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Abstract
Disposition ascription has been discussed a good deal over the last few decades, as has the revisionary metaphysical view of ordinary, persisting objects known as "four-dimensionalism". However, philosophers have not merged these topics and asked whether four-dimensional objects can be proper subjects of dispositional predicates. This paper seeks to remedy this oversight. It argues that, by and large, four-dimensional objects are not suited to take dispositional predicates.

1. Introduction

Disposition ascriptions abound. We say of objects that they are fragile, flexible, soluble, elastic, explosive, toxic, corrosive, magnetic, edible, charged, and so on. But not only are disposition ascriptions ubiquitous, they also play an important practical role in our daily life. If someone says "Careful, that one is explosive!", then, unless we have very strong reasons for thinking that the object referred to does not satisfy the dispositional predicate, we will adapt our behavior accordingly. So suppose now that we are presented with a metaphysical theory of ordinary objects according to which they rarely, if ever, satisfy dispositional predicates. Would the presentation of such a theory lead us to change our behavior towards ordinary objects? Or would its counterintuitive implications lead us to reject the otherwise (we are supposing) theoretically fruitful metaphysical theory? Or would we perhaps persist with our old behavior, accepting at the same time that in reality most of our dispositional predicates are not true of ordinary objects?

In this paper I shall present what appears to be a telling test case: I will argue that standard *four-dimensionalism* − i.e. the view that ordinary objects are not three-dimensional, enduring entities, but four-dimensional aggregates of temporal parts − *is* a

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theory of the kind just indicated: that is, it is a theory of ordinary objects according to which those objects rarely, if ever, satisfy dispositional predicates.

2. A taxonomy of dispositional predicates

Dispositional predicates can be categorized into three broad (not mutually exclusive) categories:

D_i) Predicates that ascribe to the entity in question an ability to *change intrinsically*, while surviving, under certain conditions. Examples are "*x* is flexible", "*x* is elastic", and "*x* is inflatable".

D_{ii}) Predicates that ascribe to the entity in question an ability to *perish* in a specific way under certain conditions. Examples are "*x* is water-soluble", "*x* is explosive" and "*x* is fragile".

D_{iii}) Predicates that ascribe to the entity in question an ability to *affect entities distinct from itself* under certain conditions. Examples are "*x* is poisonous", "*x* is corrosive" and "*x* is magnetic".[1]

In the subsequent sections I will argue the following: If the standard 4-D Formula for time-indexed predication (to be explained in Section 3) is accepted within the context of

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[1] Perhaps a fourth category could have been included here, namely predicates ascribing to the entity in question an ability to *change relationally*. I think, however, that many would be hesitant about allowing such a category as a sub-category of dispositional predicates. Consider Ed. Ed's only sibling, Liz, is childless. If Liz were to have a baby, Ed would become an uncle – a fact we might choose to express by saying that Ed is "uncle-able". But does the fact that Ed is uncle-able mean that Ed has a *disposition* to become an uncle, in the sense that "*x* is uncle-able" is a dispositional predicate truly applied to Ed? That seems somewhat strained. Normally we think that the manifestation events of dispositions can be released only when the subject of the disposition ascription is situated in certain contexts. But Ed may become an uncle wherever he is, no matter how far he is from the stimulus event of his sibling having a baby. Moreover, some would argue that *becoming an uncle* is not even a real event but merely a so-called Cambridge event, and that it therefore cannot constitute a genuine manifestation event. Given these reservations, I have decided not to consider this "fourth" category in this paper, although I believe that the problems pointed out in Section 4 and Section 5 apply readily to the predicates in it.

disposition ascription, four-dimensionalists will face serious difficulties with all the predicates in the first category and many of the predicates in the second and the third categories (Section 4). If, on the other hand, the standard 4-D Formula is rejected, and dispositional predicates are held to apply "non-derivatively" to four-dimensional objects (i.e. not *via* their temporal parts), predicates in the first and the third categories turn out to be applicable only if highly suspect counterfactuals are accepted; moreover, predicates in the second category now turn out to be straightforwardly unsatisfiable by four-dimensional objects (Section 5). Three-dimensional objects escape these difficulties (so I argue in Section 6). The paper ends with a survey of possible four-dimensionalist responses, all which are shown to be problematic (Section 7).

3. Four-dimensionalism

Four-dimensionalism is a revisionary theory about the metaphysical nature of ordinary, persisting objects, such as cars, trees, sticks and stones. It presupposes a certain conception of time, the so-called B-theory of time. We need to have a quick look at the B-theory before going on to consider four-dimensionalism.

The B-theory of time can be succinctly put as the conjunction of three theses:

(a) All times (times that from our position in time appear to be either present, past or future), and their contents, are ontologically on a par; together the co-existing times constitute a "timescape" or "block-universe".

(b) There are no temporal properties of *being present*, *being past* or *being future* (the so-called "A-properties"), only the temporal relations of *being earlier than*, *being later than* and *being simultaneous with* (the so-called "B-relations").

(c) A-statements (utterances of sentences containing tensed verbs and time adverbials such as "now", "yesterday" and "tomorrow") are made true by B-facts; the latter do not contain any A-properties and are most suitably described using B-

sentences, i.e. sentences containing tenseless verbs and "B-times" (dates or clock-times).[2]

On this view of time, which some philosophers argue is entailed by the special theory of relativity (e.g. Putnam, 1967), it is somewhat difficult to conceive of a persisting object as persisting by *enduring*, i.e. by being wholly present at different times as numerically the same entity. If all times are equally real, how can one and the same entity be wholly present at more than one time?[3] Philosophers baffled by the question have tended to think that things located at different times must, strictly speaking, be *distinct* things. This raises the following problem, however: granted that we want to keep ordinary, persisting objects in our ontology, and granted that persistence involves *identity* through time, how can we allow for the existence of ordinary, persisting objects in this block-universe of ours?[4]

Four-dimensionalists typically propose the following answer: by identifying ordinary persisting objects with *aggregates* or *mereological sums* of the distinct things at the distinct times.[5] More precisely, by identifying ordinary persisting objects with such four-dimensional aggregates or mereological sums whose temporal parts are

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[2] Some clarificatory remarks are perhaps in order: what thesis (a) involves is basically a denial of there being, what is sometimes called, absolute Becoming and Disappearing: (a) denies that times and their contents *come* into existence and then *cease* to be; they simply *are*. Together the co-existing times constitute a fourth dimension along which the contents of the times exist "eternally". What thesis (b) involves is basically a denial that there is a metaphysically privileged time: no time is *the* present, in some profound metaphysical sense. Rather, every time is present relative to itself. Expressions such as "at present" and "now" are to be understood as *indexicals,* analogous to spatial indexicals such as "here" or "this place" (or analogous to David Lewis's indexical reading of "actual"). Together (a) and (b) constitute a denial of the idea that time *flows*, either in the sense of existence constantly changing or of there being a moving Now. Time simply consists in "static" or "eternal" B-relations. What thesis (c) involves is an affirmation that tensed statements have truth conditions along the lines of the following example: an utterance *u* of "*e* is past" is true iff *e* is located earlier than *u*; an utterance *u* of "*e* is present" is true iff *e* is simultaneous with *u*; an utterance *u* of "*e* will occur in future" is true iff *e* is later than *u*. For a book-length defense of the B-theory of time, see Mellor (1998).

[3] Lewis, e.g., writes of the idea: "Endurance calls to mind two things. One is the power of spatial bilocation traditionally ascribed to saints. […] The other is the multiple location in both space and time that is ascribed to immanent universals" (Lewis, 2002, p. 3). Barker & Dowe (2003) go a step further and argue that the combination is contradictory; they are gainsaid, though, by McDaniel (2003) and Beebee & Rush (2003); see also Mellor (1998) for a general defense of endurance in a block-universe. The issue is controversial.

[4] The so-called stage-theorists deny that persistence involves identity (numerical identity) through time. They hold that persistence involves having *temporal counterparts* at other times. I discuss this "unorthodox" brand of four-dimensionalism (found in Sider [2001] and Hawley [2001]), in my (xxxx).

[5] See e.g. Lewis (1983, p. 59; cf. 1986, pp. 202-204), Armstrong (1997, p. 102), and Goodman (1951, pp. 93-95).

spatiotemporally continuous, related by causation, and roughly similar to each other (within the limits set by the relevant sortal *S*, which the persisting object falls under).[6]

The aggregates, moreover, are to be *maximal*: that is to say, no object falling under a "common sense" sortal *S* is allowed to be a proper part of an *S*.[7] Without this restriction there would be problems with the diachronic counting of ordinary objects. (How many tables were there in this room today? Only one, as the man on the street would say, or many indeed, as the four-dimensionalist who neglects the maximality principle would say?) Also, baptism would turn out to be a difficult project. ("I hereby name this ship 'Al'!" Which of the myriads of ships, wholly or partly in front of me, got baptized?)

On the four-dimensional picture, then, ordinary, persisting objects turn out to be entities that are *extended* and have *proper parts*, not only in the spatial dimensions, but in the temporal dimension too. Consequently, their persistence through time must be understood to consist in their having different temporal parts at different times: they must be taken to *perdure* through time.[8] It should furthermore be noticed that if mainstream physics is correct about there being instants, ordinary persisting objects will turn out to have *instantaneous* (i.e. three-dimensional) temporal parts. In this paper I shall assume, like most four-dimensionalists, that modern physics is correct in this respect and consequently that objects are four-dimensional aggregates/sums of instantaneous temporal parts (fundamentally speaking).[9]

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[6] Philosophers disagree over whether the "unity" relation is reducible to/dependent on the components stated above or whether it is rather the other way round. Philosophers taking the first position also sometimes quarrel about how the respective components should be weighted. For discussion of the first issue, see Hawley (2001, ch. 3); on the second, see Armstrong (1997, ch. 7). (Again, Hawley is not an orthodox four-dimensionalist, but her chapter on "sticking stages [temporal parts] together" is completely general and applies equally well to standard four-dimensionalism). For the special case of persons – still a sort of physical object according to materialists – see Lewis (1983). It should also be mentioned here that four-dimensionalists who accept the principle of *unrestricted mereological composition* hold that, apart from the aggregates that correspond to the ordinary, persisting objects of common sense, there are "arbitrary" aggregates with wildly heterogeneous and scattered parts (see e.g. Goodman, 1951, pp. 46-47 and Lewis, 1986, p. 211); these entities, however, are not of interest for the purpose of this paper.

[7] See e.g. Lewis (1983, p. 59); see also Hawley (2001, p. 40).

[8] Note that this is not tantamount to giving up identity through time, since it is the very same object (aggregate/sum) that is present at different times; it is just that different parts of it are present at different times, i.e. the object is partly present at different times. The technical terms "endure" and "perdure" go back to Mark Johnston's PhD thesis; see Lewis (1986, p. 202).

[9] I would deny that this presumption is *essential* to the key arguments of the paper: similar arguments can be carried through even if turns out that time, at small timescales, is granular in structure or consists of

Now, one of the theoretical virtues claimed for four-dimensionalism is that it renders *change* (both intrinsic and relational) of a persisting object transparent and unproblematic. According to four-dimensionalism, if a persisting object changes over time – for example, is F at t but not F at t' – then what goes on is simply this: the object has a temporal part at t that is F and another temporal part at t' that is not F. At bottom, then, *distinct entities* (temporal parts) are F and not F, respectively. The persisting object itself is F at t and not F at t' in a *derivative* sense only, in virtue of its temporal parts.[10]

Since no alternative story is normally told about the case in which an object remains F over time, four-dimensionalists are usually interpreted as being committed to the following general formula for time-indexed predication:

The 4-D Formula: Persisting object x is Φ at t iff x has a temporal part wholly present at t which is Φ.[11]

This formula (and the line of reasoning it encodes) has some plausibility, I think,[12] when Φ takes a categorical predicate such as "is straight" or "is bent" as value – the kind of predicate normally invoked when time-indexed predication is discussed in connection with four-dimensionalism. In the next section, however, I will ask whether four-dimensional objects can be temporally ascribed *dispositional* predicates given the 4-D Formula. The answer will be: rarely, if ever.

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intervals of non-zero length (cf. note 26). The presumption that objects have instantaneous temporal parts does make the argumentation much more straightforward, however.

[10] Lewis writes of the case of shape: "…my shapes belong in the first instance to my stages, and in a derivative, relational way to the whole of me. Persisting thing x is bent at time t iff some stage of x is at t and is bent." (Lewis, 1988, p. 66) He invokes the same kind of reasoning in connection with changing relational properties, such as changing distances between two objects (ibid., pp. 69-71).

[11] The phrase "wholly present" if often left out (cf. e.g. Hawley, 2001, p. 37). However, I think this version is to be preferred. In this form the formula explicitly asks us to ignore the temporal parts that extend beyond t, i.e. temporal parts that have the part that is wholly present at t as a proper part. This is more effective, since, clearly, given the four-dimensional line of reasoning, the temporal parts that have the temporal part that is wholly present at t as a proper part, are Φ at t in virtue of the Φ-ness of the temporal part that is wholly present at t.

[12] For some misgivings, see my (yyyy).

4. Why many dispositional predicates are not temporally applicable to ordinary objects given the 4-D Formula

Consider the rubber band that, at the time of writing, is in front of me on my desk. In commonsense, I conceive of the rubber band as elastic *now*, i.e. as currently satisfying the predicate "is elastic", where the copula is in the present tense. That the rubber band is indeed elastic now and will stay elastic for some time is, it would seem, of some practical importance to me. If the band were *not* elastic now, I would see no immediate reason for having it on my desk, poised to be used to hold papers of mine together.

Now, according to the B-theory of time, my present-tensed thought about the elasticity of the rubber band, r, is true iff r is (tenseless "is") elastic at B-time t, i.e. at the instant of B-time picked out by my thinking "now".[13] Moreover, according to the 4-D Formula, the tenseless "r is elastic at t" is true iff r has a temporal part at t (call it "r-at-t") which is elastic.

Supposing that r-at-t indeed exists and that the 4-D Formula for time-indexed predication is correct, could my commonsensical thought be true? The answer hinges on whether r-at-t is elastic, i.e. on whether "is elastic" is true of r-at-t. Intuitively, however, it would seem that r-at-t is not elastic. *Prima facie* it would seem that only persisting physical objects can be elastic. But r-at-t is no persisting physical object. It is an instantaneous temporal part of a persisting physical object. At first blush, then, it would seem that r-at-t does not belong to the category of entities that can be elastic. But if that is correct, my commonsense thought will turn out to be false (or, at least, not true) given the 4-D Formula.

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[13] If "now" only picks out an interval of time, e.g. an interval as long as it takes for me to say or think "now", then what I actually *intended* to say (or think) was that r is elastic during every instant of the "now"-interval. Alternatively put, I wanted to say that r is elastic at any *arbitrary* instant of the "now"-interval. Let "t" denote such an arbitrary instant of the "now"-interval.

Why would I, in my day-to-day thinking, be committed to r being elastic at an instant? Well, apart from the fact that I trust the conventional view of physics that there are instants (see Section 3), I take the rubber band to be a genuinely and hence continuously *persisting* entity which does not vanish during short intervals or at instants. If I did not, I would have to conceive of r as some kind of gappy entity or an entity which only *emerges* over longer time intervals. Moreover, I take the elasticity of r to be a *persisting* state of persisting r; I do not think of r as ceasing to be elastic during short intervals or at instants.

Let us, however, investigate the question whether *r-at-t* could satisfy "is elastic" more deeply. First of all, what does it *mean* to say of an entity *x* that it is elastic?[14]

There are various semantic analyses of disposition ascriptions around, but I think that we may say, without being overly simplifying, that there are two major candidates here:[15] the *simple conditional analysis* (SCA) and the *dispositional property analysis* (DPA).[16]

According to SCA, which is the traditional one,[17] disposition ascriptions are to be analyzed in terms of subjunctive conditionals. That is, if we hold that *a* is *F*, where "*F*" is a dispositional predicate, then what we are saying is simply that a certain series events involving *a* (the manifestation events characteristic of *F*) *would* take place *were* a certain series of other events involving *a* (the stimulus events characteristic of *F*) to occur (in ideal conditions).[18] And that is all that is being said. No commitment to a causal process behind the unfolding of the stimulus-manifestation events is made. In particular, no commitment is made to *a* having a particular dispositional *property* which would be causally responsible, in part, for the unfolding of the manifestation events, were the stimulus events to happen.[19] But, of course, although the conditional analysis is not *committed* to *a* having such a property, it is nevertheless *compatible* with *a* having such a property. It is neutral on the issue.

Applying SCA to "*x* is elastic" we obtain (roughly):

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[14] I here presume that meaning analysis places constraints on the possible nature of the truthmakers for dispositional statements. See Mumford (1998) and Mellor (2000) for discussion of the connection between the semantics and the metaphysics of dispositions.

[15] Quine's (1960, p. 224) analysis or regimentation of dispositional discourse has few defenders today. According to Quine, the predicate "*x* is soluble" is to be read as saying that there is a *y* such that *x* and *y* are alike in molecular structure and *y* dissolves (tenseless verbs); likewise for other dispositional predicates. As Mellor (1974, pp. 166-167) points out, this analysis is unsatisfactory, because we want to be able to predicate dispositions of things even where the manifestation events associated with the disposition never obtain in fact.

[16] These accounts are often presented as *rivals*. That may be a mistake, though. I think it is plausible that we mean somewhat different things in different contexts when we use dispositional predicates (e.g. in our day-to-day doings, and when we are doing metaphysics or simply wish to be more ontologically committed); and that the analyses consequently have application in different situations.

[17] See e.g. the presentations in Goodman, (1983, 34 ff.), Quine (1960, p. 222), and Lewis (1973, p. 38).

[18] The ideal-conditions clause is there to handle the so-called finkish cases (see Mumford, 1998, p. 88 ff.; cf. Goodman, 1983, p. 39).

[19] SCA neatly explains the entailment relation that *prima facie* holds between day-to-day statements such as "sugar is water-soluble" and "water is sugar-dissolvable". On it, both ascriptions have the same truth condition: if sugar were placed in water, the sugar would dissolve. On DPA, by contrast, these statements do not have the same truth condition. For some implications of this, see my zzzz.

(SCA) x is elastic iff, if x were suitably[20] strained, x would stretch (in ideal conditions).

According to DPA, by contrast, when we make a dispositional ascription, a is F, we are not merely saying that *this* would happen if *that* were to happen; for we are attributing a real property with a specific causal power to a – a property which, in part, at least, brings about the manifestation events when the stimulus events occur (in ideal conditions).[21] Applying DPA to "x is elastic" we obtain something like this:

(DPA) x is elastic iff x has a dispositional property such that were x suitably strained, the dispositional property would, together with the straining, cause x to stretch (in ideal conditions).[22]

The question of interest now is whether "is elastic" is applicable to *r-at-t* on either of these analyses.[23]

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[20] What does "suitably" mean here? That is vague – dispositional predicates are often vague. There are borderline cases in which we do not know whether to attribute elasticity to an entity. Notice also that the amount of strain necessary for elasticity may be a function of the *kind* of object we are talking about.

[21] Variants of the dispositional property analysis can be found, e.g., in Lewis (1997), Mumford (1998), and Mellor (2000); my handling of examples resembles Mumford's (ibid., pp. 91-92) account most.

[22] In their *metaphysical* analyses of such dispositional properties, philosophers disagree about the source of the causal power of the property: is it (1) *internal* to, or constitutive of, the property, or is it (2) *external* to the property in the sense that the causal power is confined to the property, from the outside as it were, by contingent laws of nature? In the latter case, the dispositional property is often understood, at bottom, to be a *categorical* property which has a certain causal power only contingently and thus only contingently is a dispositional property (or, alternatively, serves only contingently as part of a supervenience base for the disposition). For an opinionated overview of this debate, see Armstrong (1997, ch. 5).

[23] Proponents of the 4-D Formula may protest that in the two major analyses provided above it is taken for granted that the copula is either present-tensed or else of a tenseless variety which is possibly or implicitly accompanied by a time-clause specifying the time to which the (loose) tenseless predication is to be indexed. But in the 4-D Formula, they may complain, the copula in the right-hand side of the biconditional is a tenseless copula of a "timeless" sort – a *simpliciter* copula – which cannot be accompanied by a time-clause. Since the two analyses and the latter part of 4-D Formula involve different kinds of copula, it is inappropriate, they might argue, to ask whether a temporal part may satisfy dispositional predicates *as analyzed above*. This kind of complaint, if it were correct, could be turned against the adherents of the 4-D Formula. If it were correct that our available, respectable analyses of disposition ascriptions presume that the copula is *not* a *simpliciter* copula, then the idea that entities may have dispositions *simpliciter* would be more or less unintelligible (unless such an analysis is forthcoming). However, I do not think that such a drastic response needs to be invoked. It seems to me that a *simpliciter* reading of the copula in fact is fully compatible with the analyses supplied above, as they do not contain any explicit time-clauses and are of a subjunctive nature (the second in part). It is rather advocates of the idea that the copula should be

9

Notice to begin with that, although only the second analysis is committed to the claim that the subject of predication has a dispositional property, both make use of subjunctive conditionals. (Again, the major difference between the two analyses is basically that the first analysis leaves it open what, if anything, *grounds* the conditional, while the second analysis demands that the conditional be grounded, at least in part, in the relevant entity's possession of a dispositional property of the sort specified by the conditional.) The subjunctive conditionals have this in common: they require x to be capable of persisting. To see this, simply notice that both kinds of conditional involve x being, actually or counterfactually, strained and stretching as a result. Evidently, it takes time to be strained and stretched. Hence, although neither analysis demands that x actually persists, both require x to be such that it at least *could have* persisted. (If x could not have persisted, it cannot be such that *were it suitably strained it would stretch*, nor can x have a *dispositional property* such that, were x suitably strained, the dispositional property would, together with the straining, cause x to stretch; if x could not have exhibited the behavior of stretching, it cannot have a property whose nature it is to cause such behavior.)

What about *r-at-t*? We know that *r-at-t* is an instantaneous temporal part and so does not actually persist; but could it have persisted?

Since we are dealing with standard four-dimensionalism here, the relevant question is whether *r-at-t* could have been a four-dimensional aggregate/mereological sum persisting by *perduring*. If, in order to allow instantaneous temporal parts to satisfy "is elastic", four-dimensionalists rely at this point on the idea that such parts could have *endured*, the resulting theory will be inconsequential and inelegant. For then, despite their explicit rejection of endurance, they will be obliged to accept endurance – not of course in relation to the way in which entities (such as ordinary objects and their temporal parts) persist in the actual world, but in relation to the way in which the entities (or their the

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understood as being of the tenseless kind that can be supplied with a time-clause that should complain that the analyses are inappropriate, or incomplete, in that they *lack* explicit time-clauses. They may ask: at what precise time is the entity supposed to be elastic? To which we may answer: if we are dealing with a temporal part (such as *r-at-t*), located at one time only (at *t*), no such information is necessary; adding such information would even be misleading as it would imply, falsely, that the entity exists at several times. If we are dealing with an entity which *is* located at different times (wholly or partly), a time-clause should indeed be added. But as stated above, the analyses will be *neutral* as to the nature of the copula and the nature of the relevant entity.

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temporal parts, at any rate) persist in counterfactual situations. And since such counterfactual facts about persistence are necessary conditions for *actual satisfaction* of dispositional predicates, endurance would, in a sense, slip into the actual world. Dispositional discourse (taking place in the actual world, being about actual entities and how they actually are) would turn out to be reliant on the phenomenon of endurance. Surely, four-dimensionalists will not want to be committed to this.[24]

Thus, the relevant question for standard four-dimensionalists is whether *r-at-t* could have been a four-dimensional mereological sum persisting by perduring. Put differently: is there a possible world (not necessarily realistically construed) in which *r-at-t* − or a counterpart of *r-at-t* − is a four-dimensional mereological sum which perdures?

In the next few paragraphs I will present compelling arguments for the view that the answer to this question is "no". These arguments remain powerful regardless of whether we accept cross-world identities.

Suppose, first, that we accept cross-world identities, i.e. that one and the same entity can exist wholly and self-identically in more than one possible world (cf. Kripke, 1980). Assume that *r-at-t* exists in a non-actual possible world *w*, and that *r-at-t* in *w* is a four-dimensional mereological sum of temporal parts (*r-at-t* may still be a temporal part of a temporally larger entity.) By now applying an argument similar to one presented by van Inwagen (1990), we can produce something close to a *reductio ad absurdum* of the view that *r-at-t*, which is a non-persisting, three-dimensional temporal part in actuality, is a four-dimensional, perduring mereological sum in *w*.

Mereological sums have their parts essentially. Take away a part and you have a new mereological sum. This is presumably true of four-dimensional mereological sums as well. But given this, the four-dimensional mereological sum in the non-actual world cannot be identical with the instantaneous temporal part in the actual world. If it were, it would not have its temporal parts essentially, and hence it would not *be* a mereological

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[24] In any case, since most four-dimensionalists think that endurance through intrinsic change is a highly problematic if not contradictory phenomenon, they would most certainly want to reject the idea that *r-at-t* could have endured *through a process of getting stretched* (which being elastic involves). However, since I think that the existing arguments against endurance through intrinsic change are unsuccessful (see my z´z´z´z´ and Section 6 below), I do not want base my criticism of the current proposal on such arguments. My complaint is that such a proposal would turn four-dimensionalism into an inconsequential and inelegant doctrine.

sum of its temporal parts. Consequently, by the symmetry of identity, *r-at-t* cannot be a perduring, four-dimensional mereological sum in *w*. (Perhaps the argument goes in both directions. That depends on the status of instantaneous temporal parts. Are they, properly speaking, also mereological sums of temporal parts – perhaps limiting cases with no *proper* temporal parts? As I wish to leave this question open, I do not explicitly treat them as aggregates/mereological sums of temporal parts.)

Let us move to a framework with counterparts (see Lewis 1968). Since the counterpart relation is not always symmetrical, it is not evident that the argument above goes through in this framework: it might be the case that our instantaneous temporal part has a four-dimensional mereological sum (which may be a temporal part) as a counterpart, and that this four-dimensional mereological sum does not have the relevant instantaneous temporal part as a counterpart.[25] But *are* there four-dimensional counterparts of the instantaneous temporal part here? More precisely: are there four-dimensional counterparts of the instantaneous temporal part within the spheres of reasonably close possible worlds which are entertainable for counterfactual reasoning (cf. Lewis, 1973, p. 16)? I think the answer will have to be "no". Any four-dimensional, perduring entity will (in a reasonably close possible world) have instantaneous temporal parts. Since these temporal parts are more similar to our temporal part than the four-dimensional entity, one of *them* (if anything is) will be the counterpart of our temporal part; and none of them perdures. It seems, therefore, that we need not worry about the lack of symmetry in counterpart theory.[26]

Notice that *qua*-reasoning does not provide an escape route here. According to standard four-dimensionalism, proper temporal parts of four-dimensional ordinary objects are not themselves ordinary physical objects, i.e. they do not fall under sortals

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[25] Of course, if an instantaneous temporal part *is* a mereological sum of temporal parts, it cannot have a four-dimensional mereological sum of temporal parts as a counterpart. If it could, it would follow that it could have had parts other than those it actually has – which is impossible for aggregates/mereological sums.

[26] Suppose we admit that there are, within the set of entertainable spheres, worlds in which there are no *instants* (but rather *chronons*, or only time intervals of non-zero length) and hence no *instantaneous* temporal parts. Even in these worlds, the counterpart of our instantaneous temporal part would not extend for long enough to be suitably strained and consequently stretch. For to extend for long enough to go through such events, it would itself have to have temporal parts, and then one of these *shorter* temporal parts would be the (if any) counterpart of the instantaneous temporal part. So no counterparts of our instantaneous temporal part persist *long enough* to go through the process of being strained and consequently stretched. This is what is important for the purpose of this section.

such as "rubber band", "tree" and "stone". Proper temporal parts are simply temporal parts. (They may of course also be mereological sums, but that is of no help.) Hence, we cannot consider r-at-t *qua* rubber band, which would have yielded a counterpart relation that differs from the temporal-part counterpart relation. We are obliged to consider r-at-t *qua* temporal part.[27] And temporal extent is a heavily weighted respect of similarity for temporal parts (although not the only one, of course).

I conclude that the *prima facie* statement, made above, that r-at-t cannot be said to be elastic has been vindicated. Compelling arguments for the view that r-at-t – or a counterpart of it – does not persist in a (reasonably close) possible world have been given. And if r-at-t does not persist in a (reasonably close) possible world, then in no (reasonably close) contrary-to-fact situation does r-at-t (or a counterpart of r-at-t) stretch as a result of straining. But if so, r-at-t does not satisfy "is elastic": it does so on neither of the two analyses.

As for "x is elastic", so for "x is flexible" and "x is inflatable" and the rest of D_i-type predicates. Normally it takes time to be put under the relevant stimulus condition; and it always takes time to change intrinsically, i.e. to go through the appropriate manifestation events. And as we have seen, there are compelling arguments to the effect that in no (reasonably close) possible world does an instantaneous, proper temporal part persist.

Analogous reasoning applies to many (perhaps all) of the predicates in category D_{ii}. Consider "x is water-soluble" and "x is fragile". It takes time to be immersed in water and it takes time to be dropped. It takes time, in other words, to undergo these stimulus events.[28] It also takes time to dissolve in water and to break into pieces, so it takes time to undergo, or at the very least to take part in the initial phases of, the relevant manifestation

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[27] This makes the case in a different way from van Inwagen's case of Descartes, where the question is whether Descartes – who is not only a four-dimensional sum but also a person – could have died at an earlier/later time. Van Inwagen argues that, given counterpart theory with *qua*-reasoning (a theory he in fact rejects), there *is* room to say that Descartes could have died at an earlier/later time. But as I point out above, in the case of a *proper* temporal part, there is no room for any interesting *qua*-reasoning. In Section 5, I will further argue that *qua*-reasoning *never* provides four-dimensionalists with a route out of modal problems concerning possible life length, i.e. not even when the entity in question falls under several sortals.

[28] A caveat: perhaps the time-span of the stimulus events could be reduced significantly, even to such an extent that instants were approximated, if the ordinary analyses were revised so that they only required that "if x existed in water, then…" and "if x were suitably hit, then…", respectively.

events (admittedly, after a while the entity with the disposition no longer exists). More importantly, in order to dissolve or to break, the entity in question has to have proper spatial parts, at some level of decomposition, that survive the dissolving or breaking and are dispersed or scattered in the process. But the proper spatial parts of instantaneous temporal parts are also instantaneous temporal parts. They are instantaneous temporal parts of the persisting spatial parts of the ordinary, persisting object in question. And instantaneous temporal parts are not persistable entities. For many reasons, then, and irrespective of whether we adopt the simple conditional analysis or the dispositional property account, an instantaneous temporal part will not satisfy the predicates "x is soluble" or "x is fragile".

In general, many (probably all) of the predicates from category D_{ii} require the subject of the ascription to be located (actually or counterfactually) at the time(s) of the appropriate stimulus event *and* at some time(s) during the manifestation event, or (by logical disjunction) to have proper spatial parts that survive the manifestation event. (This requirement, then, is of the form $P \& (Q \text{ v } R)$.) But, again, there are compelling arguments to the effect that an instantaneous temporal part, its spatial parts included, could not have persisted; and if this is correct, an instantaneous temporal part cannot meet the requirement.[29]

Finally, let us turn to category D_{iii}. It would seem that an instantaneous entity x may very well affect, or have an effect on, entities located at later times, even if x's proper spatial parts (if it has any) do not exist at those later times. The causes of a given effect do not have to be simultaneous with the effect. Indeed, that is impossible, according to the special theory of relativity. Hence, *if* we are concerned with a predicate from D_{iii} that (a) does not require that the subject x takes part in a stimulus event that takes time, (b) nor requires that x is, for some reason, located at the time(s) when y becomes affected (i.e. at the time(s) of the manifestation event),[30] (c) nor requires that x has proper spatial parts that are located at the time(s) when y becomes affected, *then* the

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[29] Perhaps a few predicates from D_{ii} can be imagined or invented that neither involve the subject taking part in a stimulus event that takes time, nor involve the subject taking part of any manifestation event, nor involve the subject having persistable spatial parts. I cannot think of any, though. At least, I cannot think of any that are also applicable, if only derivatively, to ordinary, persisting objects.
[30] Notice that the advocates of the simple conditional analysis will want to get rid of "power" notions such as *affect*, *cause* and *effect* in their analyses.

predicate in question may have application to an instantaneous temporal part. It would appear, though, that predicates from D_{iii} often fail to satisfy at least one of (a)–(c).

Consider "x is poisonous", for example. In order for x to poison y, x must first be swallowed (or inhaled, or injected). Moreover, x must persist – or at least have proper spatial parts that do so – for such a long time that it, or they, also have time to be absorbed into the bloodstream, be transported to bodily organs, and there affect the organs in such a persistent and "repetitious" manner that the organs (and thereby y) are as a result *poisoned*. But if this is so, (a) is not fulfilled and one of (b) and (c) is not fulfilled.[31] It follows that an instantaneous temporal part of a dose of poison is not poisonous.

I do not, however, wish to categorically deny that dispositional predicates of type-D_{iii} are applicable to instantaneous temporal parts. The predicate "x is magnetic", for example, *may* be such a predicate, since "accelerating another entity" appears to apply no matter how small the acceleration is. Whether an instantaneous entity can indeed accelerate another entity in the manner appropriate for "x is magnetic" is a question for physics to resolve.

To sum up, in order to satisfy the dispositional predicates we have been considering (at least the concrete examples, minus "x is magnetic" perhaps), an entity must, minimally, be persistable or have proper spatial parts that are persistable. Instantaneous temporal parts are not like this. Hence, it appears that we cannot say, of an instantaneous temporal part, that it is elastic (or soluble, or poisonous, and so on). To declare such a thing would be to commit a *category mistake*.

But if the actual instantaneous temporal parts of a four-dimensional, perduring object do not satisfy such dispositional predicates, then, given the 4-D Formula, we cannot hold of an ordinary persisting object that it is elastic (or soluble, or poisonous, and so on) at a particular time. Consequently, ordinary objects are deprived of many of their dispositions on the 4-D Formula.

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[31] Perhaps the stimulus condition clause could be tinkered with so that it says merely "if x (or its spatial parts) existed in bodily organs" (cf. the reasoning of note 29 concerning "x is water-soluble"). No matter, since "x is poisonous" will still fail (b) or (c): we would never describe the miniscule effects (close in time) of a single instantaneous temporal part of an object x as "poisoning", even granting the vagueness of the concept – hence the "persistent and 'repetitious' manner" clause.

5. Rejecting the 4-D Formula within the context of disposition ascription is of little help

Proponents of four-dimensionalism might at this point object that it was a mistake to assume that dispositional predication works in accordance with the 4-D Formula. They might declare that we should allow four-dimensional objects to have certain dispositions at particular times even if their temporal parts at those times cannot be ascribed these very dispositions. Dispositional predicates, they might suggest, apply "directly" to the object in question, not "derivatively" *via* its temporal parts, although their ascription is indeed time-indexed. After all, this seems to be the case for other kinds of time-indexed ascriptions, they might point out. Consider "Object *o* has velocity *v* at *t*" for example. That sentence can hardly be true in virtue of *o* having a temporal part at *t* that has velocity *v*. Temporal parts (instantaneous ones) do not have velocity. They do not move, i.e. are not located at different places at different times (cf. Zimmerman, 1998, p. 279). Something similar obtains, they might suggest, with dispositional predication.[32]

This line of defense is costly, however. It ensures that the 4-D Formula, which has been so much discussed in the literature, now has limited generality and applies only to a very narrow and limited range of predicates such as "*x* is straight" and "*x* is to left of *y*". This in turn emasculates the celebrated four-dimensionalist account of change, since that account can now tell us only how an object can be, say, first bent and then straight (or first to the left of and then to the right of) – *not* how an object can change its dispositions.[33]

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[32] The cases cannot be perfectly analogous, however. A four-dimensional object has a certain velocity at a particular time, relative to a frame of reference, in virtue of being laid out in space-time in a certain manner, relative to the frame of reference. But a four-dimensional object cannot have a disposition at a particular time in virtue of being laid out in space-time in a certain manner.

[33] Four-dimensionalists might try out something like this in the case of dispositions: object *x* has disposition *F* at *t* iff *x* has a temporal part wholly present at *t* that is *G* − where "*G*" is a dispositional predicate from category D_{iii} saying that the temporal part has a disposition to generate a sequence of temporal parts that corresponds to (or constitutes) the manifestation events described (analytically entailed) by the dispositional predicate "*F*". Thus, if the object has a temporal part at some later time *t'* that is not *G*, then the object is not *F* at the later time, according to the revised formula. (The proposal as applied to our rubber band *r* would be that *r* is elastic at *t* iff *r-at-t* is a stretch-initiator. And *r-at-t* is a stretch-initiator iff: (SCA) if *r-at-t* were suitably strained, it would be followed by a sequence of temporal parts corresponding to the stretching of *r* after *t*; (DPA) *r-at-t* has a dispositional property such that were *r-at-t* suitably strained, the

Suppose four-dimensionalists insist that this "direct" approach to dispositional predication is worthy of pursuit. Then, obviously, the modal problem concerning possible lifespan of instantaneous temporal parts discussed above will be avoided. However, this is of little value, because the modal problem concerning possible lifespan will now apply directly to the *whole* four-dimensional object (as it does in van Inwagen's 1990). And in the case of four-dimensional objects the modal problem is more straightforward (modulo the notorious *qua*-reasoning), because standard four-dimensionalists identify such objects with mereological sums.[34] That, as I will show below, has the consequence that dispositional predicates in category D_{ii} are straightforwardly inapplicable to four-dimensional objects. Moreover, it implies that dispositional predicates in categories D_i and D_{ii} can be applied to four-dimensional objects only if highly suspect counterfactuals are treated as true. At least, these implications emerge vis-à-vis disposition ascriptions where the subject is not actually manifesting the manifestation events associated with the relevant predicate at the time specified by the ascription. (Surprisingly, the fact that the modal problem concerning possible life-length of four-dimensional objects has serious ramifications for time-indexed dispositional discourse has not been discussed by philosophers.)

Let us begin with category D_{ii}. (In this section I use a tenseless language directly.) Consider a landmine, m, which exists between t_0 and t_{10}. Although m is fully activated and put to use between t_5–t_7 it never explodes, because it is never stepped upon. But though it never explodes in fact, we would want to say of the landmine that it is explos*ive* at every point in time in the interval t_5–t_7. Pick out an arbitrary time in this interval: say t_6. Adherents of the conditional analysis will then say:

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dispositional property would, together with the strain, causally initiate a sequence of temporal parts corresponding to the stretching of *r* after *t*. Of course, it can be questioned whether instantaneous *r-at-t* can be suitably strained.) This biconditional involves the "direct" (although still time-indexed) satisfaction of the dispositional predicate by the four-dimensional object; but the biconditional nevertheless tells us (when "*G*" is spelled out) what the temporal part at the relevant time has to be like when the whole object temporarily satisfies the predicate "*F*". However, in the text I give reasons for the conclusion that both sides of the biconditional are almost always false. I do this explicitly for specifications of the left-hand side of the biconditional and indirectly for the right-hand side. (I do not address the whole biconditional in the text.) The reader should keep in mind that the analysis of the relevant "*G*" often contains reference to the four-dimensional object of which the temporal part which is *G* is a part.

[34] Remember that we charitably decided not to treat instantaneous temporal parts as mereological sums of temporal parts (see Section 4).

(SCA) *m* is explosive at t_6 iff, if *m* were stepped upon at t_6, *m* would explode shortly afterwards (in ideal conditions).[35]

The dispositional property analyst will say:

(DPA) *m* is explosive at t_6 iff *m* has a dispositional property[36] at t_6 such that the property would cause *m* to explode shortly after t_6 were *m* stepped upon at t_6 (in ideal conditions).

Both analyses presuppose that *m*, at least, *could have* exploded shortly after t_6. But given that *m* is a four-dimensional mereological sum of temporal parts, and given that *m* in fact does not explode shortly after t_6 (surviving until t_{10}), could *m* really have exploded shortly after t_6? Is there a non-actual possible world, similar to ours up to t_6 (perhaps minus a small "miracle" just before t_6, cf. Lewis, 1979, p. 468), in which *m* – or a counterpart of *m* – explodes shortly after t_6?

Suppose first that *m* itself, and not just a counterpart of *m*, exists in a world *w* which is similar to ours up to t_6 but differs from the actual world in that *m* explodes just after t_6 because someone steps on *m* at t_6. Then, in *w*, *m* will lack some of the temporal parts it has in actuality, namely the parts that in actuality are parts of its t_6– t_{10} part. But then, given that mereological sums have their parts essentially, we must conclude that it cannot be *m* itself that explodes in *w* after all.

Let us move on to a framework with counterparts. Could *m* have a four-dimensional counterpart in a non-actual possible world which explodes shortly after t_6? *Prima facie* it would seem not. Again, *m* is a four-dimensional mereological sum of temporal parts. A mereological sum cannot have another mereological sum consisting of

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[35] It may look a little odd to add an ideal-conditions clause when it is explicitly specified that we are dealing with the conditions obtaining at t_6. However, since we are dealing with a subjunctive conditional, and since we know that no one actually steps on *m* at t_6, we must in any case understand t_6 in a modified way. The ideal-conditions clause can thus be understood as removing all the so-called finks that might actually be around at t_6. Of course, if times have their contents essentially, most counterfactuals simply make no sense and dispositional discourse is doomed irrespective of the doctrine of four-dimensionalism.
[36] This property, or rather the temporal part of it that exists at t_6, might be identified with the *G*-property that the temporal part which exists at t_6 has, according to the revised 4-D Formula, proposed above in note 33.

other parts as a counterpart.[37] For if it did, it would not have its parts essentially, and then it would not *be* a mereological sum. Consequently, *m* cannot have a four-dimensional counterpart in a non-actual possible world which explodes shortly after at t_6.

At this point counterpart theorists may object as follows (adopting the reasoning of Lewis's defense of contingent identity (1971)). The counterpart relation is a relation of similarity. Things are similar to each other in certain *respects*. Reasoning about what counterparts an entity has is only meaningful when the relevant respects have been specified. Normally, the subject term specifies the relevant respects by being associated with a particular *sortal*. Take our term "*m*" used above. That term was introduced as name for a *landmine*. Thus, "*m*" comes associated with the sortal *landmine*. Therefore, when we speak of *m*, using the term "*m*", and ask what counterparts it has, we are asking what entities are similar to *m* in the respects that are relevant for *landmines*. We are asking what *landmine* counterparts *m* has. Now, *m* may very well have, and does indeed have, *landmine* counterparts that explode just after t_6, although these landmine counterparts fail to be *mereological sum* counterparts of *m*. What is important is that these entities resemble *m* enough under the sortal landmine, not that they resemble *m* under the sortal mereological sum. The latter would only be important if we considered the entity that "*m*" refers to *qua* mereological sum. In that case (i.e. if we asked whether the four-dimensional *mereological sum* – call it "*s*" – that *m* is identical with could have exploded shortly after t_6) we would indeed be asking whether *s* (= *m*) has a four-dimensional *mereological sum* counterpart that extends just beyond t_6. Hence the answer would indeed be "no". The mereological sum, *s*, then, could not have exploded shortly after t_6. But the fact that *s* could not have exploded shortly after t_6 does *not* exclude the possibility that *m* – i.e. the *landmine* – is such that it could have exploded shortly after t_6, since *m* does have a landmine counterpart that explodes shortly after t_6. In short, *s* could

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[37] "Other parts" can here be understood counterpart-theoretically. I take it that no counterpart theorist would want to hold that the parts of a non-actual mereological sum which explodes shortly after t_6 can serve as counterparts for the t_0-t_6 parts *and* the t_6-t_{10} parts of the actual entity (so that the non-actual four-dimensional mereological sum would consist of the "same" temporal parts as the actual four-dimensional sum, although the non-actual sum's lifespan is significantly shorter than the actual sum's). That would render counterpart theory too flexible and diluted to serve any attractive purpose. Everyone should agree that the following counterfactual is unacceptable: had four-dimensional *m* exploded at t_6 (which it in fact did not), *m* would have consisted of the same temporal parts as it does in actuality.

not have exploded shortly after t_6 (s is not explosive at t_6), but m could have (m is explosive at t_6).

This line of reasoning seems to be in conflict with Leibniz's Law, however. According to it, if x and y are numerically identical, then whatever is true of x is true of y, and vice versa. Thus Leibniz's Law obliges us to say that if $s = m$, it cannot be true that m could have exploded shortly after t_6 while s could not.

I suspect that four-dimensionalists would seek to block this appeal to Leibniz's Law by claiming that "… could have exploded shortly after t_6" is an intensional context prone to *predicational shift*. Strictly speaking – they might insist – the syntactic expression "could have exploded shortly after t_6" says different things when it is flanked by subject expressions associated with the sortal landmine and the sortal mereological sum. When flanked by "m" the predicate expression means "has a landmine counterpart that explodes shortly after t_6", and when flanked by "s" it means "has a mereological sum counterpart that explodes shortly after t_6". If four-dimensionalists are correct in this, the argument from Leibniz's Law falters, because then we are not strictly affirming and withholding the same predicate, semantically conceived, of m and of s.

I will not debate the plausibility of this kind of response.[38] I think we can apply Leibniz's Law somewhat differently to the situation above as follows.

Either s (*de re* – although referred to by the letter "s") has a landmine counterpart that explodes just after t_6 or it does not. Suppose the four-dimensionalist says it does not. Then, as it is true of m (according to four-dimensionalists) that it has a landmine counterpart that explodes just after t_6, something is true of m that is not true of s. And then by Leibniz's Law we must conclude that m and s are distinct, contrary to standard four-dimensionalism. (It is not remotely plausible to hold that the expression "has a landmine counterpart that explodes just after t_6" suffers from predicational shift.)

Standard four-dimensionalists should, therefore, agree that s (using the very letter "s", picking out the referent *qua* mereological sum) *does* have a landmine counterpart that explodes just after t_6. But then, since m could have exploded just after t_6 in virtue of having such a counterpart, the same must be true of s (i.e. in the same sense, whatever it

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[38] See Fine (2003) for reasons to think that in many cases, the relevant syntactical predicate does *not* in fact express different senses when flanked by different subject expressions.

is, in which m could have exploded just after t_6). For otherwise there will again be a problem with Leibniz's Law.[39] And since m could have lacked some of its temporal parts as a result of the fact that it could have exploded just after t_6, the same must be true of s. (Otherwise Leibniz's Law again rules they are different.) But then it must be concluded that s does not have its temporal parts essentially. But that is incompatible with mereological essentialism. Therefore, since standard four-dimensionalists insist that $s = m$, it must be concluded that m does *not* have a landmine counterpart that explodes just after t_6. And thus we arrive again at the conclusion that m could not have exploded just after t_6.[40] (Notice that here I depart from van Inwagen (1990), who thinks that *qua*-reasoning does provide four-dimensionalists with a route out of the modal problem.)

But if m does not actually explode just after t_6 and could not have done so, it cannot be such that, if it were stepped upon at t_6 it would explode shortly after; nor can it have a dispositional property at t_6 such that the property would cause m to explode shortly after t_6 were m stepped upon at t_6. But then, on neither analysis is m explosive at t_6. The same reasoning concerning m will apply to any point in time in the interval t_5–t_7; and, plainly, what goes for the predicate "is explosive" goes for every predicate of category D_{ii}.

Let us move on to category D_i. Consider a balloon b that exists between t_0 and t_{10} and which does not inflate at time t_5 but of which we would nevertheless want to say that it is inflatable at that very time. Proponents of the conditional analysis would say:

(SCA) b is inflatable at t_5 iff, if extra air were put into b at t_5, b would expand immediately after (in ideal conditions).

The dispositional property analyst would say:

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[39] If "could have exploded shortly after t_6" (in the sense of *has a landmine counterpart that explodes shortly after t_6*, or in whatever sense it is in which m could have exploded shortly after t_6) cannot be predicated of s, although s does have a landmine counterpart that explodes shortly after t_6, then m and s must be distinct. Why? Because "could have exploded shortly after t_6" (in the sense of *has a landmine counterpart that explodes shortly after t_6*, or whatever the sense is) can be predicated of m, due to the fact that it has a landmine counterpart that explodes shortly after t_6.

[40] Lewis thinks it is true that had Nixon pushed the button in the 1970s, a holocaust would have ensued (1979, pp. 467-472). But, given Lewis's four-dimensionalism, had a holocaust ensued in the 1970s, it would not have been Nixon who pushed the bottom! That is, it would have been neither Nixon himself nor a counterpart of him that pushed the button.

(DPA) b is inflatable at t_5 iff b has a dispositional property at t_5 such that were extra air put into b, the property would, together with higher pressure, cause b to expand immediately after (in ideal conditions).

Now, obviously, had b been inflated at t_5, it would have had a post-t_5 future quite different from its actual post-t_5 future. For one thing it would have had a greater volume. Probably it would also have taken a path in space-time other than its actual path: perhaps it would have been carried away from its actual place in space by the inflator; perhaps it would have drifted away; perhaps it would have bounced away; etc. That *some* such path would have been taken by the balloon is highly likely. That the balloon would have followed *exactly* the same (albeit "thicker") path is highly unlikely. In view of this, it also seems most plausible that the balloon would have had a total lifespan different from its actual lifespan. Perhaps it would have drifted into a cactus and exploded; perhaps it would have bounced into a fireplace and gone up in smoke. In any case, the idea that the balloon would have had *exactly* the same lifespan seems incredible. But given the four-dimensional aggregate view, if the total lifespan of the counterfactually perduring entity differs from the actually perduring entity's lifespan (however minute the difference), the two entities cannot be identical. As I have argued, nor can the counterfactually perduring entity be b's counterpart. From this it follows that it would not really have been b or a counterpart of b that inflated.

Four-dimensionalists who insist that b *is* inflatable at t_5 must therefore accept the following implausible counterfactual: *had b displayed the disposition at t_5, b would have persisted exactly for as long as it does in actuality*. I take it that most four-dimensionalists would reject this counterfactual. But if this is so, the notion that b is inflatable at t_5 must also be rejected. Likewise, of course, for any particular time falling in the interval.

This difficulty affects all dispositional predicates from category D_i. Normally we suppose that had a persisting object changed intrinsically when, in fact, it did not change, then, as it would have had different properties, it would most likely have interacted differently with its surroundings; and that this would probably have resulted in a different

lifespan (however minute the difference). But this line of reasoning simply does not make sense in the conventional four-dimensionalist picture. For given the different lifespan result, we must be dealing with a counterfactual object that is distinct from the actual one – an object that is not even a *counterpart* of the actual object. Thus true disposition ascriptions from category D_i must be taken only to involve counterfactual scenarios in which occurrences of the stimulus and manifestation events have no impact whatsoever on the lifespan of the subject (as compared with its actual lifespan). When the subject is specified in the antecedent of the conditional entailed by the disposition ascription, the lifespan of the subject is laid down, in advance, as it were. Hence, the only worlds in which the antecedent clause holds true (and so the only worlds to be considered) are those in which the subject – or its counterpart – survives until, and no later than, the time of the subject's actual perishing. But how can the counterfactual occurrence of the stimulus and manifestation events fail to make the slightest difference to the lifespan of the subject? The idea that they might fail so seems almost fantastic, especially if the laws of nature are deterministic (cf. Lewis, 1979). At the very least, such counterfactual scenarios seem to involve a series of astonishing coincidences which enable the counterfactual world and the actual world to match perfectly in respect of the lifespan of the subject in question.[41]

Now, do four-dimensionalists want to claim that such scenarios *are* what we are talking about (indirectly, through the entailed conditionals) when we make disposition ascriptions (and when the subject is not actually manifesting the disposition at the time in question)? Or do they want to say that these are the scenarios we *ought to be* talking about? I doubt four-dimensionalists would make either claim. If this is right, however, disposition ascriptions from category D_i have to go.

A similar difficulty arises for predicates in category D_{iii}. When, counterfactually, we imagine an entity x affecting y at a particular time, we are more or less obliged to suppose that x would not have lasted exactly as long as it actually lasts. Things in x's surrounding would be different, which would in all likelihood result in a different future and a different lifespan (however minute the difference). But four-dimensionalists

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[41] One dubious escape route here would be to claim that the insertion of the ideal-conditions clause, widely interpreted, makes such scenarios tolerable.

wanting to say of x that it has disposition F at t (where "F" is a D_{iii}-type predicate and x does not in fact display the manifestation events of F at t) are committed to the following counterfactual: had x displayed the manifestation events of F at t, x would have lived for exactly as long as it lives in actuality. That is a scarcely credible proposition.

6. Three-dimensionalism and disposition ascriptions

Three-dimensionalists wanting to ascribe dispositions (from categories D_{i-iii}) to objects are not vulnerable to the kinds of difficulty mentioned so far. On the three-dimensionalist account, a persisting object is not an aggregate or mereological sum of temporal parts persisting by perduring, but is rather an enduring entity which is wholly present at different times as numerically the same entity. Obviously, the 4-D Formula has no application to three-dimensional objects and thus the difficulties mentioned in Section 4 are avoided. Equally, because a three-dimensional object that counterfactually persists longer or less long than it does in actuality is not a four-dimensional mereological sum that lacks some of its actual temporal parts or has some extra ones in other possible worlds, the criticism leveled above in Section 5 is avoided. And since three-dimensionalists in general reject aggregative conceptions of objects – objects are not held to be four-dimensional mereological sums of temporal parts, nor three-dimensional sums of properties (e.g. Kripke, 1980, p. 52),[42] nor three-dimensional sums of concrete parts (e.g. Wiggins, 1968; Simons, 1987; Mellor, 1998, p. 87) – they are not vulnerable to analogous difficulties having to do with the inability of three-dimensional mereological sums to lose or gain parts either across times or across worlds.

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[42] Kripke does not explicitly endorse three-dimensionalism in his lectures (1980); but the lectures seem to presuppose three-dimensionalism. (A caveat: at one point he appears to argue for some version of the stage theory (p. 51, n. 18); but that footnote is incompatible with the rest of the text. Think, for instance, of his insistence that the Morning Star is numerically identical with the Evening Star. In the morning we dub an entity "The Morning Star". In the evening, some months later, we dub an entity "The Evening Star". As it turns out, we have named *one and the same planet* twice. Moreover, Kripke does not seem to be thinking that we have named the same four-dimensional planet twice, although this would also be incompatible with stage theory.) In any case, in an unpublished series of lectures, delivered in the 1970s, Kripke explicitly argues for three-dimensionalism by invoking the, since then, much discussed homogenous spinning sphere thought experiment (see also Armstrong, 1980).

It might be thought that the three-dimensionalist will nevertheless have difficulties with dispositional predicates from category D_i. Such dispositional ascriptions presuppose that the object changes intrinsically when the manifestation events occur. But – it might be objected – endurance through intrinsic change is highly problematic, if not impossible. For even if three-dimensionalists generally reject aggregative conceptions of objects, the idea that a three-dimensional entity can change (or could have changed) intrinsically is – it might be claimed – thrown into doubt by two simple arguments: the argument from Leibniz's Law and a complementary argument from supposed possession of incompatible properties.

Take our rubber band r again. Suppose that in some world w r is circular at t_1 and elliptical at t_2 due to the straining of it during the interval. Call the circular rubber band at t_1 "c" and the elliptical rubber band at t_2 "e". The argument from Leibniz's Law then runs as follows:

> Something is true of c which is not true of e. c is circular, e is not. Hence, by Leibniz's law, we have to conclude that they are not identical, contrary to the thesis of endurance.[43]

The complementary argument from incompatible properties runs as follows:

> If c and e are identical, then c/e (i.e. r) is *both* circular and elliptical. But then $c/e/r$ has incompatible properties, which is impossible unless the intrinsic properties are construed as relations to distinct times. But if the relevant properties are construed as relations to times, the properties are no longer intrinsic, so we cannot be dealing with intrinsic change after all.[44]

Elsewhere (see my z´z´z´z´) I have argued in detail that both of these arguments are unsound *given* the theory of endurance: they contain premises that only four-dimensionalists will accept. There is no room to rehearse that reasoning here. Suffice it to

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[43] This argument can be found in Armstrong (1989, p. 3), Jubien (1997, pp. 72-73), and Sider (2001, pp. 4-5).

[44] This argument can be found in Lewis (1986, pp. 202-204; 1988).

say that in my view arguments against three-dimensional objects satisfying dispositional predicates from category D_i cannot safely rely on a notion that objects cannot endure through intrinsic change grounded in the argument from Leibniz's Law and the argument from incompatible properties.

Even if, as I contend, there is no immediate *logical* objection to the claim that three-dimensional objects satisfy dispositional predicates, the *metaphysical* concern about how an object can endure in a block-universe mentioned in Section 3 remains. So B-theorists may want to reject the idea that three-dimensional objects satisfy dispositional predicates nevertheless. But such a rejection, it should be noticed, would not really be a rejection of the idea that three-dimensional objects *satisfy dispositional predicates*. It would be a rejection of *endurance* in a block-universe *per se*; and it may very well be overhasty (see the defenses of the endurance/block-universe combination in Mellor (1998), McDaniel (2003) and Beebee & Rush (2003)).[45]

Others may reject the idea that three-dimensional objects satisfy dispositional predicates on the grounds that the metaphysical *nature* of a three-dimensional object is too elusive. If an enduring object, wholly present at a particular time, is not identical with the mereological sum of its parts existing at that time, then what exactly is it that is wholly present at that time? An entity which is, in some way, something "over and above" the sum? A substrate or thin particular which has, or owns, the parts only temporarily? Or what? It might be held that although the four-dimensional metaphysics initially appears revisionary, it is clearer; and that therefore four-dimensionalism is to be preferred. But again, such a rejection would be a rejection of three-dimensionalism as such, not a rejection of the very idea that three-dimensional objects can take dispositional predicates *if* they exist.[46]

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[45] Moreover, those philosophers who, notwithstanding the defenses of it, think that the endurance/block-universe combination is unacceptable, and who are more certain that objects are three-dimensional than they are that we live in a block-universe, may adopt presentism, i.e. the view that only the present moment is real. (See Bourne, 2006, for a book-length defense of presentism.) Of course, anyone who makes this move will struggle with the argument from special relativity, the no truthmaker objection, and so on.

[46] Suppose that there are no three-dimensional, changeable objects but only three-dimensional aggregates or mereological sums (cf. Chisholm, 1976). What kinds of disposition can be ascribed to them? Since aggregates cannot change their parts, dispositions from category D_i are definitely in trouble. Dispositions from category D_{ii}, however, seem unproblematic, because there is no difficulty with enduring aggregates counterfactually living for a longer/shorter time than they do in actuality. Moreover, I see no reason to deny that enduring aggregates can have dispositions from category D_{iii} (as long as the relevant predicate does not

Finally, some may wish to deny that three-dimensional objects satisfy dispositional predicates because they harbor hostility to dispositional predicates as such. But this would not be a rejection of three-dimensional objects satisfying dispositional predicates, but a rejection of dispositional predicates as such.

7. Some options for four-dimensionalists

To conclude, there are powerful reasons for holding that if standard four-dimensionalism is correct, many of our dispositional predicates are inapplicable to ordinary objects. Three-dimensionalism avoids this problem. How should four-dimensionalists respond to this? I wish to end the paper by sketching some possible reactions.

1) Four-dimensionalists may simply bite the bullet and declare that, contrary to what most of us believe, strictly speaking, objects rarely, if ever, satisfy dispositional predicates. We speak as if they do, but in reality they do not. But so what? they might ask. We speak as if the sun rises over the horizon although in reality it does not.[47] We say the Earth is round although strictly speaking it is not. "Descriptive" discourses of certain kinds may possess pragmatic utility when they do not depict the literal truth. Dispositional discourse is a case in point.

I do not wish to claim that this response is completely unreasonable, but I do think that four-dimensionalists adopting it owe us some account of how it is that dispositional talk can be of pragmatic utility if it does not depict the truth. That is, I think that they should help us answer questions of this type: why is it of any pragmatic utility to exclaim, for example, "Careful, that vase is fragile!" if the vase is not really fragile? The four-dimensionalist must explain why we should hold on to our old behavior, if we should, when ordinary objects rarely satisfy dispositional predicates.

It should be noticed, moreover, that this line of defense threatens to eliminate some kinds of object from our ontology. Consider litmus-paper, for example. It seems

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entail that the aggregate must change intrinsically in order to manifest its power to affect entities distinct from itself). Predicates from category D_{iv} (see note 1) seem completely unproblematic here.

[47] Given the general theory of relativity, though, such a statement, made on Earth, seems capable of being treated as literally true, relative to Earth's frame of reference, if that frame of reference is taken to be non-accelerating (cf. Reichenbach, 1958, pp. 217, 237-241).

that, in order to be a piece of litmus-paper (to fall under the sortal), an entity must have a disposition to change color when put in acid (category D_i). Hence if no entity satisfies this predicate, it would seem that there is *no* litmus-paper. We talk *as if* there are pieces of litmus-paper – that is all. In general, objects of kinds that are essentially dispositional, such as computers, thermostats and electrons, are threatened with elimination, given this line of defense.

2) Four-dimensionalists not wishing to downgrade dispositions (and certain kinds of object) to an "as-if"-status, could respond by rejecting mereological essentialism. If mereological essentialism is rejected, the argumentation of Section 4 and Section 5 presents no threat to the idea that objects, identical with four-dimensional mereological sums, satisfy dispositional predicates. Mereological essentialism, however, seems to be close to being a conceptual truth. It is part of what is *meant* by "mereological sum", I take it, that a mereological sum is an entity *x* that cannot lose or gain any parts (if it endures through time) and could not have had any other parts than those it actually has. True, the standard formalizations of mereology (see e.g. Simons 1987 for the systems of Leonard & Goodman and Lesniewski) involve no such essentialist definitions or statements. What we have, rather, are (timeless) extensional principles to the effect that sum *x* and *y* are numerically identical iff every part of *x* is part of *y* and every part of *y* is part of *x*.[48] But the reason we do not find modally loaded principles in these formalizations is that they were developed precisely to be intra-worldly; and the reason for that is that their inventors happened to be skeptical of modality (and of abstract entities in general, sets included).[49] But the "broader", intuitive conception of a mereological sum *does* involve an essentialist component. Or so I claim.[50] And other philosophers have relied on this intuition too (most famously, perhaps, Chisholm, 1976). Here the concept of a mereological sum somewhat parallels the concept of *set*, I think. The axioms of standard set theory (i.e. Zermelo-Frankel set theory) contain no modality. Nevertheless we think it a conceptual truth that sets have their members essentially (cf. van Cleve, 1985).

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[48] Strictly speaking, the variables *x* and *y* range over not only sums but individuals in general. However, if one is a three-dimensionalist one will want to deny that such a principle is true of ordinary physical objects: see Simons (1987) and Thomson (1983).

[49] Again, see Simons (1987). Note, however, that in their 1940 paper Leonard and Goodman did make use of sets. Goodman jettisoned sets in his (1951).

[50] Cf. Simons, who writes that "essentialist principles […] are, rather, constitutive of what extensionality for part-whole comes to" (1987, p. 280).

3) Four-dimensionalists wishing to retain mereological essentialism may respond by giving up Leibniz's Law. They might argue that if the law is given up, there is no difficulty in saying, of the mereological sum s that made an appearance above in Section 5, that it could not have exploded at t_6, while saying of the landmine m, in the same section, that it could have exploded at t_6 – even supposing that the predicate means the same thing when predicated of m and withheld from s. For if Leibniz's Law is rejected the proposition "$s = m$ & $(s \neq m)$" is not deducible from their position. However, this I think would be a mistake. Since the position would be that there is a *single* entity,[51] e, of which one and the same predicate is *both* true and not true, four-dimensionalists would end up in a contradiction.[52] And any proposition follows from a contradiction, including the proposition "$s = m$ & $(s \neq m)$".

The rationale for Leibniz's Law is precisely that contradictions are to be avoided. There cannot be contradictory entities. If something is true of x that is not true of y, it can only be because x and y are numerically distinct: ergo Leibniz's Law is correct. (Of course, four-dimensionalists may take refugee in the philosophy of Priest (1998), who argues that there are true contradictions.) At the very least, giving up this law in order to accommodate four-dimensional object that satisfy dispositional predicates seems unbalanced.[53]

4) Finally four-dimensionalists may want to *revise* their theory and deny that persisting objects are numerically identical with four-dimensional aggregates of temporal parts. Instead they may hold that persisting objects are *constituted* by aggregates of temporal parts – by analogy with the three-dimensionalist conception of the relationship between an enduring object and the aggregate of its parts at a particular time. (Wiggins (1968), for example, holds that a tree is not identical with the aggregate of cellular cells

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[51] One might seriously worry, however, whether "=" still expresses strict and absolute numerical identity if Leibniz's Law is given up. What exactly can "$s = m$" mean if the "=" relation is not taken to be governed by Leibniz's Law? For the radical view that the concept of absolute identity is to be altogether given up in favor of *relative identity*, see Geach (1967). On Geach's view, we cannot simply say "$x = y$", but must say "x is the same F as y", where "F" is a genuine count sortal ("entity" is disqualified on Geach's view); and x may be the same F as y although y is not the same G as x. For discussion and criticism of Geach's position, see Hawthorn (2003) and Wiggins (2001, ch.1).

[52] Let predicates stand for extensions. Then *qua* mereological sum e will not be a member of the predicate's extension; *qua* landmine it will. Hence, e will both be and not be a member of the predicate's extension: contradiction.

[53] For a general defense of Leibniz's Law, see Wiggins (2001, pp. 27-28).

that constitute it at a particular time t; the tree and the aggregate, although they fully coincide at t, have different temporal and/or modal properties (see also Fine, 2003).) If four-dimensionalists revise along these lines, they can presumably hold that objects satisfy dispositional predicates although the aggregates of the temporal parts that constitute them do not.

Three-dimensionalists should be sympathetic to such a development of four-dimensionalism, as they tend to advocate similar views themselves. I think that four-dimensionalists will be reluctant to revise their theory in this direction, however.[54] After all, *they* criticize three-dimensionalists severely for accepting distinct entities that fully coincide (e.g. Lewis, 1986, p. 252; for overviews, see Sider, 2001, ch. 5 and Hawley, 2001, ch. 5). They allege that three-dimensionalists cannot explain the difference between properties of the object and properties of the aggregate of its constituting parts, asking what it is that *grounds* those differences. It is sometimes claimed that one of four-dimensionalism's real virtues is that it avoids such difficulties. The revision we are considering would nullify this claim and put three-dimensionalists and four-dimensionalists in the same boat in this respect.

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[54] But see Heller (1993) for a hypothetical proposal along these lines. Heller does not wish to adopt such a view himself. He has made the case (1990, ch. 2) for eliminating ordinary objects from our "strict" ontology and allowing only four-dimensional hunks of matter.

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