelow and Pargetter [4] and [5], and Field [11] and [12]. But those discussions are often intertwined with other issues about quantites, so it will help to clarify the issue I have in mind before considering arguments either way.

I stated both views in terms of one kind of fact "holding in virtue of"

another. As I use the phrase, to say that a fact holds in virtue of another is to say that the latter explains the former in a distinctively metaphysical sense.[1] To illustrate, imagine asking what explains Europe's being at war in 1939. A causal answer might describe events during the preceding 50 years that led, say, Chamberlain to declare war on Germany. But there is another kind of answer that would try to say *what it is* for Europe to have been at war in the first place. Regardless of what caused Chamberlain to declare war in 1939, someone in search of this second answer wants to know what goings on in the continent at that time *made it* a continent at war rather than (say) one at peace. For example, one might say that what made it a continent at war was the fact that large numbers of its citizens mobilized and fired guns at each other. As I use the phrase, an answer of this second kind is a statement of that *in virtue of which* Europe was at war. I take this sort of explanatory relation to be reasonably intuitive: regardless of the truth of this claim about what Europe's being at war held in virtue of, we have a strong pre-theoretic grasp of what the claim means.

Thus, whenever some material bodies stand in a mass relationship, the absolutist thinks that this is explained (in this metaphysical sense) by the particular intrinsic mass that each body has.[2] In contrast, the comparativist thinks that the fundamental, unexplained facts about mass are facts about the mass relationships between bodies, and all other facts about mass hold in virtue of those mass relationships. This leaves open what kinds of mass relations those fundamental facts concern: they might concern *mass ratios* such as an object being twice as massive as another, *orderings* such as an object being more massive than another, or even just *linear structures* such an object lying between two others in mass. But this in-house dispute will not matter for our purposes. For simplicity I will often assume that the comparativist under discussion is of the first type, but nothing will hang on this. As stated, both views are claims about what *actually* holds in virtue of what and so are neutral on the relation between intrinsic mass and mass relationships in other possible worlds. One might of course argue that comparativism is necessarily true if true at all (*mutatis mutandis* for absolutism) but I will not take a stand on this issue here.[3]

I have not yet mentioned facts about mass in a particular scale, such

[1] The term 'ground' has also been used to describe this sense of metaphysical explanation.

[2] An absolutist might also appeal to higher-order relations between those intrinsic masses when explaining how the material bodies are related in mass, but this in-house debate will not concern us here. See Armstrong [3], Bigelow and Pargetter [4] and Mundy [19] for more on this issue.

[3] Both views, I should say, are neutral as to the status of facts about the nomic relation between mass and other quantities. The issue just concerns the status of "catergorical" facts concerning the masses of things.

as my laptop's being 2 kgs, and one might consider this omission strange since it is this sort of fact that we most often express when talking about mass. But it is not immediately obvious whether this is ultimately a fact that holds in virtue of my laptop's intrinsic nature or in virtue of its mass relationships, so to avoid begging questions it is best to state the absolutism/comparativism issue without mentioning these facts and leave their status as a further question (I discuss this question in Section 5).

I have so far assumed that "holding in virtue of" is a relation between facts and I will continue to do so for ease of prose. But those wary of facts may express claims about what holds in virtue of what with the sentential operator 'because'. Thus, when I previously said that Europe's being at war holds in virtue of facts about the actions of its citizens at that time, one could re-state this without reference to facts as

> Europe was at war in 1939 *because* a battalion of troops marched to Normandie in 1939 and fired their guns and...[4]

so long as 'because' is understood in the metaphysical rather than causal sense. On this way of talking, the absolutist will assert things like

> My laptop is more massive than my cup *because* my laptop has the intrinsic mass M and my cup has the intrinsic mass M*.

whereas the comparativist will deny such a claim.

Moreover, I have so far made free reference to such things as intrinsic masses and mass relations. For example, the natural interpretation of the indented sentence takes 'M' to be a term referring to a property and the expression 'has the instrinsic mass' to be a relational predicate holding of my laptop and the property M. But nominalists wary of properties and relations can also make sense of the absolutism vs comparativism issue by reading the indented sentence in another way. For example, they might take 'has the intrinsic mass M' to be a primitive monadic predicate containing no referential devices at all. Still, in what follows I will continue to refer to properties and relations for ease of prose.[5]

Although I have focused on the case of mass, it should be clear that the same issue arises for other quantities too. For example, consider the case of

[4]This way of expressing claims about what holds in virtue of what is endorsed by Fine [13]. Strictly speaking the right hand side will consist of a list of sentences rather than a conjunction, but this complication does not matter to us here.

[5]This is not to say that the absolutism/comparativism issue is entirely independent of the issue of realism about properties. One might argue, for example, that the nominalist has a hard time being an absolutist since her vocabulary would then be required to include an infinite number of primitive predicates, one for each determinate mass. Still, logically speaking the issues are orthogonal and in what follows I will not be concerned with considerations that depend on a resolution to the question of realism about properties.

spatial distance. When material bodies X and Y stand in the determinable relation of being spatially related, there are two kinds of determinate relationships that they enter into. On the one hand, it is natural to think that X stands in a determinate distance relation to Y. But it is also natural to think they stand in various comparative spatial relations to other bodies, for example the relation of X being twice as far from Y as Z is from W, or even just of X being further from Y than Z is from W. But of the former fact about the distance between X and Y, and the latter facts about the comparative relationship between X, Y, Z and W, which are fundamental? The absolutist claims that it is the former while the comparativist asserts that it is the latter.[6] This is why I used the terminology 'absolutism' and 'comparativism' in the case of mass rather than 'intrinsicalism' and 'relationalism': when we generalize to other quantities such as spatial distance, the facts that the absolutist takes to be fundamental are themselves facts about relationships.

As I said, my reason for rejecting absolutism (developed in Section 8) is that the intrinsic masses posited by the absolutist would be undetectable in a very strong sense. The Occamist principle described earlier deems this to be a significant mark against absolutism, but whether it is a decisive mark depends on whether there are stronger considerations in absolutism's favor. So in Sections 2–7 I consider six kinds of arguments for absolutism—from *intuition*, from *modality*, from *semantics*, from *kilograms*, from *Humeanism*, and from *physics*—and argue that none are compelling.

2 From Intuition to Absolutism?

Let us start with arguments from intuition. When first introduced to the issue, absolutism strikes many as being the more intuitive and plausible view. If my laptop is more massive than my cup, it initially seems that this is because of their intrinsic masses. Moreover, comparativism conflicts with an intuitive "locality" principle: namely that given a connected region of spacetime R composed of two sub-regions R_1 and R_2, the fundamental intrinsic nature of R_1 and that of R_2 determines the fundamental intrinsic nature of R. According to comparativism this intuitively plausible principle fails, since the mass relationships within R_1 and those within R_2

[6]The absolutism/comparativism issue about distance should not be confused with the substantivalism/relationalism issue. The latter issue concerns the relata of spatial relations and asks whether they are, fundamentally speaking, material bodies or regions of space. Whichever way that dispute is resolved, we may then raise the absolutism/comparativism debate by asking whether, at the fundamental level, those relata stand in 2-place absolute distance relations or 4-place comparative relations.

do not determine the mass relationships between them.[7]

So let us agree that absolutism is initially the more plausible view. One might then argue that this is a reason to think that it is true. But the last sentence conflates a number of arguments. One unconvincing argument is that just as we are endowed with a reliable faculty of perception, we are also endowed with a reliable faculty of intuition which delivers the verdict that absolutism is true. But to this we might well object that there is good reason to doubt that we have a faculty of this sort (for one thing, anatomists and neurologists have yet to find anything corresponding to it). Here we need not deny that we have a faculty of intuition that is a reliable guide to math and logic; all we need insist is that we do not have one that delivers reliable verdicts about what the fundamental physical properties and relations are, for it is this that absolutists and comparativists disagree about. The denial of such a faculty should therefore be uncontroversial.

Still, one might argue that the intuitive plausibility of absolutism carries epistemic weight without appealing to a faculty of intuition. For example, one might say that absolutism is a "Moorean truth", a proposition in whose truth we are more certain than any premise used in an argument to the contrary. Or one might point out that absolutism is our starting point in the inquiry, and then argue for a principle of epistemic conservatism according to which our starting point is (defeasibly) justified merely by virtue of being our starting point. Either way, the upshot would be that our initial absolutist inclinations are epistemically significant.

In response, I do not object to the principle of epistemic conservativism or to Moorean approaches to philosophy. In particular, I concede that absolutism's initial plausibility is at least *some* reason to believe it. But any such reason is defeated by my Occamist argument. To see this, consider the case of absolute simultaneity. While it is initially plausible that there is such a thing as simultaneity, most would agree that considerations from special relativity are enough to defeat any consideration from Mooreanism or epistemic conservativeness in simultaneity's favor.[8] Now, I take the initial plausibility of simultaneity to be at least as strong as the initial plausibility of absolutism. Therefore, since my reason to reject absolutism is the same as our reason to dispense with simultaneity (I leave it untill Section 8 to make good on this claim), it will be be strong enough to defeat considerations from Mooreanism or epistemic conservativeness in absolutism's favor.

[7]Thanks to Eliot Michaelson for elucidating this locality principle for me.

[8]To the Moorean, this shows that our belief in simulteneity is not, after all, more certain than the premises of any argument against it. To the epistemic conservative, it shows that while our belief in simultaneity may have been epistemically privileged by virtue of being our starting point, its privilege was not enough to ward off arguments to the contrary.

3 From Modality to Absolutism?

Another class of arguments for absolutism appeal to modal considerations. I believe that those with absolutist inclinations are often moved by them, so I will consider four such arguments in some detail. The first is that while it is possible for everything's mass to double tonight at midnight, the comparativist cannot make sense of this since the mass relationships would be exactly the same tomorrow as they were today. But in response, the comparativist may claim that some of the fundamental facts about mass concern how something's mass at one time relates to its mass at another. If so, she can make sense of the possibility after all.

A second, more compelling argument along these lines would appeal to doublings of mass across worlds rather than times. Here is Hawthorne:

> It seems, for example, that there could be a pair of worlds w_1 and w_2 such that the same pattern of [comparative mass-relations] obtains between the objects in w_1 and their counterparts in w_2, yet the mass of each particle in w_1 is double that of its counterpart in w_2. From a [comparativist] point of view, it seems difficult to make sense of such possibilities.[9]

Now, I defined absolutism and comparativism to be views about the nature of *our* world, so for our purposes we should take w_1 to be actual. The argument, then, is that while it is possible for everything's mass to have been double what it actually is, comparativism cannot make sense of this.

Why think that the comparativist cannot make sense of the possibility of uniformly doubled mass? Because of the plausible principle that if the fact X holds in virtue of the fact Y, then every world in which Y obtains is also a world in which X obtains. Along with this principle, comparativism implies that worlds agreeing on mass relationships agree on all facts about mass. But the "doubled" world agrees with the actual world on all mass relationships; hence it is not a world that differs regarding facts about mass and is therefore not a world in which everything's mass is doubled.

Now, one response is to become a modal realist in Lewis' sense and say that the fundamental facts of the world are really facts concerning a plurality of worlds. The comparativist may then think that the fundamental facts concerning mass relationships include how objects in different worlds relate to one another in mass. A comparativist of this sort will consider the argument in the last paragraph unsound, since on her view the actual world and the doubled world disagree on their inter-world mass

[9] Hawthorne [14], pp. 230–231, though he doesn't explicitly endorse this argument. A similar argument is given by Eddon [9].

relations. But this an unsatisfying response. Putting aside the unpopularity of modal realism, a more important worry is whether the modal realist can legitimately allow the fundamental facts to concern these kinds of relations between objects in different worlds. For example, the generalization of this approach in the case of spatial distance is that fundamental spatial relations hold between bodies in different possible worlds, and one might argue that this conflicts with Lewis' account of a possible world as the mereological sum of spatio-temporally related things.

So let us restrict attention to the comparativist who concedes that there are no inter-world mass relationships. Still, there are two responses available to her. One is to argue that her failure to make sense of the possibility of uniform doubling is no real vice; the other is to argue that she can, perhaps surprisingly, make sense of the possibility without inter-world mass relations after all.

Start with the first. The argument under consideration rests on the idea that a uniform doubling of mass really is possible, but is this right? I find that my inclinations here depend on my theoretical convictions: when absolutism strikes me as attractive it seems possible, but when I am in the grip of comparativism I feel that the possibility is a silly philosophical mistake. This should not be surprising, since the absolutist and the comparativist are both likely to agree that *if* absolutism is true *then* uniform doubling in mass is possible. Now, if our intuition that doubled worlds are possible rests on a prior belief that absolutism is true, the current argument would at best collapse into the argument from intuition just considered or, at worst, beg the question. So the question is whether we have an inclination to think that uniform doubling is possible that is independent of any prior belief in absolutism, and if so how strong that inclination is. I am not sure how one might go about answering this question, but an answer is crucial to the current argument. For now, then, it is reasonable to take the issue of uniform doubling to be a case of "spoils to the victor".

The second response is that the comparativist can, surprisingly, make sense of the possibility of uniformly doubling without using inter-world mass relations. To see how, it will help to consider the third modal argument against comparativism and then return to the current issue. The third argument is that while it is surely possible for just my laptop to have been twice as massive as it actually is, the comparativist cannot make sense of this. To be sure, she can make sense of a world W just like ours except that the mass-ratio between my laptop and all other things is double what it actually is. But without inter-world mass relationships, there is no fact of the matter as to whether W is a world in which my laptop is twice as massive as it actually is, or one in which my laptop is the same mass and

everything else is half as massive as they actually are. If the actual bodies and those in W had intrinsic masses then the problem would not arise, for those intrinsic masses would determine mass relationships between bodies in the one world and bodies in the other. But without fundamental inter-world mass relationships, the comparativist has no resources to make a similar inter-world comparison.[10]

This argument is far more compelling than the last, for while we might reasonably deny that it is possible for everything's mass to have been doubled we must surely agree that my laptop could have been twice as massive. If the comparativist cannot even make sense of this, that is a vice indeed. I am therefore surprised not to have seen or heard this argument expressed by those with absolutist inclinations.

How might the comparativist respond? I believe she can accuse the argument of using an incorrect model of how a possible world represents my laptop's mass and introduce a better model that allows her to make sense of the possibility in question. To see this, it will help to work with a specific model of how a possible world represents something *de re* of my laptop in the first place. I will work with Lewis' famous proposal that it does so not by containing my laptop but by containing one of its counterparts, though nothing hangs on this choice. Given this assumption, the world W introduced above can be re-described as a world containing counterparts of every actual material body such that if my laptop is r times as massive as another body x, my laptop's counterpart in W is $2r$ times as massive as x's counterpart in W. Clearly, the mass ratios that my laptop enters into differ systematically from those that its counterpart in W enters into by a factor of 2. But other objects differ from their counterparts in W only with respect one mass ratio: for example, my cup's mass ratio to all bodies other than my laptop is exactly the same as its counterpart's mass ratio to theirs. So the comparativist may say that it is in virtue of this asymmetry that W represents my laptop as being twice as massive as it actually is and everything else as being the same mass as they actually are.

In effect, the comparativist just introduced a "mass-counterpart" relation in addition to the ordinary, Lewisian counterpart relation. Since my cup and its counterpart in W resemble one another with respect to their mass role, we call them mass-counterparts. And because my cup's counterpart is also its mass-counterpart, W represents my printer as being the same mass as it actually is. Here the mass-counterpart relation is doing analogous work to Lewis' counterpart relation: just as the latter is not

[10]The situation is not improved by noting that comparativism is a contingent claim and allowing the material bodies in W to have intrinsic masses. For so long as the *actual* material bodies lack intrinsic masses, there remains no fact of the matter as to whether W is a world in which my laptop is twice as massive as it actually is.

identity but stands in for it when determining what a world represents *de re*, the mass-counterpart relation is not the same-mass-as relation but stands in for it when determining what a world represents about mass.

More generally, the comparativist can introduce a whole slew of mass-counterpart relations, one for each real number. My cup's mass role resembles its counterpart's mass role, so we call them mass_1-counterparts. My laptop's mass role does not resemble its counterpart's in the same way, but since the mass ratios my laptop stands in are uniformly half those of its counterpart, their mass roles resemble each other perfectly *modulo* a factor of 2. As a result, we call them mass_2-counterparts. We may then propose the general principle that, relative to a counterpart relation and a set of mass-counterpart relations, W represents an actual object x as being r times as massive as it actually is just in case x has a counterpart in W that is also x's mass_r-counterpart. Relative to the mass-counterpart relations just described, this delivers the desired result that W represents my laptop as being twice as massive as it actually is.

Like the ordinary counterpart relation, we can allow that the aspects of a body's mass role that determine its mass_r-counterparts depend on the conversational context. With a bit of conversational coaxing, we might engineer a lax enough context in which my laptop's counterpart in W is also my laptop's mass_1-counterpart. Relative to this mass-counterpart relation, W represents my laptop as being the same mass as it actually is and everything else as being half as massive as they actually are!

Although the discussion so far assumed Lewis' own theory of *de re* modality, the mass-counterpart theory just introduced is consistent with many other theories including ersatz ones. There is of course much more to about it, but instead let me return to the second modal argument we left earlier and explain how the comparativist can use mass-counterpart theory to make sense of the possibility of uniform doubling. The problem, remember, was that a "uniformly doubled" world would agree with ours on all mass relationships and so, by the comparativist's own lights, on all facts about mass whatsoever and would therefore not be a doubled world after all. But with mass-counterpart theory in hand, I believe the comparativist can accuse the objection of ignoring the distinction between *worlds* and *possibilities*. That is, she can concede that she can make no sense of a uniformly doubled world, but insist that she can make perfectly good sense of the possibility of uniform doubling.

It is a familiar fact that worlds and possibilities come apart in ordinary counterpart theory. To use Lewis' example, I might have been either one of a pair of twins: I might have been the first born, and I might have

been the second born.[11] Here we have one possible world with twins but two possibilities, one in which my counterpart is the first born and the other in which my counterpart is the second born. Indeed, we have already seen an analogous distinction between worlds and possibilities in mass-counterpart theory: the world W discussed above represented two possibilities depending on which mass-counterpart relation we focused on, one in which my laptop is twice as massive as it is and one in which everything else is half as massive as they are. In his discussion of worlds and possibilities, Lewis also says that our counterparts need not always be in other worlds. When I consider the unhappy possibility of being my neighbor Fred, Fred himself (my worldmate) is acting as my counterpart and represents me as having all his properties.[12] In this case the actual world, along with a certain counterpart relation, is representing a non-actual possibility for me.

With mass-counterpart theory, the comparativist can model the possibility of uniform doubling analogously to how Lewis models the possibility of my being Fred, namely by using the actual world along with a suitable mass-counterpart relation. For suppose in a lax enough context each material body were its own counterpart and its own mass_2-counterpart. Relative to these relations, the actual world represents the non-actual possibility of everything being twice as massive as they actually are!

That is the basic idea, but it needs refining. I said above that x is y's mass_2-counterpart just in case x's mass role resembles y's *modulo* a factor of 2. So, since my mass role *perfectly* resembles my mass role *modulo* a factor of 1 rather than 2, one might object that even the most lax conversational context will not count me as my own mass_2-counterpart. But the comparativist can avoid the objection by developing the idea more carefully. When we consider the possibility of uniform doubling, we are considering a possibility for every material body at once. And according to Lewisian counterpart theory, we should model possibilities for many objects by considering counterparts of ordered sets of those objects. So, let S be an ordered set containing every material body. Surely S can be its own counterpart. And S's mass role—the pattern of mass-relations displayed by the members of S—resembles its mass role perfectly *modulo* a factor of 2: the pattern of mass-relations are exactly as they would be were everything doubled in mass! Therefore, in most contexts S is a counterpart and a mass_2-counterpart of itself, in which case our mass-counterpart theory—suitably generalized to apply to ordered sets—implies that the actual world itself represents the possibility of uniform doubling.

[11] See Lewis [16], p. 231.

[12] See Lewis [16], p. 232.

This might come as a surprise. In all discussions of this issue I have enccountered, comparativists and absolutists have agreed that the former cannot account for the possibility of uniform doublings; the disagreement has only been whether this is a vice. But if I am right the shared assumption is wrong and the comparativist can make sense of the possibility after all.

It is worth briefly mentioning a fourth kind of modal argument against comparativism, namely that the comparativist cannot make sense of a possible world containing just one massive body.[13] In particular, one argument is that she cannot make sense of it having the determinable property of having mass, while a second argument is that she cannot make sense of it having any particular determinate mass (say, the mass of an electron). But in response to the first argument, the comparativist can say that having mass consists in standing in a determinate mass relation, and then point out that the lone particle stands in such a relation with itself, namely the same-mass-as relation. And in response to the second objection, the comparativist can appeal to mass-counterpart theory and say that whether the particle counts as having the mass of an electron depends on the mass-counterpart relations allowed by the conversation in which the world is being discussed.

I conclude, then, that the arguments for absolutism based on modal considerations are not convincing.

4 From Semantics to Absolutism?

Absolutists might instead try to argue for their view on semantic grounds. To see how, recall Kripke's famous claim that we use the term 'meter' with the stipulation that it is to refer to the length of the standard meter in Paris.[14] The analogous view in the case of mass is that we use 'kilograms' with the stipulation that it is to refer to the mass of that lump of platinum-iridium alloy in Paris that serves as our standard of measurement, known as the International Prototype Kilogram (IPK). But the entity that the Kripkean theory takes the referent of 'kilogram' to be, namely *the mass* of IPK, sounds suspiciously like an intrinsic property of IPK. After all, if the fundamental facts about mass were just facts about mass relationships, it is difficult to see what "the mass" of IPK could possibly be. So, the argument goes, if comparativism were true then 'kilogram' would fail to refer and sentences like 'My laptop is 2 kilograms' would fail to be

[13]Thanks to Michaela McSweeney for helping me to appreciate the force of this argument.

[14]See Kripke [15].

true.

Of course, the comparativist might bite the bullet and concede that kilogram sentences are not true. According to this "error theory" response, the term 'kilogram' is similar to 'phlogiston': both were used with the stipulation that they are to refer to whatever entity satisfies some description, but since nothing answers to the description they both fail to refer. The main difference between the two cases is that there is a pragmatic reason to continue using the term 'kilogram' that is lacking in case of 'phlogiston'. The idea is that as long as our use of 'kilograms' to be governed by the inference rule

a is r kilograms

b is s kilograms

Therefore, a is r/s times as massive as b

then we can use 'kilogram' as a convenient way of storing and communicating information about mass ratios even if sentences containing it are not true.[15] If this error theory sounds radical and unwarranted, compare it to the case of absolute simultaneity. If semantic investigation revealed that the truth of our ordinary talk requires there to be such a thing as absolute simultaneity but it subsequently turned out for reasons of physics and metaphysics that there is no such thing, we would have no qualms concluding that our ordinary talk is in error. Similarly, if the above semantic argument showed that the truth of 'kilogram' sentences requires the truth of absolutism but it subsequently turned out for reasons of physics and metaphysics that absolutism is false, we should have no qualms accepting the resulting error theory.

But while this error theory is defendable, there is no need for the comparativist to adopt it since the semantic argument fails to establish that the truth of kilogram sentences requires the truth of absolutism in the first place. In fact, it fails for two reasons. First, the Kripkean theory of reference-fixing it presupposes is false. To see this, imagine reading in the Times that the French have been subjecting us to an illusion that makes IPK appear twice as massive as it actually is. Imagine that the article explains that the illusion has been systematic, so that whenever we used IPK to calibrate our measuring instruments, the calibration succeeded even though we were misled about the properties of the lump. So, if we were to put IPK on one of the many calibrated measuring instruments around the world, it would read '500 grams' rather than '1 kilgoram'.

[15] I discuss the role of this form of inference in more detail in Dasgupta [8].

How would we report this discovery? Intuitively, by saying that we discovered the surprising fact that IPK is 500 grams! But the Kripkean theory predicts otherwise. Since the theory is that '1 kilogram' is stipulated to refer to the mass of IPK *whatever that mass is*, it implies that the article should instead be reported as telling us that while the standard object is (of course) still 1 kg, all other material bodies are actually half the mass in kilograms that we previously thought they were. And this, I claim, is not how we would intuitively report it.

But there is a second and perhaps more decisive reason why the semantic argument fails to establish that the truth of 'kilogram' sentences requires absolutism. Even if we granted the Kripkean theory of reference, the argument is supposed to be that the entity to which 'kilogram' is stipulated to refer, namely the mass of IPK, is not identical to IPK's mass relationships, and it concludes that the comparativist must say that there is no such thing. But this last step is a non sequitur. All the comparativist claims is that the *fundamental* facts about mass are facts about mass relationships; it is perfectly consistent with this that there is such a thing as the mass of IPK which is not identical to any mass relationships, so long as any fact of the matter concerning it holds in virtue of facts about IPK's mass relationships. So the comparativist is free to agree that there is such a thing as the mass of IPK to which the term 'kilogram' refers after all.

The non sequitur exhibited by the semantic argument is vividly exemplified in the following case. Consider a physicalist who claims that all facts hold in virtue of facts concerning physical entities, and imagine an objector who says 'The term 'stock market' refers to the stock market, but the stock market is not a physical entity; therefore your physicalism is false.' In response, our physicalist will surely point out that the argument misses its mark entirely: her view was never that everything is a physical entity but rather that all facts about the world hold in virtue of facts concerning physical entities. The comparativist can say exactly the same about the semantic argument.

In sum, I do not believe that there is semantic evidence that the truth of 'kilogram' sentences requires absolutism to be true. But even if there were, I believe that the appropriate response for the comparativist would be to adopt an error theory about 'kilograms'.

5 From Kilograms to Absolutism?

Since comparativism holds that all facts about mass hold in virtue of mass relationships, one might naturally try to refute the view by finding a counterexample, i.e. a fact about mass that does not hold in virtue of mass

relationships. For example, consider the fact that my laptop is 2 kgs. If one can argue that there are no mass relationships in virtue of which this obtains, one would naturally take oneself to have refuted comparativism.

Absolutists should find this strategy promising, for I believe that there are good arguments to the effect that my laptop's being 2 kgs does not hold in virtue of any mass relationships. Unfortunately there is no room to discuss these arguments in full detail, but let me say something to motivate the idea.[16] First, note than an absolutist has no problem accounting for my laptop's being 2 kgs: she can say that it is either identical to, or else holds in virtue of, my laptop's having a certain intrinsic mass. If absolutism were true, this would be an extremely plausible view. For if material bodies really did have intrinsic masses, it would be natural to think that terms of the form '*r* kilograms' would refer to those properties (even if the Kripkean view about what fixes the referents of the terms is incorrect). If so, then it is almost irresistible to say that my laptop's being 2 kgs is either identical to, or else holds in virtue of, its having a certain intrinsic mass; namely the one that is the referent of '2 kgs'.

But the fact that this account of my laptop's being 2 kgs is so natural and satisfying shows that, at least intuitively, the mass relationships that it enters into are entirely irrelevant when it comes to explaining what makes it 2 kgs. My laptop stands in all sorts of mass relationships to standard objects in Paris and measuring instruments in Paruguay and electrons on Pluto, but the fact that the absolutist's explanation is so satisfying shows that, intuitively, all these relationships are irrelevant to an explanation of its being 2 kgs. Therefore, the argument goes, whichever mass relationships the comparativist picks in order to explain its being 2 kgs, she will violate our intuitions as to what is relevant to explaining that fact. Of course, the comparativist might concede this and reply that revising our opinions about what is explanatorily relevant is a natural consequence of theoretical inquiry. To an extent, this reply is well taken. But all hands should agree that this would be a significant revision of pre-theoretic belief and therefore counts as at least a point against her view.

As I said, there is no space to develop this kind of argument in detail. But let us give the absolutist the benefit of the doubt and suppose that there are no mass relationships in virtue of which my laptop is 2 kgs. Where does this leave the comparativist? One option would be to sidestep the entire issue by adopting the error theory described earlier, according to which there are no facts about mass-in-kilograms in the first place.

But I believe that there is a better option. The key is to recognize that the *in virtue of* relation is irreducibly plural, in the sense that a plurality of

[16]These arguments are developed in more detail in Dasgupta [8].

facts Y can sometimes hold in virtue of another plurality of facts X even though no Y when taken on its own holds in virtue of anything. Given this "pluralistic" conception of the *in virtue of* relation, the comparativist may take the set K of all kilogram facts and the set R of all facts about mass relationships, and propose that the members of K (plurally) hold in virtue of the members of R even though no kilogram fact taken on its own holds in virtue of anything. This view neatly sidesteps the problem of relevance discussed above, for R does not contain irrelevant information when it comes to explaining the members of K. To be sure, R contains irrelevant information when explaining my laptop's being 2 kgs, such as information about its mass relationships to electrons on Pluto, but since K contains facts about how massive those electrons are in kilograms the relationships between them are perfectly relevant when explaining K's members all together. By adopting this position, the comparativist can then agree that there is a fact of my laptop's being 2 kgs (*contra* error theory), concede that there are no mass relationships in virtue of which it obtains, and yet nonetheless insist that this is perfectly consistent with comparativism since it remains the case that all the facts about mass in kilograms taken together as a plurality hold in virtue of the underlying mass relationships.

There are many virtues of this view. One is that the comparativist can respect the intuition described earlier that facts about my laptop's mass relationships are not part of what explains my its being 2 kgs. They are not part of the explanation of this fact, on this view, because the fact on its own has no explanation in the first place! Another virtue is that it neatly explains why absolutism is initially the more intuitive and attractive view. For as we have seen, we have a strong intuition that my laptop's being 2 kgs does not hold in virtue of its mass relationships to other bodies. According to the current approach, the absolutist's mistake is just to take this to imply that its being 2 kgs must be explained in terms of its intrinsic nature, when instead the correct conclusion is that we can only explain facts about mass in kilograms when they are taken all together as a plurality. The absolutist's mistake is therefore understandable, but a mistake nonetheless.

Now I have not argued that this pluralist explanation of kilogram facts is satisfactory, and unfortunately there is no space to do so here.[17] But at the very least, it is clear that if the *in virtue of* is irreducibly plural, it is not enough for the absolutist to argue that my laptop's being 2 kgs fails to hold in virtue of its mass relationships. In addition, she would need to argue that the plurality of kilogram facts taken together do not hold in virtue of the totality of mass relationships. Until she shows this, comparativism

[17] I motivate and defend this pluralist explanation at some length in Dasgupta [8].

remains a live option.

6 From Humeanism to Absolutism?

Humean Supervenience (HS), says Lewis, is the view that

> all there is to the world is a vast mosaic of local matters of particular fact, just one little thing and then another... We have geometry: a system of external relations of spatio-temporal distances between points... And at those points we have local qualities: perfectly natural intrinsic properties which need nothing bigger than a point at which to be instantiated... And that is all. There is no difference without a difference in the arrangement of qualities. All else supervenes on that.[18]

So stated, HS is inconsistent with comparativism since it asserts that the fundamental physical quantiites like mass are intrinsic and are instantiated at single points of spacetime. But HS is supported in the literature by wide range of arguments. If it is inconsistent with comparativism, the argument would be, so much the worse for the latter.

However, most arguments for HS are perfectly consistent with comparativism. To see this, note that HS is the conjunction of two theses: one stating that everything supervenes on the categorical nature of the physical world, and a second describing what the categorical nature of the physical world is like. The above quote focuses on the second and says that the categorical nature of the world consists in the distribution of intrinsic properties across spacetime. And that second thesis is indeed inconsistent with comparativism.

But most of the literature on Humean Supervenience focuses on the first thesis, the view that everything else—including chances, causes, counterfactuals, minds, morals, etc—supervenes on the world's categorical nature. And a brief glance at that literature reveals that none of the arguments depend on whether those underlying categorical facts consist in the instantiation of intrinsic properties (as Lewis says) or in the instantiation of comparative relations (as the comparativist says). Even if one is moved by those arguments, one may still adopt comparativism.

To be sure, the second thesis does play a role in Lewis' metaphysics. For example, he famously analyzes *de re* modals in terms of counterparts, and he says that objects are counterparts insofar as they resemble each other, and he says that resemblance is ultimately a matter of sharing *intrinsic* properties. But one can easily restate his view in terms friendly

[18] Lewis [17], p. ix.

to the comparativist by allowing resemblance to ultimately be a matter of participating in the same pattern of *relations* instead. Indeed, Lewis only thought that resemblance was ultimately a matter of sharing intrinsic properties because he thought that it was a matter of sharing *perfectly natural* features, and the second thesis of HS states that those perfectly natural features are all intrinsic (save for geometric relations). Thus, if one gives up that second thesis in favor of comparativism and allows that some perfectly natural features are relations, it will follow from the rest of his system that resemblance is sometimes a matter of participating in the same pattern of relations after all. As a result, a large chunk of Lewis' system remains essentially unchanged even if we endorse comparativism.

This is not to say that all of Lewis' views are easily recast in comparativist terms. Still, once one sees how many of them can be, the above quote stating that the categorical world consists in the distribution of intrinsic properties sounds less like an essential part of his view and more like a convenient working assumption.

7 From Physics to Absolutism?

The arguments for absolutism considered so far have been broadly apriori, but is there empirical evidence in its favor? If we could see the intrinsic mass had by a given material body or detect it with the help of mechanical devices, that would be empirical evidence for absolutism. But I will argue in Section 8 that if material bodies had the intrinsic masses posited by the absolutist, those intrinsic masses would be invisible to the naked eye and undetectable by any physically possible device.

Still, if the absolutist could show that intrinsic mass is indispensible to our best confirmed scientific theories, one might then think that empirical evidence confirming those theories would count as empirical evidence that each material body has an intrinsic mass even if we cannot tell which particular one it is. To see how this idea might be developed, consider one simple law governing mass, $f=ma$, and let us pretend for simplicity that our best confirmed physical theory states that it is the only law governing the motions of material bodies. Now, consider a world W exactly like ours with the one exception that everything's mass is double what it actually is. One might argue that if the equation $f=ma$ actually obtains then it does not obtain in W since doubling everything's mass while leaving their forces and accelerations unchanged would break the equality.[19] Since W is just

[19]This is where it helps to ignore any other laws specifying the force acting on each particle and pretend that $f=ma$ is the only law governing our world. For we thereby sidestep the complication that with the identification of inertial mass and gravitational

like ours in all mass relational respects, the argument would be that the truth of *f=ma* depends not just on the mass relations between things but also on which intrinsic masses they have. Therefore, empirical evidence confirming *f=ma* is *ipso facto* empirical evidence confirming absolutism.

But the argument does not convince, for it depends on a controversial interpretation of the equation '*f=ma*'. Taken at face-value, it states a mathematical relationship between the numbers and vectors that represent force, mass and acceleration in a particular scale. But what does it state about the quantities themselves? It can either be interpreted as stating something about absolute quantities or as stating something about comparative quantities. On the first interpretation it states that the absolute masses, accelerations and forces all line up in a specific way, for example that anything with the mass M and with the force F acting on it will accelerate at the rate A (where 'M', 'A' and 'F' refer to a determinate absolute mass, acceleration and force respectively).[20] More generally:

(L1) For any material thing x,

- (a) For any reals r_1 and r_2, if x has mass r_1M and acceleration r_2A, then x has force r_1r_2F acting on it.
- (b) For any real r_3, if x has force r_3F acting on it, then there are reals r_4 and r_5 who's product is r_3, such that x has mass r_4M and acceleration r_5A.

By contrast, the second interpretation of the equation takes it to state how the mass, acceleration and force relationships line up, for example that if a particle x has twice as much force exerted on it than y and they are of the same mass then x will accelerate at twice the rate as y. More generally:

(L2) For any material things x and y,

- (a) For any reals r_1 and r_2, if x is r_1 times as massive as y and is accelerating r_2 times the rate of y, then x has r_1r_2 times as much force acting on it than y.

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mass, mass plays a unique role in classical mechanics: not only is it a "brake" on acceleration as described in *f=ma*, it is also a determiner of the gravitational force between things as described in the inverse-square gravitational force law. The fact that it plays this dual role might tempt one to think that doubling everything's mass would preserve the truth of the classical mechanical laws, since the increase in gravitational forces would be counter-balanced by the increased "brake" effect experienced by each body. But even if this line of reasoning were sound, it would not generalize to other quantities. I consider *f=ma* in isolation from whatever force laws it might couple with precisely because we are looking for general considerations.

[20]For simplicity I ignore the directional aspect of acceleration and force and focus on their magnitudes.

(b) For any real r_3, if x has r_3 times as much force acting on it than y, then there are reals r_4 and r_5 such that $r_4 r_5 = r_3$, and such that x is r_4 times as massive as y and is accelerating r_5 times the rate of y.

The argument under consideration assumed that *f=ma* does not obtain in the world W in which all masses are doubled. We can now see that this is correct *if* the law expressed by the equation is (L1), since in W the absolute masses, forces and accelerations line up differently. But the assumption is false if the law expressed is (L2), for (L2) only talks of mass relationships and those are the same in W as they are in the actual world. Indeed, it is clear that if '*f=ma*' expresses (L2), then its obtaining does not depend on material bodies having the intrinsic masses posited by the absolutist, *contra* the argument under consideration.

The absolutist might now argue that the empirical evidence confirming *f=ma* is evidence that confirms (L1) and disconfirms (L2), in which case absolute quantities would be indispensable to what is confirmed by our evidence after all. But what evidence would favor (L1) over (L2)? The difference between the laws is this: (L1) implies that if the state of the world at present differed only in that everything's mass were double what it actually is, things would proceed to accelerate at half their actual rate.[21] (L2) does not imply this because the mass ratios would be exactly the same in the doubled state and that is all that the law makes reference to. So the two laws issue these different predictions, but how could we test which prediction is correct? The obvious idea is to construct two isolated laboratories that are exactly alike at an initial time except for the fact that one is a doubled-mass version of the other. One might think that if the bodies in the doubled-mass laboratory proceed to accelerate at half the rate as the bodies in the other, this would confirm (L1) and disconfirm (L2).

But on further reflection this experimental outcome is predicted by (L2) and would therefore not disconfirm it. After all, the bodies in the doubled-mass laboratory are twice as massive as their counterparts in the other and are subjected to the same forces as those counterparts, and the experimental outcome is that they accelerate at half the rate as their counterparts. But this is exactly what (L2) would predict! The trouble is that the two laws make different predictions about what would happen if *the entire world* were doubled in mass, but when attempting to test which prediction is correct we can do no better than to compare different *parts of the*

[21] Again, I am bracketing the effect that doubling everything's mass might have on the forces acting on things. See footnote 20.

world (our two laboratories) and the laws make exactly the same prediction about what would then occur.

This suggests that there is no possible evidence that would confirm (L1) but disconfirm (L2). Now in arguing for this I have so far assumed in what I argue for in Section 8, namely that even if absolutism were true it would be impossible to see or detect which particular intrinsic mass each material body has. But it will be important later on to see that even if that assumption were false, there would still be no empirical data confirming (L1) that disconfirms (L2). For suppose that we observed that the absolute quantities of mass, force and acceleration line up in the way stated by (L1). Would this disconfirm (L2)? No, because that observation is consistent with the hypothesis that material bodies have absolute quantities but are governed by (L2). For if that were the case then the absolute quantities are bound to line up in one way or another, it would just be a matter of accident that they line up as they do whereas according to (L1) they would line up like that as a matter of law.

It therefore appears that there is no possible evidence that would confirm (L1) and disconfirm (L2). Under the pretense that $f=ma$ is the only law of our best confirmed physics, then, the intrinsic masses posited by the absolutist are not indispensable to our best physics after all. The pretense is of course false, but it seems reasonable to expect that similar reasoning will apply in the case of better confirmed physical theories. I leave it to others more qualified to discuss those theories to determine whether that is true.[22]

8 In Favor of Comparativism

8.1 The Occamist Argument

Having surveyed a number of arguments for absolutism, I find none convincing. But is there any positive reason to be a comparativist? I believe there is. I will argue that if material bodies really did have the intrinsic masses posited by the absolutist, those intrinsic masses would be undetectable. Since our Occamist principle says that it is a mark against a theory if it posits undetectable structure, this is reason to prefer comparativism.

[22] Field [11] has famously made a good start at expressing a portion of physics in purely comparativist terms. However, the current point does not depend on the success of Field's project, which was to express physics without reference to numbers, sets or other abstracta. For example, (L2) serves the comparativist's purposes but it freely quantifies over real numbers.

Much depends on what I mean by 'undetectable'. If I used the term to include anything that we cannot see with the naked eye, our Occamist principle would recommend that we become radical scientific anti-realists and dispense with so-called "theoretical" entities such as electrons. But that is not how I use the term here. Instead, something is undetectable in my sense of the term if, roughly speaking, it follows from the structure of the laws of motion governing our world that it is physically impossible for it to have an impact upon our senses. Electrons are therefore perfectly well detectable in this sense because there are physically possible processes, such as those that occur in particle accelerators, which reveal their presence to us. In contrast, features like absolute velocity and absolute simultaneity are undetectable in my sense: even if they were real, it turns out that the laws of motion governing our world are set up in such a way as to guarantee that it would be impossible for them to ever have an impact on our senses. That is why they are considered to be 'redundant' or 'superfluous' in modern physics, and most physicists and metaphysicians therefore believe on Occamist grounds that those features are not real after all. I will argue here that the same goes for intrinsic mass.

Now our Occamist principle does not say that we should *always* dispense with undetectable features. It just says that undetectable features are undesirable, so that all else being equal—or at least near enough equal—we should prefer theories like comparativism that dispense with them. But the previous sections showed that all is indeed near enough equal, for they showed that there are no overwhelming reasons to reject comparativism.

Our crucial premise, then, is that if material bodies really possessed the kind of intrinsic mass posited by the absolutist, those intrinsic masses would be undetectable in our sense of the term. How should we argue for this? There is a reasonably well known argument for the analogous claim in the case of absolute velocity, so let us rehearse it before applying it to the case of intrinsic mass.

8.2 The Case of Velocity

What is absolute velocity? We often talk of a material body's velocity relative to another body: a car might have a velocity of 65 mph in a particular direction relative to the highway and 10 mph in the same direction relative to the train traveling alongside it. But how fast is it *really* going, independent of any material reference point? If there is an answer to this question, that is a statement of its absolute velocity.

Now if there were such a thing as absolute velocity, why would it be undetectable? At least naively, one might think that the speedometer found in an ordinary car is a device that detects the vehicle's absolute

velocity. But we can argue that such a device at best measure relative velocity and that absolute velocity is undetectable after all.[23] For in order to detect absolute velocity, there would need to be some physically possible process that, when initiated at t_0 to measure the absolute velocity of a given body, will generate a reading—an image on a computer screen, say, or the position of a needle—that indicates what that body's velocity was at t_0. Moreover, the outcome that would be produced if the body were traveling at one velocity must be discernibly different from the outcome that would be produced if it had a different velocity, on pain of our not being able to tell what velocity a given outcome indicates.[24] So, if we simply wanted to measure whether a given body was in a state of absolute rest or absolute motion, the process would need to produce one outcome if the body was at rest at t_0—for example an inscription of 'At rest'—and a discernibly different outcome if the body was moving t_0—an inscription of 'Moving', say. Finally, since the process is a physical process, the outcome produced will depend on the physical laws governing our world. Putting this all together, we can therefore say that absolute velocity is detectable only if there is a physically possible device which at a given time t_0 has two properties: first that, according to the laws, it will display 'At rest' on a computer screen at a later time t_1 iff it was presented with a body at rest at t_0; and second that (according to the laws) it will display 'Moving' on a computer screen at t_1 iff it was presented with a body that was moving at t_0.[25]

But according to most of our best confirmed physical theories, it is physically impossible for a device to have both properties. For suppose I take a device with the first property and present with a body at rest at t_0, and it therefore displays 'At Rest' at t_1. We can show that it does not have the second property by considering a world W just like ours with the one exception that at all times the absolute velocity of all bodies is five mph greater in a certain specified direction. Now, W is a world in which the

[23]This argument that follows has received perhaps its clearest written expression in Roberts [20]. I heard similar arguments orally in seminars given by Tim Maudlin at Rutgers and David Albert at Columbia. However, all these theorists run the argument in importantly different ways. My presentation here is similar to my presentation in Dasgupta [6]. For a more thorough discussion of this style of argument, see Dasgupta [7].

[24]At least, that is the ideal: in practice, we do not mind if the outcomes that would be produced by velocities differing only by some tiny amount are indiscernible. More accurately, then, what we require is that the outcomes would be discernible when the velocities differ by more than some amount x, in which case we say that the process measures absolute velocity up to an accuracy of x.

[25]We use biconditionals here because we not only want each initial velocity to issue in a readable outcome, we also want each outcome to be *uniquely* associated with that initial velocity so that we know what the outcome indicates.

device is presented with a *moving* body at t_0, and yet—since the relative positions of all bodies at all times are (by construction) the same in W as they actually are—the device still displays 'At rest' at t_0. But it turns out that according to our best physics, the laws of motion governing W are the same as those governing ours. Therefore, the behavior of the device in W represents how it behaves according to our laws of motion; hence it does not have the second property listed above. QED.

This is not to say that speedometers in cars are useless, for the argument here is consistent with the thesis that they detect the car's velocity relative to a given body such as the road. All the argument shows is that they do not detect the car's absolute velocity.

8.3 Devices and Our Knowledge of Them

Returning to the case of intrinsic mass, let us suppose for reductio that material bodies have the intrinsic masses posited by the absolutist. For similar reasons as just discussed in the case of velocity, I claim that which particular intrinsic mass each body has would be undetectable.

The claim may initially sound implausible. After all, my laptop and my cup feel different in mass when I pick them up, so am I not thereby detecting the intrinsic mass of each item? Similarly, one might naturally think that an ordinary bathroom scale is a device that allows us to detect the intrinsic mass of the object placed on it by displaying its mass in the position of a needle. But it turns out that this is a mistake: just as a speedometers at best allow us to detect the velocity of a car relative to the highway, so too picking things up or putting them on bathroom scales at best allows us to detect the mass relationships between things and not their intrinsic masses.

The argument is a little more complex than in the case of velocity, but let us start by running an analogous argument and modify it as required. For convenience, let us suppose that the terms '1 kg' and '2 kgs' label particular intrinsic masses. Following the above discussion, we can then say that intrinsic mass is detectable only if there is a physically possible device which at a given time t_0 has two properties: first, that (according to the laws) it will display '1 kg' on a computer screen at a later time t_1 iff it was presented with a 1 kg object at t_0; and second, that (according to the laws) it will display '2 kgs' on a computer screen at t_1 iff it was presented with a 2 kg object at t_0. We now argue that it is physically impossible for a device to have both properties. To this end, suppose I take a device with the first property and present it with a 1 kg object at t_0 and it therefore displays '1 kg' on a screen at t_1. We show that it does not have the second property by considering a possible world W just like ours

with the one exception that everything's mass is double what it actually is; that is, a world in which our device is presented with a 2 kg object at t_0 but in which it nonetheless displays '1 kg' at t_0. And we now make a key assumption, namely that the laws of motion governing W are the same as those governing ours. It then follows that the behavior of the device in W represents how it behaves according to our laws of motion; hence it does not have the second property listed above. QED.

But is the key assumption correct? As before, let us suppose for simplicity that our best confirmed physical theory states that there is only one law of motion governing our world: $f{=}ma$. In the last section, we saw that this equation might express one of two things: a law governing absolute quantities like (L1), or a law governing comparative quantities like (L2). We also saw that if the actual law turns out to be of the second kind then it would obtain in W too, while if the actual law turns out to be of the former kind then it would not obtain in W (in the latter case W does not represent how our device behaves according our laws of motion and it remains open that it has the two properties after all). So the assumption that the law of W are the same as the actual laws amounts to the assumption that the laws are like (L2) and govern comparative quantities.

Can the comparativist assume this? The assumption does not presuppose the falsity of absolutism, since the hypothesis that the laws govern comparative quantities is consistent with the idea that material bodies also have intrinsic quantities in virtue of which those comparative quantities obtain. But is the comparativist entitled to believe that the assumption is true? Recall that in the last section we argued that there is no possible evidence that would confirm the hypothesis that law governs absolute quantities but disconfirm the hypothesis that it governs comparative quantities. Importantly, the argument did not assume that intrinsic mass is undetectable, so we can appeal to the result of that argument without begging questions. So, if the evidence does not settle the matter either way, what is the comparativist entitled to assume?

This is a delicate issue in epistemology concerning what it is reasonable to believe given certain evidence. An extremely "permissive" view of rationality would say that if the evidence does not settle whether p or q, it is reasonable to believe either. On this view, the comparativist may reasonably believe that the actual law governs comparative quantities, in which case she can run the above argument as written. But one might worry that the argument would be dialectically weak, since on this permissive view the absolutist would presumably be entitled to believe that the laws govern absolute quantities, in which case she will remain unmoved by the argument. Moreover, other views in epistemology would insist that if the

evidence equally supports two views, we should remain agnostic between the two.

Luckily there is no need to settle the issue here. For what our central argument shows is that a given device has the two properties listed above only if our laws govern absolute rather than comparative quantities. Therefore, my evidence that a given device has those two properties can be no higher than my evidence that the laws govern absolute quantities rather than comparative quantities. But the conclusion of the last section was that there is no possible evidence that the actual laws govern absolute quantities and not comparative quantities. Therefore, regardless of the delicate epistemic question of what it is reasonable to believe given certain evidence, all hands should agree that I can have no evidence that a given device has the two properties listed above. And this conclusion is strong enough for our purposes. For even if a given device does in fact have the two properties and gives a reading of ' 1kg' when I present it with a material body, the fact remains that if I have no evidence that the device has those two properties then the reading gives me no evidence as to what the body's intrinsic mass is. So the conclusion of this "epistemic" version of the argument is that even if absolute mass is in some sense detectable *by the device*, it is not detectable *by us*; which is presumably the point we were trying to establish all along.

The argument here trades on the familiar point that the outcome of a measurement depends on three things: the value of the feature being measured, the initial state of the device being used to measure the feature, and the laws that govern the interaction between the feature and the device. If we know enough about the last two factors, we can use the outcome of the measurement to infer what the value of the feature was. But if we do not know enough about what laws govern our world, then we may not be in a position to make the inference. The argument here is that if we lack evidence as to whether our laws govern absolute or comparative quantities, then we have exactly this kind of handicap when trying to detect which particular intrinsic mass a given body has.

8.4 A Third Argument for Undetectability

So here are two strategies available to the comparativist. First, she might argue on the basis of a permissive view of rationality that she is entitled to the key assumption that the laws of W are the same as the actual laws, and therefore argue that intrinsic mass is undetectable in exactly the way that we argued in the case of velocity. Or, second, she might argue that since we lack evidence as to what our laws are, it follows that intrinsic mass is undetectable by us (even if it is in some sense detectable by a device). My

own preference is for the second strategy.

But there is also a third strategy. Suppose, perhaps *per impossible*, that we were to acquire evidence that the actual law governs absolute quantities and that devices with the two properties listed above are therefore physically possible. The idea is that there would still be some evidential uncertainty as to the details of what that law is in such a way that we could never acquire evidence that a given device has the two properties. As with the second strategy, the conclusion is then that even if intrinsic mass is detectable by certain devices, it would remain undetectable by us.

To see this, suppose we are given a device and are asked to determine whether it has the two properties listed above. One of those properties was that it will behave in a certain way *according to the laws governing it*, namely it will register '1 kg' on a computer screen at t_1 iff it is presented with a 1 kg object at t_0. Now suppose that, in fact, the device in front of us will behave like that *according to (L1)*. And suppose that (L1) is the actual law, so the device really does have the property. Now (L1) does not obtain in W but something closely related does, namely the result of replacing all occurrences of 'M' with '$2M$' (where this latter term refers to the mass that is double that of M). Call this law (L1*). Then what W shows is that if everything's mass were uniformly doubled then, *according to (L1*)*, the device will not behave in the same way. Rather, it will register '1 kg' on a computer screen at a later time t_1 iff it is presented with a 2 kg object at t_0, rather than with a 1 kg object. So whether or not the device in front of us has the required property depends on which of two hypotheses is true: hypothesis H, which attributes to the device its actual mass and states that (L1) obtains, or H*, which attributes to the device the mass it has in W and states that (L1*) obtains.

But the trouble is that no evidence could possibly favor either hypothesis over the other. For on the assumption that W is indiscernible from the actual world (that I will discuss in a moment), it follows that no empirical evidence would falsify either hypothesis. And (L1) and (L1*) are of exactly the same form: both are equally simple, elegant, unifying and explanatory. So neither hypothesis trumps the other on any theoretical virtue we use to choose between hypotheses that agree on the empirical data. But the device in front of us has the required property only if hypothesis H is true. Therefore, since there can be no evidence that would favor H over H*, there can be no evidence that the device has the required property. And as we just saw when discussing the second strategy, this means that even if a given device does in fact have that property, the readings it delivers will give us no evidence as to what a body's intrinsic mass is and therefore

intrinsic mass will remain undetectable by us.[26]

Admittedly, this strategy is rather more involved than the second strategy described above. But still, some comparativists might be interested in developing it.

8.5 Indiscernibility

We have assumed if intrinsic mass is detectable, it is detectable by processes that indicate mass with inscriptions of '1 kg' and '2 kgs'.[27] This is not to deny that it might be detectable in other ways too; our assumption was just that if it is detectable at all, it must at least be detectable in this way. Our strategy was then to argue that intrinsic mass is not detectable in this way; hence it is not detectable at all.

How plausible is the assumption? Borrowing an idea of Albert's, the comparativist might argue that it should be extremely plausible. For given anything D that counts as an intrinsic mass detector, it is presumably possible for us to decide in advance to record the result of the measurement produced by D by writing '1 kg' or '2 kgs' on a piece of paper depending on what the result is. If so, then the result of coupling D with our decision to record the outcome of D in that way constitutes a composite device that detects mass with the inscriptions '1 kg' and '2 kg', and our assumption is vindicated.[28]

Still, one might try to resist the assumption. For one might try to argue that there are physically possible process by which something's intrinsic mass can have a discernible effect on the qualitative character of our experience, and that we can therefore detect which intrinsic mass a given body has by noticing what kind of qualitative experience we enjoy at the end of the measurement process. According to this objection, my argument so far only shows is that it would then be physically impossible for us to record the result of the measurement by writing '1 kg' or '2 kgs' on a piece of paper depending on what the result is.

[26]This argument appeals to the assumption that the actual world and W are indiscernible, and one might worry that this begs the question by assuming that absolute mass is undetectable. But the worry is misplaced. At most, the indiscernibility of the two worlds just shows that absolute mass is invisible to the naked eye, but it remains open that it is possible to build measuring devices that might reveal them to us. The fact that the worlds have such similar laws is then being used to show that no such device is possible.

[27]In full, remember, we assumed that intrinsic mass is detectable only if there is a physically possible device which at a given time t_0 has two properties: first, that (according to the laws) it will display '1 kg' on a computer screen at a later time t_1 iff it was presented with a 1 kg object at t_0; and second, that (according to the laws) it will display '2 kgs' on a computer screen at t_1 iff it was presented with a 2 kg object at t_0.

[28]See Albert [1] for more on this way of thinking of about detectability.

In response, the comparativist might emphasize that the scenario being envisaged is extremely implausible. For it seems compelling that whenever I am able to enjoy two discernibly different qualitative states, I am also able to produce *some* bodily movement—inscribing '1 kg', say, or putting my arm in the air—in response to the one experience and not the other. The objection must therefore deny what we take to be an obvious fact about our life.

But there are two further responses available to the comparativist. One is to deny that differences in intrinsic mass has any effect on the qualitative character of our experience. To argue this, the comparativist might argue that the doubled world W would be indiscernible from the actual world, in the sense that everything would look and feel and taste and smell exactly the same as it actually does. But is this true? The question is subtle. In the case of velocity, we have empirical evidence that a boosted world would be indiscernible from the actual world based on our experiences in trains. That is, we have experienced reasonably small environments that are to some extent isolated from external interference and have noticed that they look the same while in motion as they do at rest in the station. Now this evidence is not conclusive, since it remains open that if *everything* were put in smooth motion there would be some discernible difference in the qualitative nature of our experiences (perhaps our visual field would be tinged with yellow). But it seems that our best theory of what determines the character of our conscious states implies that the subject's state of absolute motion is not a relevant factor.

Now in the case of mass we lack the same kind of empirical evidence that the doubled world W is indiscernible from the actual world, since we have had no experience of reasonably isolated environments that differ only in a doubling of mass. Nonetheless, there is some reason to believe that W would be indiscernible, for our best theory of what determines the character of our conscious states seems to imply that intrinsic masses are not a relevant factor. Insofar as one's conscious life is determined by physical facts at all, it seems to be determined by the positions of particles composing one's brain (and perhaps the local environment). When a headache pill cures your pain, that is because it altered the positions of various particles in your brain, not because it made any of those particles more massive. Since W agrees with the actual world in all facts about particle positions, there is some reason to think it is indiscernible after all.

A full discussion of this issue would take us too far into the philosophy of mind. But in any case the issue is not crucial, for a third response to the initial objection is to argue that even if intrinsic mass has an effect on the character of our experience, it would still be undetectable! To see this,

suppose that the effect that intrinsic mass has on our experience means that our visual field would be tinged with yellow in W. Does this mean that we can infer, on the basis of the character of our visual field, which intrinsic mass each thing has? It does not, for to make that inference we would need to appeal to a hypothesis stating which intrinisic masses give rise to which sort of experience. But the hypothesis that one set of intrinsic masses (i.e. those instantiated in the actual world) give rise to my actual experiences and the hypothesis that another set of intrinsic masses (i.e. those instantiated in W) give rise to my actual experiences are both left open by my actual experience, and are both equally simple, elegant, explanatory, and so on; and so the fact that I am enjoying my actual experiences is not evidence for either hypothesis over the other. As a result, my enjoying these experiences does not put me in a position to infer which particular mass any given body has.

So here are three responses available to the comparativist. I will not try to assess which response is most plausible, but it should be emphasized that one's choice of response is likely to affect the extent to which the argument will generalize to other quantities. For example, if the comparativist makes the second response, resting her case on the fact that W is indiscernible, then the argument will only generalize to a given quantity if uniform transformations of its absolute values while leaving the comparative values fixed results in an indiscernible world. And if the comparativist makes the third response, resting her case on the fact that the experiential difference in W leaves open which intrinsic masses are instantiated, then the argument will only generalize to a given quantity if the experiential difference in those transformed worlds still leaves open which absolute values are instantiated.

8.6 Inexpressible Ignorance

This, then, is my reason for preferring comparativism, at least in the case of mass. If material bodies had the intrinsic masses posited by the absolutist, those masses would be undetectable. Our Occamist principle states that all else being near enough equal, this is a mark against absolutism. I argued in Sections 2–7 that there are no decisive objections to comparatativism, so all else appears near enough equal.

This Occamist argument rests on the premise that we would be in principle ignorant of the intrinsic masses posited by the absolutist, but there is a sense in which the the ignorance would be inexpressible. For how could we express it? If I said that I do not know whether everything is twice as massive as it actually is, I would be lying since I know very well they are not! The trouble is that I just described the non-actual possibility W in

such a way that I can infer from my description that it is non-actual. To remedy this, I could try giving each absolute mass a name and describing the non-actual possibility in those terms. For example, suppose that Kripke was right that we use terms of the form 'n kgs' with the reference-fixing stipulation that it is to refer to the absolute mass that is n times that had by the standard kilogram in Paris. Since W differs in the mass in kilograms of my laptop, I could try saying that I do not know whether my laptop is 2 kgs or 4 kgs. But this is not clearly right either. By discovering that my laptop is twice as massive as the standard kilogram, and then appealing to the reference-fixing stipulation, I can infer that the sentence 'My laptop is 2 kgs' is true. And while knowing that a sentence is true does not imply knowing the proposition it expresses, many theorists would say that in this case I would know that my laptop is 2 kgs. So this is the sense in which my ignorance is inexpressible: I do not know which absolute mass my laptop has, but there is no sentence s that expresses its absolute mass for which I can truly say 'I do not know that s'.

Those who identify "knowing which" with "knowing that" might now conclude that I am not ignorant of my laptop's absolute mass at all, but this would be to let theoretical opinion obscure the phenomena. In the last section I described a clear and vivid sense in which the particular absolute mass of my laptop lies beyond my epistemic grasp, and we can expressed this by saying that I do not "know which" absolute mass it has. If this epistemic state cannot be analyzed in terms of "knowing that", so be it: we would be guilty of theoretical prejudice if we concluded that there is no such state at all.[29]

9 Conclusion

The absolutism/comparativism issue has received very little discussion in the philosophy or physics literature, and I consider this a significant

[29]In this respect the case of absolute mass diverges from the case of absolute velocity, for our ignorance in the latter case is expressible: I can truly say 'I do not know whether I am at rest'. Indeed, the case of absolute mass is more akin to the case of absolute location in space. For if there were such a thing as absolute space then worlds that differ only in a uniform shift of all matter three feet to right would look and feel and smell the same, and as in the case of velocity we can argue that no physically possible measuring device could reveal which particular region of space we are in. For this reason, our position in absolute space is undetectable. Still, as Maudlin [18] point out, there is nothing I can say to express what I am ignorant of, for it is clearly false to say that I cannot not know whether I am here or three feet to the right of here! In this regard I agree with Maudlin entirely. But he went on to argue that there is no sense at all in which I am ignorant of my location in space, and here I believe that he made the mistake described in the last paragraph of allowing theoretical prejudice to obscure the phenomena.

lacuna in our understanding of what the natural world fundamentally consists in. In this paper I have tried to clarify what the issue amounts to and describe where I see the major battle lines as lying. I believe that comparativism is probably the correct view for mass, but if I have not convinced you of that I hope to have shown that the issue is important and that there is interesting further work to do in the area.[30]

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