Ordinary Objects in the Relativistic World

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Can our ordinary conception of macroscopic objects be transposed to the framework of relativity theory? According to common sense, ordinary objects cannot undergo radical variation in shape, whereas according to a compelling and widely accepted metaphysical picture of ordinary objects' shapes in Minkowski spacetime, they do undergo such radical variation. This problem raises doubts about the compatibility of the ordinary conception and the relativistic conception of the world of objects. I shall propose to reconcile common sense with relativistic metaphysics by viewing ordinary objects as double-layered compounds of matter and form. The different layers permit different perspectives on the objects, the one perspective focusing on form and the other focusing on matter. This ontology allows the conception of common sense and the conception of relativistic metaphysics to manifest different and compatible perspectives on the same objects.

1 The relativistic world

According to the special theory of relativity, ordinary objects, such as chairs and persons, are subject to relativistic variation in shape; they have different shapes in different inertial frames of reference. The purpose of this section is to sketch an elegant and widely accepted metaphysical model of shapes in Minkowski spacetime. This model will later allow us to recognize a certain limiting case of relativistic shape-variation with disturbing consequences for our common-sense conception of the world.

In special relativity there is no absolute space in which objects have a true shape. Macroscopic objects may vary in their shapes across frames of reference. Suppose that a given ordinary object has different three-dimensional shapes at different times in different reference frames. Many find it overwhelmingly plausible that there must be something permanent standing behind the different three-dimensional shapes of the object, namely, an invariant four-dimensional shape, such that the different three-dimensional shapes may be construed as perspectival representations of the single invariant shape. As Yuri Balashov (2010: 202) puts it, "'separate and loose' 3D shapes come together in a remarkable unity, by lending themselves to an arrangement in a smooth 4D volume". So we see different three-dimensional shapes of an object when viewing the object's unique four-dimensional shape from various angles in spacetime. All shapes an object has at different times in different reference frames are unified by an invariant shape from which the various shapes are derived.[1] I shall call this elegant account of macroscopic objects' shapes in Minkowski spacetime the *unified view*.

The unified view may be fleshed out as follows. First of all, Minkowski spacetime contains a four-dimensional manifold of spacetime points. Any fusion of spacetime points is a spacetime region. While simultaneity is an invariant notion in classical spacetime, it is not an invariant notion in Minkowski spacetime; it is not meaningful to ask whether two spacetime points are simultaneous. Although absolute simultaneity is not well-defined in Minkowski spacetime, it is possible to define a relative notion of simultaneity. The fusion of any maximal set of points that are simultaneous relative to an inertial frame of reference F is an F-relative hyperplane of simultaneity. Simultaneity relativized to an inertial frame of reference is an equivalence relation, and hence each inertial frame defines a different slicing of the same spacetime into hyperplanes of simultaneous points. These frame-relative hyperplanes of simultaneity may be conceived of as frame-relative moments of time. Given an inertial frame of reference F, t^F is a familiar moment of time relative to F.[2]

How are ordinary, macroscopic objects related to Minkowski spacetime? According to standard four-dimensionalism, upgraded to meet the demands of special relativity, a macroscopic object exactly occupies a unique four-dimensional region in Minkowski spacetime. This invariant trajectory is known as the object's *world volume*. An object's world volume overlaps with various frame-relative hyperplanes of simultaneity, or frame-relative

[1] See Balashov 2010: 200-202 for examples of the analogous phenomenon of perspectival shape-variation in space.

[2] It should be emphasized that frame-relative times are not assigned any privileged metaphysical status. From the point of view of physics, the content of spacetime may be described in terms of "flat" hyperplanes relative to a particular inertial frame of reference. But, as Gibson and Pooley (2006: 162) put it, "one can equally choose to describe the content of spacetime with respect to some frame that is not so optimally adapted to the geometric structure of spacetime, or indeed, choose to describe it in some entirely frame-independent manner." It should also be noted that Gibson and Pooley (2006: 166-7) propose an alternative, causal and frame-independent conception of a time. For considerations of length, I shall not be able to discuss this alternative.

moments of time—that is, there is a spacetime region that is both a part of the world volume and a part of the hyperplane. According to standard four-dimensionalism, for each region of overlap between an object's four-dimensional world volume and an F-relative time, for some frame of reference F, the object has a part that exactly occupies that region. I shall say that an object that exactly occupies a sub-region of an F-relative time t^F is a *stage* at t^F, and that an object that has a part that exactly occupies a sub-region of t^F has a stage at t^F. An ordinary, macroscopic object has a stage at each time that overlaps with its world volume.[3]

In ordinary language, we do not describe an object in terms of its world volume and its stages. We rather describe an object as existing at various times, or as persisting through time. There is, however, a straightforward way of linking familiar facts of an object's existing at a time with facts about stages. Given that there are frame-relative times in Minkowski spacetime, ordinary talk of persistence may be transposed to a relativistic framework by straightforward frame-relativization, yielding statements of the form 'o exists at t^F', for some ordinary object o. Truth conditions of frame-relativized statements of temporal existence may be specified as follows: for any ordinary object o, any inertial frame of reference F, and any frame-relative time t^F,

(O1) o exists at t^F iff o has a stage at t^F.

At each frame-relative time at which an ordinary object exists it has a certain shape. Given that an object o's existence at t^F consists in o's having a stage at t^F, standard four-dimensionalists say that o's having a certain shape at t^F consists in o's stage at t^F having that shape simpliciter. For any ordinary object o, any inertial frame of reference F, any frame-relative time t^F, and any shape ϕ,

(O2) o has ϕ at t^F iff o has a stage at t^F that has ϕ.

For illustration, suppose that F is the rest frame of a macroscopic object o, and that F* is the rest frame of an observer who is moving near the speed of light relative to o. Object o has a certain invariant world volume in Minkwoski spacetime. This world volume overlaps with various frame-relative times. Consider time t^F in o's rest frame, F, and time t^{F^*} in the observer's rest frame, F*, such that both of these times overlap with o's world volume as specified in the following spacetime diagram:

[3] For details on four-dimensionalism in Minkowski spacetime, see Balashov 1999, 2000 and 2010, Gibson and Pooley 2006, Gilmore 2006, Sider 2001, and Sattig 2006.

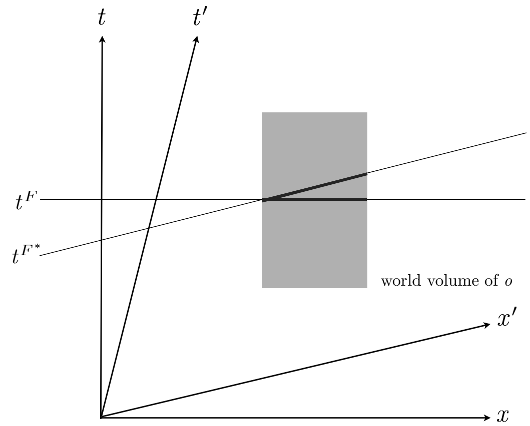

Figure 1

The region where o's world volume overlaps with t^F and the region where o's world volume overlaps with t^{F^*} are exactly occupied by distinct stages of o. These stages may have different three-dimensional shapes. If so, it follows by principle (O2) that o has one three-dimensional shape at t^F and another three-dimensional shape at t^{F^*}. This four-dimensionalist picture of an object's frame-relative shapes in Minkowski spacetime provides a foundation for the idea that the latter are perspectival representations of an invariant four-dimensional shape. Each shape a four-dimensional object has at any frame-relative time is the shape of a stage of the object. Different shapes of the object at different times are just cross-sections of a single four-dimensional shape of that object. This is how the object's shapes at different frame-relative times "fit into" a single four-dimensional volume. The unified view is standardly fleshed out in this four-dimensionalist way. I shall work with this framework, but leave open the possibility of placing the unified view on an alternative foundation.[4]

In the following two sections, I will show that the unified view of macroscopic object's shapes in Minkowski spacetime, as captured by four-dimensionalists, threatens our ordinary conception of macroscopic objects. I shall begin by tracing these foundations.

[4]Balashov (2010: Ch. 8) argues that four-dimensionalism offers the only sensible basis for the unified view of relativistic shapes.

2 The ordinary world

While ordinary objects can vary in many of their properties over time and across worlds, they cannot vary in any way with respect to certain specific kinds to which they belong. These ordinary kinds are strictly invariant. As it is often put, the ordinary world is partly individuated by these kinds; it is carved into persons, chairs, trees, mountains, and so on. Assuming that for any kind K and any ordinary object o, o is *essentially* a K iff o is a K at all times at which it exists and in all worlds in which it exists, certain specific ordinary kinds are essential to the objects falling under them. The doctrine that certain kinds are essential to their instances is known as *sortal essentialism*. It is part and parcel of the common-sense conception of macroscopic objects that certain ordinary kinds are essential to the objects falling under them. Chairhood, for example, is commonly regarded as an essential property of its instances. Whatever properties make an object a chair, we bring a chair into existence by causing these properties to be instantiated, and a chair cannot lose these properties without going out of existence.[5]

Sortal essentialism is the doctrine that certain ordinary kinds are strictly invariant, that the world is carved by these kinds. It rules out variation with respect to these kinds along all dimensions, and hence it rules out relativistic variation as well as modal and temporal variation. Relativistically sensitive sortal essentialism is thus the doctrine that ordinary kinds are essential to the objects falling under them, where for any kind K and any ordinary object o, o is essentially a K iff o is a K at all times at which it exists, *in all frames of reference*, and in all worlds in which it exists. If ordinary objects, such as chairs, have a place in the relativistic world, then chairhood does not vary relativistically; being a chair does not shift with relativistic point of view. This is a straightforward consequence of transposing the compelling doctrine of sortal essentialism to a relativistic framework.

If sortal essentialism holds—if K-hood is strictly invariant, for any ordinary kind K—then it is not necessary to ascribe K-hood to an object at a world or at a frame-relative time. Modal and relativistic-temporal modification of K-hood may simply be dropped, and K-hood may be ascribed to an object *simpliciter*, where for any ordinary object o, and any kind K, o is a K simpliciter iff o is a K at any frame-relative time, in any possible world,

[5]The familiar label 'sortal essentialism' is here intended to apply to the doctrine that certain specific sortals, or kinds, are invariant properties of their instances. Those who reject the account of essence in terms of invariance should substitute 'sortal eessentialism' with the less familiar label 'sortal invariance'.

at which o exists.

The doctrine of sortal essentialism is one pillar of our ordinary conception of macroscopic objects. Another pillar is the doctrine that there is an informative answer to the question what it is to be a chair, to the question what determines membership in the class of chairs. It seems, in other words, to be constitutive of the folk conception of Ks, where K is some ordinary, invariant kind, that an object is a K at a time in virtue of instantiating a range of K-determining attributes at that time. Let us say, for simplicity, that being a K is partly determined by being K-shaped, whatever exactly being K-shaped involves: for any object o, any ordinary, invariant kind K, and any time t, if o is a K at t, then o is K-shaped at t. Since K-hood is invariant, K-hood applies to an object simpliciter, and hence the sortal-determination doctrine may be expressed as follows: for any object o, and any ordinary, invariant kind K, if o is a K, then o is K-shaped at all times at which o exists. (While it also follows that an object is a K only if it is K-shaped in all worlds in which it exists, I shall focus on temporal invariance.) As an instance of this sortal-determination principle, something is a chair only if it is chair-shaped at all times at which it exists. Being made of wood is not what makes an object a chair, but being chair-shaped partly is. I am not claiming that there is a universal chair-shape; there are many such shapes. Nor am I claiming that there are necessary and sufficient conditions for the application of the concept of a chair that all competent users have on their finger-tips. But I am claiming that there are minimal qualitative constraints on what counts as a chair, which guide us in singling out clear non-chairs. The mentioned principle is such a constraint.

If Ks are to be found in a relativistic world, then the pre-relativistic sortal-determination principle linking Ks with K-shapes must have a relativistic descendant. The obvious way of transposing the sortal-determination principle to a relativistic framework is to frame-relativize as follows: presupposing sortal essentialism—the doctrine that certain ordinary kinds K are invariant—for any object o, and any invariant kind K,

(K) If o is a K, then o is K-shaped at all frame-relative times at which o exists.

Being chair-shaped is part of what makes an object a chair. Thus, there are strict limits to the extent to which chairs can vary in shape, limits that obtain whether the variation happens within a single frame of reference or across different frames of reference. No object can be a chair unless it is chair-shaped in all circumstances in which it finds itself.[6]

The doctrines of sortal essentialism and sortal determination seem to be constitutive of the common-sense conception of macroscopic objects. There is, accordingly, a place for ordinary objects in the relativistic world—a place for objects as the folk know them—only if these doctrines are preserved. I will show now that these doctrines cannot be jointly sustained in the face of extreme cases of relativistic variation in shape.

3 The problem of the point-shaped chair

Consider a macroscopic object o in its rest frame F in Minkowski spacetime.[7] Suppose that o comes into existence at t_1^F and that o goes out of existence at t_2^F. Moreover, let F* be the frame of reference of an observer who is moving near light speed relative to o. In F*, there is a time t^{F^*} that overlaps with o's world volume in a single spacetime point, p, as illustrated by the following diagram:

[6]Sortal-determination principles specify partial persistence conditions. A chair, to take the case at hand, cannot lose its chair-shape without going out of existence. This seems obvious. And yet we can imagine picking up a wildly distorted piece of metal, saying "Look what happened to this chair." It would, in my view, be an overreaction to drop the compelling chairhood-determination principle in response to these sorts of puzzling cases. More conservative routes are open. One might, for instance, consider a fictionalist interpretation, according to which the relevant assertion is made under some kind of pretense. We want to draw attention to a certain course of events involving a radical shape-change, which task is simplified if we pretend that a single object is subject to the change.

[7]I owe the following case to Cody Gilmore, who appeals to it for different reasons than I do; see Gilmore 2006: 212-13.

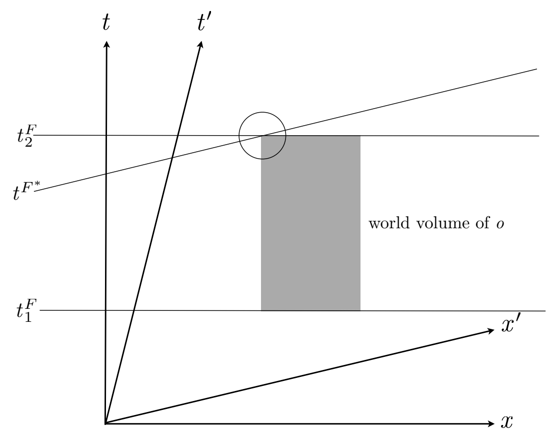

Figure 2

Since o has a stage that exactly occupies p, it follows by principle (O1) that o exists at t^{F^*}. Since o's stage in p is point-shaped, it follows by principle (O2) that o is point-shaped at t^{F^*}. By analogous considerations regarding times that lead up to t^{F^*} in frame F* and that overlap with o's world volume, it follows that o shrinks to a point over a certain period of time in F*.

This limiting case of relativistic variation in shape threatens our ordinary conception of macroscopic objects. Suppose that object o in the scenario sketched above is a chair. That is, suppose that a chair comes into existence at t_1^F and that it goes out of existence at t_2^F. To suppose that the property of being a chair applies to o simpliciter reflects the common-sense doctrine that this property is essential to its instances, and hence that possession of the property is not sensitive to the relativistic point of view, the inertial frame of reference, from which o is viewed. According to our ordinary conception of chairs, the property of being a chair is partly a matter of being chair-shaped. This doctrine is captured by principle (K): a chair is chair-shaped at all frame-relativistic times at which it exists. Since o exists at t^{F^*}, by (O1), it follows by (K) that o is chair-shaped at t^{F^*}. By (O2), however, it follows that o is point-shaped, and hence not chair-shaped, at t^{F^*}. Contradiction.

Let me present the problem in a more intuitive, somewhat embellished fashion. A plurality of point-particles become arranged chair-wise very abruptly, say by a powerful machine, at t_1^F, and lose their chair-wise arrangement equally abruptly, say in an explosion, at t_2^F. Accordingly, a chair comes into existence at t_1^F and goes out of existence at t_2^F; and this chair is composed of the mentioned particles at all times at which it exists in F.[8] It must be emphasized that the particles are not assumed to pop into and out of existence at t_1^F and t_2^F, respectively. Such a scenario would transgress the boundaries of physical possibility, due to a violation of the conservation laws.[9] Instead, the particles are merely assumed to begin to compose the chair at t_1^F and to cease to compose the chair at t_2^F. In the rest frame of the chair, F, the explosion and associated mutual separation of the particles occur instantaneously. In a reference frame, F*, associated with an observer who is moving at a high speed relative to the chair the explosion and associated mutual separation of the particles occur gradually. In F* the chair loses its atomic parts one by one, as the chair-wise arrangement of particles gradually breaks up. Given how the chair is individuated in its rest frame, and given how the chair's world volume is fixed in this frame, F*-relative time t^{F^*} intersects the chair's world volume in a single point. By principles (O1) and (O2), the chair exists at t^{F^*}, and ends up being (composed of) a single particle at this time. Hence, the chair is point-shaped at t^{F^*}. But no chair can shrink to a point![10,11]

[8]The assumption that the chair is created and destroyed instantaneously is here made for ease of exposition. The assumption will be lifted in §4.2.

[9]See Balashov 2010: §5.5.

[10]Terrell (1959) and Penrose (1959) pointed out independently that Lorentz contraction is invisible. Owing to the time it takes for light from different parts of a mereologically complex object to reach the eye, an object passing at a significant fraction of the speed of light appears to be rotated. This effect is known as Penrose-Terrell rotation. In light of this effect, I shall refrain from making any assumptions about what our chair looks like in reference frame F*.

[11]Note also that the chair shrinks to a point very quickly. To give a sense of the values of time dilation obtaining for ordinary objects, consider a metal disk and a pair of events, diametrically opposed on the outer edge of the disk, separated by one meter and simultaneous in frame of reference F. Consider, moreover, a frame of reference F*, moving very rapidly relative to F. What sorts of time differences obtain between the two events in F*? Given that u is the relative velocity of the frames, here are the time differences for various values of u: $u = .9c$, time difference $= 6.88 \times 10^{-9}$ seconds; $u = .95c$, time difference $= 1.01 \times 10^{-8}$ seconds; $u = .99c$, time difference $= 2.24 \times 10^{-8}$ seconds. These values are very small. (Note, however, that the time-dilation interval tends to infinity as u approaches c.) The problem stated above is that if our chair goes out existence exactly at t_2^F, then it shrinks to a point until t^{F^*}. If the antecedent is true, then the problem arises irrespectively of the size of the time-dilation intervals in play. How quickly the chair

The problem of the point-shaped chair is that given the unified view of frame-relative shapes in Minkowski spacetime, chairs are forced to change their shape in ways incompatible with our ordinary conception of chairs. If one holds that principle (K) is constitutive of the meaning of *chair*, then it is a conceptual truth that nothing that shrinks to a point is a chair. In this case, the object that we took to be a chair really is not. If (K) is not meaning-constituting, then the conclusion is not that the object fails to be a chair, but rather that we were completely misguided about what chairs can do. Either way, the news is that something we took to be a chair can be point-shaped. This comes as a shock. We thought we were experts on chairs.

4 No easy way out

Is the problem of the point-shaped chair easy to avoid? In this section, I shall look at three attempts to shrug it off, and raise doubts about each of them. My aim is to provide reasons for taking the problem seriously, before recommending substantive and unusual metaphysical commitments in order to avoid it.

4.1 Restriction to rest frames

In an attempt to save the ordinary conception of chairs, one might consider the view that this conception is implicitly restricted to rest frames. Ordinary thinkers, so the view might go, do not believe that chairhood applies to an object invariantly, period. What they really believe is that chairhood applies to an object at all times at which that object exists in its rest frame.[12] Alternatively, one might hold that ordinary thinkers do not believe that being a chair is partly a matter of being chair-shaped, period. What they really believe is that an object's being a chair is partly a matter of being-chair-shaped in that object's rest frame. Both restriction strategies would avoid the problem: if an object's kind-membership in its rest frame is all that counts, it is irrelevant that the object that is a chair in its rest frame is not a chair in the frame in which it shrinks to a point; similarly, if a chair's

shrinks in F* doesn't matter, only that it shrinks counts. The status of the antecedent is a different issue. See §4.2 on temporally fuzzy boundaries of ordinary objects.

[12] I shall set aside worries about the notion of a rest frame of a spatially extended, mereologically complex object. See Balashov 2010: 191-94 and Gibson and Pooley 2006: 194, n.29 for discussion of this issue.

being chair-shaped in its rest frame is all that counts, it is irrelevant that the chair is point-shaped in another frame.

This response will not do. It is highly implausible that the common-sense conception of ordinary objects should be restricted in these ways. Our sortal-invariance intuition is an intuition about the individuation of ordinary objects: there are specific kinds whose instances could not fail to belong to these kinds, in any possible circumstances; these kinds are essential to their instances; they specify what their instances fundamentally are, they individuate them. This conception clearly rules out sortal variation across *all* frames of reference, and hence it doesn't leave any room for a restriction to rest frames. For if a given chair fails to be a chair in certain reference frames, then it is possible for this chair to fail to be a chair; and if this is possible, then the object is not individuated by the kind *chair*. Since common sense parses the world into objects by certain kinds, relativistic variation with respect to these kinds is deeply at odds with common sense.

Moreover, our sortal-determination intuition is that there are specific kinds K, such that being a K partly consists in being K-shaped. The explanatory force of this belief clearly rules out variation in sortal determination across *all* frames of reference. If being a chair is partially grounded in being chair-shaped, then a four-dimensionalist object is invariantly a chair only if each partitioning of the object into stages relative to any reference frame is a partitioning into chair-shaped stages, and hence only if the object is chair-shaped at each frame-relative time at which it exists. No restriction to rest frames will plausibly avoid the problem of the point-shaped chair.[13]

4.2 Indeterminate temporal boundaries

The problem might seem to depend upon the idea that an ordinary object might be destroyed in such a way that it neatly ceases to exist at a particular moment in a particular frame of reference. For this scenario allows us to consider another frame of reference, moving very rapidly relative to the first, in which the object would gradually wither down to a single point, rather than coming to a clear-cut end. It will be objected that there is no particular moment at which an ordinary object clearly goes out of existence. When a chair is distorted or fragmented, even when done with the most violent and speedy means, this takes some time, and it is far from clear at which point

[13]The same considerations discredit the related suggestion that common sense only requires that chairhood apply to an object at all times at which it exists in *some* reference frame; or that an object's being a chair partly consists in being-chair-shaped in *some* reference frame.

the chair ceases to exist. Chairs have fuzzy temporal boundaries.[14]

I reply that the problem does not depend on the assumption that ordinary objects have clear-cut temporal boundaries. Consider again our original scenario involving chair o, reference frames F and F*, and times t_2^F and t^{F^*} (as illustrated in Figure 2). It is plausible that it fails to be determinate that o goes out of existence at t_2^F, contrary to what was previously assumed. It is also plausible that it fails to be determinate that o does not go out of existence at t_2^F—that is, t_2^F seems to be a perfectly good candidate to mark o's end in reference frame F. In short, it is indeterminate whether o goes out of existence at t_2^F (where it is indeterminate whether p iff it is neither determinate that p nor determinate that not p). We know from previous considerations that if o goes out of existence at t_2^F, then o is point-shaped at t^{F^*}. Since it is not determinate that o does not go out of existence at t_2^F, it follows by the foregoing conditional that it is not determinate that o is not point-shaped at t^{F^*}. If we cannot rule out that o goes out of existence at t_2^F, then we cannot rule out that o is point-shaped at t^{F^*}. Intuitively, however, it is determinate that o is not point-shaped at t^{F^*}. For o is determinately a chair, and it is perfectly clear that a chair cannot be point-shaped at any time in any frame. Being point-shaped is a determinate impossibility for chairs.

This response may be put another way. Any candidate temporal-boundary of a given chair must preserve what makes this object a chair. Specifically, no boundary that leaves an object-point-shaped is a candidate boundary for a chair. If t_2^F is a candidate for the time at which o goes out of existence in frame F, then t^{F^*} is a candidate for the time at which o goes out of existence in frame F*. But this temporal boundary in F* does not preserve o's chair-shape, and hence is not a candidate boundary for o. Then t_2^F is not a candidate boundary for o either, which contradicts our initial assumption. In the face of indeterminacy, the initial problem concerning what makes a spatiotemporal boundary a boundary of a chair becomes a problem concerning what makes a spatiotemporal boundary a candidate for a boundary of a chair. This is not supposed to be the last word on the relationship between indeterminate temporal boundaries and relativistic shape-variation. My aim was merely to show that there is a prima facie plausible way of re-

[14]We are led to this judgment by common-sense considerations about the temporal boundaries of ordinary objects. It should be noted that considerations from physics also support this judgment. Destroying a complex material object involves breaking bonds between particles. These are quantum-level events. Accordingly, a complex object around the time of its annihilation is in a fuzzy state: a superposition of many different states. Hence, the object lacks a determinate boundary in spacetime.

booting the problem in the face of indeterminacy worries, and hence that the problem does not go away so easily.

4.3 Kind-dependent persistence

A third approach to the problem is to question the account of existing at a frame-relative time that has been assumed so far. Suppose, as before, that some particles become arranged chair-wise at t_1^F and stay thus arranged exactly until t_2^F, at which time the arrangement breaks up. Thus a chair comes into existence exactly at t_1^F and goes out of existence exactly at t_2^F, and is composed of the mentioned particles at all times at which it exists.[15] The problem is generated by first fixing the chair's invariant world volume and four-dimensional shape in frame F in this way and then viewing this trajectory and shape in a different frame, F*. The crux is that if the chair is allowed to exist at t^{F^*}, then it is point-shaped at that time.

Why not deny that the chair exists at t^{F^*}? One might suggest that the existence at a frame-relative time of a macroscopic object of kind K partly consists in the object's constituent particles being K-shaped at that time. The familiar idea behind this suggestion is that the trajectory of an ordinary object of kind K is determined by K-dependent persistence conditions. If existing at a frame-relative time is constrained in this way, then our chair does not exist t^{F^*} anymore, because its atomic parts are no longer arranged chair-wise at that time. In general, no ordinary, mereologically complex object will shrink to a point in any reference frame, because kind-dependent metaphysical principles of composition and persistence will rule out this possibility.[16]

We started with an account of persistence and shapes of ordinary objects that sustains the unified view of shapes in Minkowski spacetime but loses the folk conception of these objects. Now we are looking at an account of persistence and shapes of ordinary objects that respects the folk conception but is at odds with the unified view of relativistic shapes. Here is why. A macroscopic object o's trajectory in a frame of reference F is the region through which o persists in F. More perspicuously, o's world volume in a reference frame F is the fusion of all regions exactly occupied by o at any time in F. This is how we naturally determine an object's trajectory in a reference frame. Consider now the familiar scenario that the world volume

[15] Given the considerations of §4.2, issues of indeterminacy of temporal boundaries will henceforth be set aside.

[16] I take Balashov (2010: §5.5) to suggest this reply to a related but relevantly different problem.

of chair o in reference frame F is a four-dimensional region bounded by times t_1^F and t_2^F, as illustrated by the following diagram:

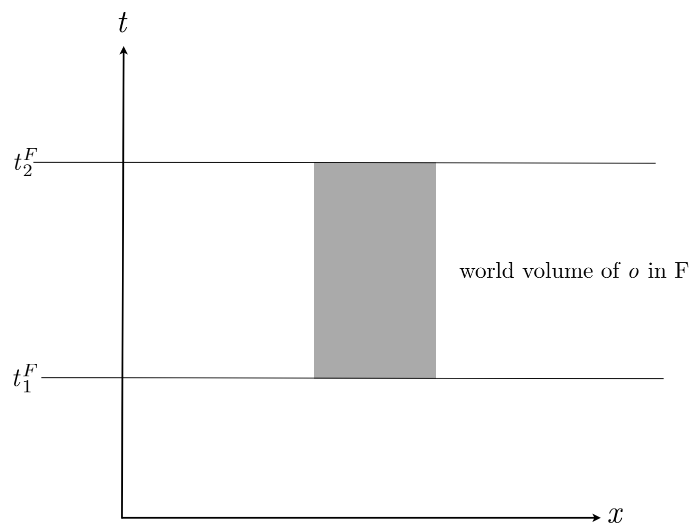

Figure 3

Given a kind-dependent criterion of existing at a frame-relative time, o ceases to exist at $t_1^{F^*}$, prior to $t_2^{F^*}$, in reference frame F*, with the consequence that o does not end up being point-shaped at $t_2^{F^*}$. Since o's trajectory in F* is the fusion of all the regions that o occupies at any time in F*, o's world volume in F* is distinct from o's world volume in F, as illustrated by the following diagram:

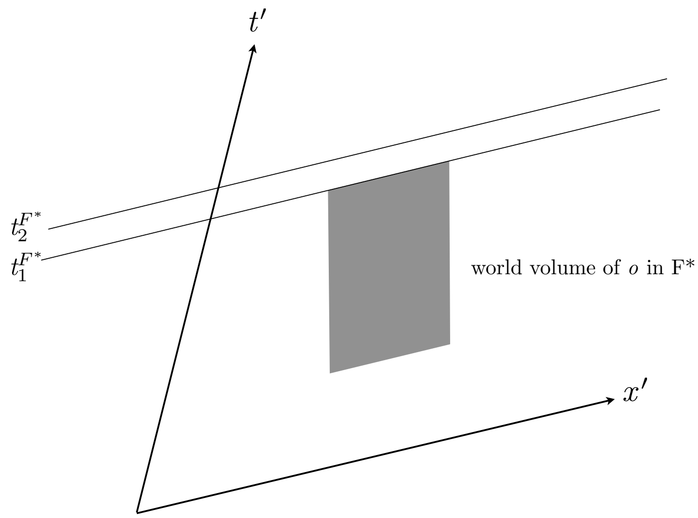

Figure 4

So o persists through different four-dimensional regions relative to different reference frames. Since an object has an invariant world volume only if the object persists through the same four-dimensional region no matter which relativistic angle it is viewed from, o does not have an invariant world volume; o does not exactly occupy the same four-dimensional region in each frame of reference.

Now recall that according to the unified view of a macroscopic object's shapes in Minkowski spacetime, the object has an invariant world volume and a corresponding four-dimensional shape that underlies the object's different shapes at different times in different reference frames. The object's possession of a permanent four-dimensional shape with different cross-sections associated with different relativistic times renders the object's different shapes at these times mere perspectival representations. Compare relativistic variation in shape with modal variation in shape. The plenum of possible worlds constitutes a real dimension of change: an object's sequence of shapes in one possible world and its different sequence of shapes in another possible world are not grounded in a unique, modally invariant shape or sequence of shapes. The plenum of reference frames, on the other hand, does not constitute a real dimension of change: an object's sequence of shapes in one reference frame and its different sequence of shapes in another reference frame are grounded in an invariant four-dimensional shape. Modal shape-variation is non-perspectival, whereas relativistic shape-variation is perspectival. Since object o in the scenario above lacks an invariant world volume, its relativistic shapes cannot be construed as perspectival representations of a stable four-dimensional shape. Kind-dependent accounts of an ordinary object's existing at a frame-relative time therefore seem incompatible with the unified view of relativistic shapes of these objects. These accounts implausibly assimilate relativistic shape-variation to modal shape-variation.

The kind-dependence response to the problem of the point-shaped chair may be worked out in various ways. One strategy is to render the standard four-dimensionalist picture kind-sensitive by saying that an object of kind K exists at an F-relative time t^F only if it has a K-shaped stage as a part at t^F. Another strategy, in the neighborhood of the first, is to adopt a counterpart-theoretic analysis of persistence in terms of stages related in kind-relevant ways, and to say that an object of kind K exists at an F-relative time t^F only if it has a K-counterpart at t^F. A third strategy is to get kind-dependent persistence conditions on the basis of a broadly Aristotelian picture of ordinary objects as depending in their existence and identity on a kind-determining "principle of unity" holding among its parts. If combined with three-dimensionalism about an object's location in spacetime, the view could be that an object of kind K exists at an F-relative time t^F only if it exactly occupies a subregion R of t^F and is K-shaped at R. Here I am not concerned with the details of these and related versions of the view that ordinary objects have kind-dependent persistence conditions. For all of these versions share the same defect: they are incompatible with the unified view of shapes in relativistic spacetime. To repeat the main point, if an object's persistence is kind-dependent, then the object has different world volumes in different reference frames, and hence it lacks an invariant shape that underlies its different shapes at different times in different frames.

4.4 Relativistic metaphysics versus common sense

There is no easy way to reconcile the unified view of relativistic shapes of ordinary objects with the common-sense conception of the latter. So what to do? An understandable reaction at this point is simply to live with the outcome, and to view the problem of the point-shaped chair as a counterintuitive consequence of relativity theory that is to be accepted with natural piety. Faith in common sense should be limited when folk beliefs clash with physics. But the problem of the point-shaped chair does not, strictly speaking, concern such a clash. It rather marks a clash between common sense and relativistic *metaphysics*. As presented here, the problem rests partly on the metaphysical assumptions of four-dimensionalism and the unified view of shapes in relativistic spacetime. This is an important difference. For it is primarily philosophical attacks on the folk conception, not scientific ones, that Mooreans are skeptical about. Furthermore, a Moorean philosopher intent on saving the appearances will be particularly concerned with saving the folk principles of sortal essentialism and sortal determination. For these principles are fundamental from the point of view of common sense. If they break down, then our failure is not just one of qualification, but one of individuation. If they break down, then we did not just describe the world incorrectly; we carved the world incorrectly—we got the essence of objects wrong. These are good reasons to look for another way out. In the remainder of this essay, I will show that reconciliation is possible.

5 One world, two perspectives

Our ordinary conception of macroscopic objects apparently clashes with the unified view of these objects' shapes in Minkowski spacetime, because according to common sense, ordinary objects do not undergo radical variation in shape, whereas according to the relativistic metaphysics associated with the unified view they do. I shall offer a response to this problem that rests on a novel ontology of ordinary objects. The ontology and the response look roughly as follows.

Ordinary objects are double-layered compounds of form and matter. The different layers permit different perspectives on the objects, the one perspective focusing on form and the other focusing on matter. An ordinary object belongs to a kind K because its form realizes K, whereas the object's underlying matter is independent of the kind to which the object belongs. Thus, from the formal perspective an ordinary object's behavior in different reference frames is constrained by the specific kind (or kinds) to which the object belongs, whereas from the material perspective the object's behavior in different frames is unconstrained by any kind. Correspondingly, from the formal perspective ordinary objects do not undergo radical variation in shape across different frames, for their shape-variation obeys the limits set by ordinary kinds. From the material perspective, on the other hand, ordinary objects do undergo radical variation in shape across different frames. The formal perspective is the one adopted by common sense. The material perspective is the one adopted by relativistic metaphysics. Owing to the compatibility of these perspectives, the unified view of relativistic shapes of ordinary objects does not clash with the foundations of the folk conception.

The plan of this section is the following. First, I shall formulate the basics of a relativity-sensitive ontology of ordinary objects and of a semantics of relativistic predications about ordinary objects. Then I shall apply these ideas in dissolving the problem of the point-shaped chair. Finally, I shall respond to an objection to my proposal.[17]

5.1 Ordinary objects

An *ordinary object* will be characterized in terms of *material objects*, *K-states*, *frame-bound K-paths* and *proper K-paths*, where K is an ordinary, invariant kind of object.

To begin with, a *material object* will be given a four-dimensionalist characterization. A material object has a certain non-derivative trajectory in Minkowski spacetime, a region that it exactly occupies. This spacetime region is its world volume. For each region of overlap between a material object's world volume and an F-relative time, for some frame of reference F, the object has a part that exactly occupies that region. For a time t^F, the part of an object that occupies the region of overlap between its world volume and t^F is the object's stage at t^F. According to the ontology sketched at the outset, ordinary objects just are material objects in this technical sense. According to the ontology being developed now, ordinary objects are more than material objects.

Each invariant kind K is associated with a K-role. This is the qualitative content of K, comprising the characteristic properties of Ks, the locus of differences between kinds. The chair-role, for example, is a causal-functional role, the tiger-role is a biological role, the person-role is a psychological role, and so on. For each K-role, there are specific properties (and relations) of material objects that play that role—in short, there are properties that *realize* the kind K. (I shall say that an individual property partially realizes a kind, whereas a set or plurality of properties realizes the kind.) These specific role-players, K-realizers, will typically be different ones in different cases. In the case of chairhood, there is a cluster of shapes and decompositions, such that each shape and decomposition in the cluster partially realizes chairhood; different chairs may have different shapes and parts.

[17]For reasons of space, I shall not be able to present the ontologico-semantic picture at a very high resolution. The picture is further motivated and developed, and some of the questions that may arise are answered, in Sattig 2010 and forthcoming.

Some ordinary kinds are presumably completely realized by intrinsic properties of material objects, while others are partially realized by extrinsic as well as intrinsic properties. It is important that being a K does not reduce to playing the K-role: a material object's possessing a range of properties that jointly play the chair-role—that is, a material object's possessing a set of chair-realizing properties—does not make that object a chair. More is required in order to belong to this kind.

A *K-state*, for some invariant kind K, is the intrinsic and K-realizing qualitative profile of a stage. For a stage s at time t^F, for some frame of reference F, a K-state of s is the maximal conjunction of the facts that s has ψ_1, that s has ψ_2, ..., that s has ψ_n, such that each ψ_i is an intrinsic property of s or a property of s that realizes the kind K-hood. For example, a chair-state of a stage s at a given frame-relative time is a conjunctive fact that has all intrinsic properties and all chair-realizing properties of s as constituents. I shall say that a K-state of a stage at time t^F, for some F, is a K-state at t^F, and that a K-state that has a property ψ as a constituent *contains* ψ.

A *frame-bound K-path* is a series of K-states with the following properties:

- All of the K-states in a frame-bound K-path are K-states at times in the same reference frame: if K-states j and $j*$ are conjuncts of a K-path, t_j^F is the time of j, and t_{j*}^{F*} is the time of $j*$, then F = F*.

- A frame-bound K-path is interrelated by qualitative continuity: any two K-states in a K-path that are temporally close contain massively similar intrinsic and K-realizing properties. Local property-variation encoded by a K-path is small.

- A frame-bound K-path is interrelated by K-connectedness: the K-realizing properties in any two K-states in a K-path, no matter how temporally distant they are from each other, are similar to some minimal degree. Global property-variation encoded by a K-path can be extensive but happens within limits set by K. How much similarity is required is a vague matter.

- A frame-bound K-path is interrelated by lawful causal dependence: if K-state j at a given time in F and K-state $j*$ at an earlier time in F are K-states in the same frame-bound K-path, j causally depends on $j*$.[18]

[18]Notice that spatiotemporal continuity is not included among the properties of frame-

- A frame-bound K-path is maximal: no segment of a larger conjunction of K-states interrelated by similarity and causal dependence is a frame-bound K-path. Only the largest conjunction of K-states interrelated in this way counts as a frame-bound K-path.[19]

- The subject of a frame-bound K-path is the fusion of the stages that are the subjects of the K-states in that frame-bound K-path. So each frame-bound K-path has a material object as its unique subject.

A *proper K-path* is a series of frame-bound K-paths with the following properties:

- A proper K-path is interrelated by extensive overall similarity: the four-dimensional distributions of intrinsic and K-realizing properties contained in any two frame-bound K-paths in a proper K-path are massively similar.

- A proper K-path is interrelated by massive spatiotemporal overlap: if K-paths bound to distinct frames fill the same four-dimensional spacetime region or distinct, massively overlapping regions, then they belong to the same proper K-path.[20]

- A proper K-path is maximal: no segment of a larger conjunction of frame-bound K-paths interrelated by similarity and massive spatiotemporal overlap is a proper K-path. Only the largest conjunction of frame-bound K-paths interrelated in this way counts as a proper K-path.[21]

A proper K-path is a series of K-states obtaining at various times and in various reference frames. Just as the K-states in the proper K-path may differ across times, so they may differ across frames. In other words, a proper

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bound K-paths, in addition to similarity and causal dependence. One reason is that the temporal trajectory of an ordinary object may arguably be gappy, as illustrated perhaps by cases of disassembly and reassembly of artifacts such as watches and ships. Since K-path are brought in to capture the familiar qualitative profile of ordinary objects (more below), K-paths should be allowed to be gappy. But here is not the place to discuss these issues.

[19] It may be added that a frame-bound K-path has a unique K-state at a frame-relative time: for a K-state j, let t_j^F be the time of j. If j and $j*$ are conjuncts of a K-path and $t_j = t_{j*}$, then $j = j*$.

[20] The spacetime region filled by a frame-bound K-path is the region exactly occupied by its unique subject.

[21] It may be added that a proper K-path has a unique frame-bound K-path in a frame of reference: if an F-bound K-path i^F and an F*-bound K-path i^{F^*} are conjuncts of a proper K-path and F = F*, then $i^F = i^{F^*}$.

K-path may encode qualitative change, such as a change in shape, across times in a frame and across frames. Conditions of persistence across times and frames standardly associated with an ordinary kind K are here understood as the "unity criteria" of proper K-paths—as the conditions under which a series of K-states counts as a proper K-path. Suppose, then, that a proper K-path encodes a substantive qualitative change across different reference frames, a shift in the distribution of K-realizers across frames (an example will be provided shortly). In such a case, a proper K-path may fill multiple, massively overlapping four-dimensional spacetime regions, each one exactly filled by a frame-bound K-path in the proper K-path. Given that material objects have an invariant four-dimensional world volume, distinct frame-bound K-paths in the same proper K-path, filling distinct four-dimensional regions, may have distinct material subjects. Hence, a proper K-path may lack a unique material subject. I shall say that each material object that is the unique subject of a frame-bound K-path in a proper K-path is a (derivative) subject—possibly one of many—of that proper K-path. The important point here is that while proper K-paths always behave in a K-ish way, material objects need not behave in such a way. Since the persistence conditions of proper K-paths are kind-dependent, and the persistence conditions of material objects are not, the trajectories of proper K-paths and those of their material subjects may diverge. Finally, a further piece of terminology: if a K-state j at time t^F is a constituent of a proper K-path i, then i has j at t^F.

With material objects and K-paths in the picture, *ordinary objects* may be characterized. Ordinary objects are the things to which ordinary, invariant sortal concepts, or kinds, apply.[22] Kind K determines a class of proper K-paths. An ordinary object of kind K is a compound of a material object and a proper K-path, such that the material object is a subject, perhaps one of many, of the proper K-path—that is, the unique subject of some frame-bound K-path included in the proper K-path. How are these compounds related to their components? The simple plan that will be adopted here is to view a compound as a mereological sum, or aggregate, of a material object and a proper K-path which has the latter as a subject. Sums are formed by the standard operation of fusion that takes any given plurality of entities into a sum of those entities. On this account, if o is an ordinary object, then for some material object a and some proper K-path i, $o = a + i$. Thus, a and i, are parts of o. Moreover, ordinary objects are absolutely identical just in case they have the same components; where $o = a + i$ and

[22] I am here assuming that invariant kinds apply to an object *simpliciter*; see §2.

$o^* = b + i^*$, $o = o^*$ iff $a = b$ and $i = i^*$.

This ontology of ordinary objects may be viewed as a variant of hylomorphism. For a given material object that is a subject of a proper chair-path, the sum of the material object and the proper chair-path is a chair. The material object may be characterized as the chair's *matter*, and the proper chair-path may be characterized as the chair's *form*. The proper chair-path is a form of a chair because it contains properties that realize chairhood; and it is an *individual* form of a chair because it is localized, a distribution of facts across a particular four-dimensional region of spacetime. The material object is the chair's underlying matter, because we get to it by stripping away the chair's form.[23]

I anticipate an immediate objection. As pointed out earlier, a proper K-path may have distinct material objects as subjects. Suppose, then, that a proper chair-path i has distinct material objects, a and b, as subjects. Then there are two chairs, $a + i$ and $b + i$. Intuitively, however, there is just one chair. The issue of counting ordinary objects will be addressed in §5.4.

5.2 Perspectivalism

Having sketched an ontology of ordinary objects, let us turn to the semantics of discourse about these objects. I shall put forth the semantic thesis that ordinary predication about objects is perspectival, employing modes of predication that correspond to different perspectives on ordinary objects.

When describing macroscopic objects in ordinary language we may conceive of them from different perspectives in different contexts. These perspectives correspond to different methods of individuating ordinary objects.[24] From the *sortal-sensitive* perspective, we conceive of an object in ways that are sensitive to the kind or kinds to which the object belongs. When we conceive of an object as a chair, we conceive of it as belonging to a specific kind, as having properties that realize that kind, and as having certain persistence conditions associated with that kind. This is the default perspective of unreflective common sense. From the *sortal-abstract* perspective, we strip away an object's sortal covers and conceive of it as a mere

[23] This variant of hylomorphism diverges drastically from the Aristotelian tradition; see, e.g., Koslicki 2008 on Aristotelian and neo-Aristotelian hylomorphism about ordinary objects. For reasons of space, I won't be able to address the proposed ontology's historical context.

[24] Here the intended sense of individuation is psychological. I link the following distinction between perspectives with influential work in the psychology of object individuation in Sattig forthcoming.

physical body, without representing it as belonging to any specific kind, and without ascribing to it any specific persistence conditions.[25]

To a perspective on objects corresponds a mode of predication, a certain way of predicating a property (or relation) of an object. Let us focus on frame-relativized ordinary predications of the form 'o exists at t^F' and 'o has shape ϕ at t^F', where o is an ordinary object.[26] By adopting the sortal-sensitive perspective on o, a speaker employs the *formal* mode of predication in temporal predications of existence and shape about o: o exists formally at t^F and o has ϕ formally at t^F. By adopting the sortal-abstract perspective on o, a speaker employs the *material* mode of predication: o exists materially at t^F and o has ϕ materially at t^F. The thesis that ordinary discourse about objects may employ both the formal and the material mode of predication will be called *perspectivalism.* The availability of a sortally independent method of individuating macroscopic objects in ordinary contexts, in addition to a sortally dependent one, and the corresponding availability of different modes of predication are controversial. Here perspectivalism will be motivated solely by its service in solving the problem of the point-shaped chair.[27]

How do these modes of predication work semantically? Formal and material predication are modes of predicating a property of an object that has a proper K-path and a material subject of that K-path as components, the former being the object's form, the latter the object's matter. While formal predication concerns which properties are contained in the object's form, material predication concerns which properties are instantiated by the object's underlying matter. In short, formal, sortal-sensitive predication concerns form, whereas material, sortal-abstract predication concerns matter. The truth conditions of frame-relative temporal predications of existence and shape in the formal mode and in the material mode may be stated as follows: for any ordinary object o, any inertial frame of reference F, any time t^F, and any shape ϕ,

(O3) o exists formally at t^F iff the proper K-path, for some K, that is a part of o has a K-state at t^F.

[25] These perspectives are obviously not the "relativistic perspectives", the inertial frames of reference, invoked in previous sections. I shall henceforth be careful to distinguish the sortal-sensitive and the sortal-abstract perspective on ordinary objects from reference frames.

[26] In §5.4, the perspectivalist framework will be extended to predications of identity.

[27] I offer more detailed exposition and independent motivation of the thesis in Sattig 2010 and forthcoming.

(O4) o has ϕ formally at t^F iff the proper K-path, for some K, that is a part of o has a K-state at t^F that includes ϕ.

(O5) o exists materially at t^F iff the maximal material object that is a part of o has a stage at t^F.

(O6) o has ϕ materially at t^F iff the maximal material object that is a part of o has a stage at t^F that has ϕ.[28]

These truth conditions are intended as replacements of conditions (O1) and (O2) of §1. While the latter characterize single-layered discourse about ordinary objects, understood as material objects (in my technical sense), (O3)-(O6) characterize double-layered discourse about ordinary objects, understood as compounds of matter and form. Notice that (O5) and (O6) are the perspectivalist analogues of (O1) and (O2).

The core idea of perspectivalism is that we can describe ordinary objects under a sortal cover, *qua* chairs or persons, or we can strip away this cover and describe them *qua* mere physical bodies. The formal, sortal-sensitive description tracks properties that are contained in an ordinary object's component proper K-path, whereas the material, sortal-abstract description tracks properties that are instantiated by stages of an ordinary object's maximal component material object.

This framework has two features of particular importance. First, perspectivalism is not metaphysically extravagant, because the formal and the material mode of predication do not correspond to multiple modes of instantiation a property (or relation). Predications that are syntactically in the formal or the material mode are made true by facts concerning the *absolute* instantiation of properties (or relations). If the statement 'o has ϕ formally at t^F' is true, then it is true because o has a proper K-path as a part that has a K-state at t^F, which contains ϕ. And if the statement 'o has ϕ materially at t^F' is true, then it is true because a material object is the maximal material part of o and has a stage at t^F that instantiates ϕ. We should thus recognize an absolute mode of predication, in addition to the formal and the material mode.[29] This absolute mode is triggered by conceiving of an object from the absolute perspective, the perspective of the foundational ontologist who does not aim to describe objects in ordinary-language terms,

[28] As a whole of a material object, a, and a proper K-path, o does not only have a as a part, but also has the parts of a as parts. It is thus important that the truth conditions of material predications are stated in terms of the biggest material object that is a part of o.

[29] The semantics of absolute predication will be taken as understood.

but rather to analyse them in the fundamental, technical terms of the seminar room. So we may describe objects in ordinary, temporally sensitive terms, as existing at different times and as having properties at different times, conceiving of them from the sortal-sensitive or the sortal-abstract perspective. Or we may describe objects in technical, temporally insensitive terms, and analyse them as compounds of individual form and underlying matter. This is not to say that metaphysical claims about objects are only made from the absolute perspective and only phrased in absolute terms. It is quite common for metaphysicians to make highly general claims about objects in natural-language terms. Not all metaphysics of ordinary objects is foundational.

Second, the recognition of different perspectives on ordinary objects and of accompanying modes of predication allows judgements about these objects to diverge: it may be true to say one thing about a given compound in the formal mode, while it is false to say it in the material mode. This is possible because the trajectories of proper K-paths and those of their material subjects may diverge; the conditions of persistence across times and frames of material subjects of proper K-paths differ from the persistence conditions that are associated with ordinary, invariant kinds and that are mirrored by proper K-paths. Such divergence comes in different flavors. A particular variety arises from discrepancies between matter and form regarding their shapes in different frames of reference. It is of central interest when the framework of perspectivalism is applied to the problem of the point-shaped chair.

Semantic perspectivalism has been set up on the basis of a compound ontology of ordinary objects. Is a double-layered ontology needed for a double-layered semantics? Consider the construal of an ordinary object as being identical with a proper K-path, for some K.[30] This single-layered ontology, according to which ordinary objects are just complex facts, is simpler than the compound ontology. What are the prospects of running perspectivalism on the basis of this alternative ontology of ordinary objects? For reasons of space, I shall rest content with a brief response.[31]

The core perspectivalist idea is that we can conceive of an ordinary object under a sortal cover or we can strip away this cover and conceive of the same object as a mere physical body, with the effect that it may be true to say one thing about the object in the formal mode, while it is false

[30] This type of view has enjoyed support from C. D. Broad and the later Chisholm, though relativity was none of their concerns. See Broad 1925: 34-8 and Chisholm 1986: 66-7.

[31] I discuss the alternative in more detail in Sattig 2010.

to say it in the material mode. If an ordinary object is just a proper K-path, and hence if the subjects of ordinary predications are proper K-paths, then it is easy to make sense of formal predications of shape: an ordinary object o has shape ϕ formally at t^F iff o has a K-state at t^F that contains ϕ. On the other hand, material predication that is independent of formal predication is much harder to make sense of. A proper K-path can have distinct material objects as subjects. If so, it is hard to make sense of the idea of stripping an ordinary object down to its underlying matter. If it has many underlying quantities of matter, which one are we stripping it down to? For example, we want to be able to give determinate and divergent answers to the questions whether a given chair exists formally at a given frame-relative time and whether it exists materially at that time. If chairs are just proper K-paths having multiple material subjects with different trajectories, it is entirely unclear how determinate material descriptions of a chair's trajectory should be possible. On the compound ontology, by contrast, each ordinary object has a unique maximal material component. Therefore, perspectival divergence is clearly available.

5.3 Ordinary objects in the relativistic world

According to common sense, ordinary objects do not undergo radical variation in shape, whereas according to the metaphysics suggested by the unified view of shapes in Minkowski spacetime—for short, according to relativistic metaphysics—they do. Common sense sees limits to how much objects can change, to which relativistic metaphysics is blind. In order to focus the problem, recall principle (K): for any ordinary object o, and for any invariant kind K,

(K) If o is a K, then o is K-shaped at all frame-relative times at which o exists.

According to common sense, (K) is true. According to relativistic metaphysics, (K) is false. Yet common sense and metaphysics do not compete. For their claims manifest different perspectives, and are therefore compatible. In the remainder of this section, I shall spell out this relationship between common sense and relativistic metaphysics in detail.

Common sense parses the world into chairs and poles and barns. Relativistic metaphysics recognizes these objects but abstracts from what makes them chairs and poles and barns. Common sense adopts the sortal-sensitive perspective and thinks of Ks as Ks, whereas relativistic metaphysics adopts the sortal-abstract perspective and thinks of Ks as mere physical bodies. The unified view of how an object's various shapes at different frame-relative times are related is independent of which specific kind or kinds the object belongs to. It is a view about how an object's shapes are *really* related, casting aside our sortal representations of these objects.

To think of an object as a K is to recognize that it has K-realizing properties. This is the sortal-sensitive perspective. If we think of the object as a K, then we expect it to be K-shaped throughout its life, because being a K is an invariant property and being K-shaped partially realizes that property. Thus, the adoption of the sortal-sensitive perspective on ordinary objects naturally leads to the acceptance of principle (K). To think of the object as a mere physical body is to abstract from K-realizing properties. This is the sortal-abstract perspective. If we think of the object as a mere physical body, then we do not ascribe any specific persistence conditions to the object, and hence we have no reason to expect it to be K-shaped throughout its life. The only constraints concerning which shapes an object can assume that are recognized from the sortal-abstract perspective are independent of the specific kind or kinds to which the object belongs; the constraints apply to macroscopic objects as a class. The unified view of relativistic shapes is such a constraint. Thus, the sortal-abstract perspective is a natural backdrop for questioning principle (K).

Given that statements made from the sortal-sensitive perspective employ the formal mode of predication, common sense claims that (K_{form}) is true: for any ordinary object o, and any invariant kind K,

(K_{form}) If o is a K, then o is formally K-shaped at all frame-relative times at which o formally exists.

And given that statements made from the sortal-abstract perspective employ the material mode of predication, relativistic metaphysics claims that (K_{mat}) is false: for any ordinary object o, and any invariant kind K,

(K_{mat}) If o is a K, then o is materially K-shaped at all frame-relative times at which o materially exists.

The distinction between a formal and a material reading of (K), manifesting a perspectival shift, puts an end to the apparent disagreement over (K). I will show that in the semantic framework of perspectivalism, which is based on an ontology of ordinary objects as double-layered compounds, the falsity of (K_{mat}) is compatible with the truth of (K_{form}).

Let i^F be an F-bound chair-path that has material object a as its unique subject, where F is the rest frame of a. So i^F traces a smooth distribution of chair-realizing properties across a's world volume. Further, let i^{F^*} be an F*-bound chair-path—where F* is the frame of reference of an observer who is moving very rapidly relative to a—that has material object b as its unique subject, such that a and b are distinct but overlap extensively, and i^F is massively similar to i^{F^*}, containing the same or very similar chair-realizing properties. While the last stage of a in F, at time t_2^F, is chair-shaped, let the last stage of a in F*, at time $t_2^{F^*}$, be point-shaped (setting aside temporal indeterminacy). The case is illustrated by the following two diagrams:

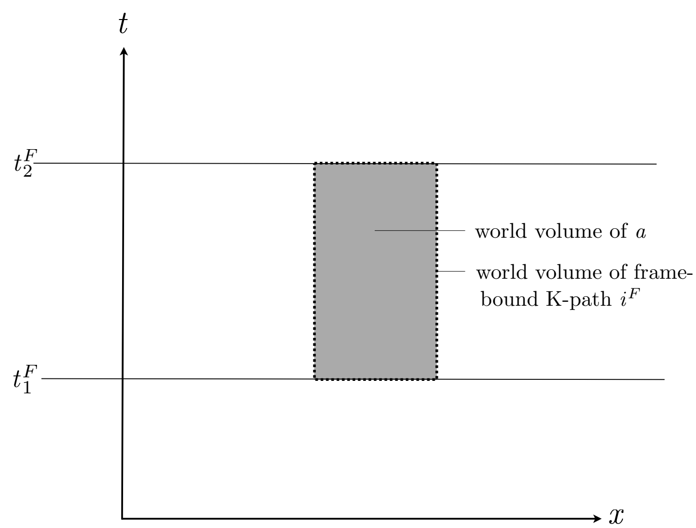

Figure 5

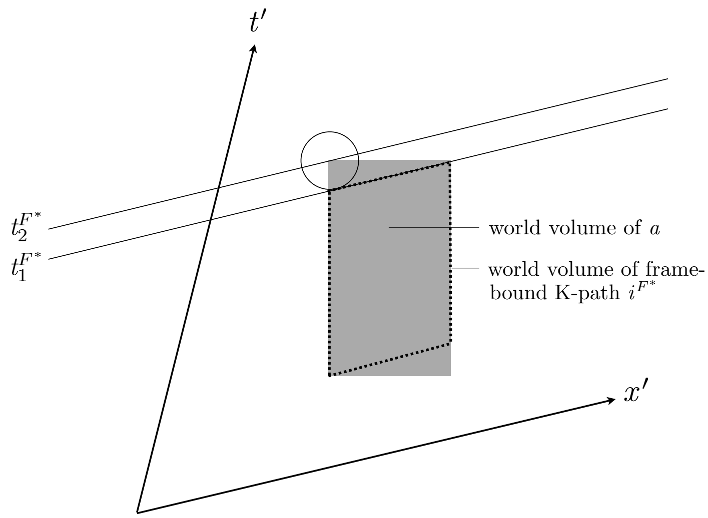

Figure 6

Given that there is a range of massively similar and massively spatiotemporally overlapping frame-bound chair-paths, including i^F and i^{F^*}, there is a proper chair-path, i, that is the maximal union of all these frame-bound chair-paths. Since material object a is a subject of i, there is a chair, o, such that $o = a + i$. (That b is also a subject of i, and hence that there is another chair, composed of b and i, will become relevant in §5.4.)

This case renders (K_{mat}) false, but does not touch (K_{form}). Since o's maximal material component, a, has a stage at $t_2^{F^*}$, it follows by (O5) that o exists materially at $t_2^{F^*}$. Since a's stage at $t_2^{F^*}$ is point-shaped, it follows by (O6) that o is materially point-shaped at $t_2^{F^*}$. Since o is a chair, and since a point-shaped object is not chair-shaped, (K_{mat}) is false, as expected.

This limiting case of material relativistic variation in shape does not clash with the folk conception of macroscopic objects, since the common-sense version of principle (K) is (K_{form}), which says that Ks are formally K-shaped. While chair o exists materially at $t_2^{F^*}$ and is materially point-shaped at $t_2^{F^*}$, o does not exist formally at $t_2^{F^*}$. The last F*-relative moment at which o exists formally is the earlier $t_1^{F^*}$, and o is still formally chair-shaped at that moment. This is so because o's formal behavior in different reference frames is constrained by the kind o belongs to: o's proper chair-path is a series of chair-states which are partly characterized by chair-realizing properties, including chair-shapes; any chair-state that a proper chair-path has at any time includes the property of being chair-shaped. By (O3) and (O4), it follows that for any time t^F, if o is a chair and if o formally exists at t^F, then o is formally chair-shaped at t^F. Hence, (K$_{form}$) is preserved.

The present picture captures the unified view of ordinary objects' shapes in Minkowski spacetime by construing this view as manifesting the sortal-abstract perspective on these objects. In brief, an ordinary object's various material shapes at different frame-relative times are just cross-sections of the invariant four-dimensional shape of its underlying matter, and are not constrained by the kind or kinds to which the object belongs. As a consequence, the object may undergo radical variation in material shape across different reference frames. The present picture also captures the folk view of ordinary object's shapes by construing this view as manifesting the sortal-sensitive perspective on these objects. In brief, an ordinary object's various formal shapes at different frame-relative times are shapes contained in the object's individual form, and are constrained by the kind or kinds to which the object belongs. As a consequence, ordinary objects do not undergo radical variation in formal shape across different reference frames. Correspondingly, an ordinary object has an invariant trajectory from the sortal-abstract perspective. Its unique material world volume is the four-dimensional spacetime region exactly occupied by its matter. Yet the same object may have different trajectories in different reference frames when viewed from the sortal-sensitive perspective. Its potential plurality of largely overlapping formal world volumes are the various four-dimensional spacetime regions filled by the various frame-bound K-paths making up the object's proper K-path—its form. Owing to the compatibility of these views, ordinary objects have their place in the relativistic world.

5.4 Counting ordinary objects in the relativistic world

I shall conclude this essay by addressing an objection to the proposed picture of ordinary objects. The objection is that the proposed ontology gets the expected number of ordinary objects wrong. It arises because proper K-paths are allowed to have distinct material objects as subjects. In the scenario sketched in the previous section, frame-bound chair-paths i^F and i^{F^*}, as illustrated in Figures 5 and 6, have distinct material objects as subjects. Accordingly, proper chair-path i, which includes i^F and i^{F^*}, has distinct material subjects. These two material subjects are a and b. Thus, there are at least two nearly spatiotemporally coinciding chairs, o and o^*, where $o =$

$a + i$ and $o^* = b + i$. Intuitively, however, this scenario contains just one chair.[32]

An extension of perspectivalism to ordinary statements of identity will handle this problem.[33] Such statements, I suggest, do not ascribe identity absolutely; they only do so formally or materially. This is an instance of my thesis that the absolute mode of predication is not represented in ordinary discourse about objects, but only in the technical, non-derivative descriptions of objects employed in foundational ontology. Consider a chair o and a chair o^*. Adopting the sortal-sensitive perspective, we can ask whether o is formally identical with o^*; and adopting the sortal-abstract perspective, we can ask whether o is materially identical with o^*. Both of these questions are distinct from the fundamental question whether o and o^* are absolutely identical. When we ask whether o and o^* are formally identical, we ask whether they have the same individual form. When we ask whether o and o^* are materially identical, we ask whether they have the same underlying matter. And when the foundational ontologist interested in the metaphysical structure of ordinary objects asks whether o and o^* are absolutely identical, she asks whether they have the same individual form and the same underlying matter. Furthermore, given the close relationship between the concept of identity and the concept of number, if statements of identity can be read in these different ways, then so can statements about the number of things.

The truth conditions of predications of identity in the formal mode and the material mode may be stated as follows: For any ordinary objects o and o^*,

(O7) o is formally identical with o^* iff the proper K-path, for some K, that is a part of o is identical with the proper K*-path, for some K*, that is a part of o^*.[34]

(O8) o is materially identical with o^* iff the maximal material object that is a part of o is identical with the maximal material object that is a

[32] If an ordinary object were just identical with a proper K-path, then this problem would not arise. For the scenario under consideration contains only one such K-path, namely i. As pointed out at the end of §5.2, however, this alternative ontology of ordinary objects does not allow for the type of perspectival divergence desired in order to dissolve the problem of relativistic variation, given that proper K-paths may have multiple material subjects.

[33] Cf. Sattig 2010.

[34] If a distribution of facts across spacetime contains properties that realize K-hood as well as properties that realize K*-hood, then the distribution is both a K-path and a K*-path.

part of o^*.

Many have objected to the idea that ordinary statements apparently predicating strict identity in fact predicate another relation.[35] I do not endorse this revisionary idea. Formal predications of identity, as well as material and absolute ones, neither have unexpected subjects nor predicate unexpected relations. They predicate the same familiar relation, strict identity, to the same familiar objects in different modes. Strict identity is ascribed to the same objects from different perspectives. Here it is important not to confuse predications in the formal or the material mode with their truthmakers. While the statement that o is formally identical with o^* is made true by the fact that o and o^* have the same proper K-path as component, the statement does not predicate the relation of having the same proper K-path as component to o an o^*. The statement rather predicates the relation of strict identity to o and o^* in the formal mode. Similarly for identity statements in the material mode.

Now back to the problem of counting ordinary objects in relativistic contexts. In the case sketched above, an observer in frame F singles out a chair, o, where $o = a + i$, and an observer in frame F* singles out a distinct, nearly spatiotemporally coinciding chair, o^*, where $o^* = b + i$, while we would expect there to be just one chair. This apparent tension may be removed by appeal to different modes of counting chairs. Since the common-sense intuition that o and o^* are the same chair is a sortal-sensitive intuition, identity is ascribed in the formal mode, and accordingly the intuitive count of one chair is a formal count. While o and o^* are absolutely and materially distinct, they are formally identical, by (O7), because they have the same component proper K-path, i. As regards the number of chairs in the scenario under consideration, there are many from the sortal-abstract perspective, but there is one from the sortal-sensitive perspective. This is how common-sense expectations concerning the number of ordinary objects are preserved.[36]

[35] See Bishop Butler's view, and more recently Chisholm's, that we typically identify and count ordinary objects by a "loose and popular sense" of 'identity'; see Butler 2000: Dissertation I and Chisholm 1976: Ch.3.

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