Shape Perception in a Relativistic Universe

*Forthcoming in *MIND* (https://doi.org/10.1093/mind/fzw034)

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How should we think of the spatial content of perceptual experience? In particular, how should we think of the content of our experience of shape, when, for example, we see an object as square? On what I will call the 'placeholder' view, an experience of squareness just represents *whatever* property it is that usually causes such experiences; this reference-fixing content will pick out different determinate properties in different circumstances.[1] On the 'presentationalist' view, by contrast, experiences of squareness are more committal: their content always represents the same determinate shape property—*squareness*—rather than merely providing an open-ended description. One natural way to develop this latter view is as follows: the particular property all experiences of squareness represent is the geometrical property of squareness about which we reason in doing *a priori* Euclidean proof.

Such a presentationalist view has deep intuitive appeal. But Einsteinian relativity theory—by calling into question the idea that our physical universe instantiates Euclidean spatial properties—seems to confront the presentationalist with a dilemma: either she must give up the thesis that our shape experiences represent Euclidean spatial properties; or she must accept that all of our shape experiences misrepresent the objects we perceive.

In what follows, I will argue for the presentationalist view, defending it against the charge that contemporary science makes it untenable. Einsteinian relativity theory does not force us to accept that, as the placeholder view holds, our shape perceptions provide only an opaque reference-fixing device, leaving the determinate property thereby represented outside our ken; nor does it imply that shape perceptions *misrepresent* objects as instantiating Euclidean shapes. Rather, what we learn from contemporary physics is that our shape experiences directly present determinate Euclidean properties, while *implicitly* representing those properties as instantiated in a particular *manner*: namely, relative to our own frame of reference. As I will show, such a presentationalist view does not have the implication that our spatial perceptions are illusory: even a relativistic universe like ours can be veridically represented in this way. Properly understood, Einstein's theory poses no threat to the commonsense idea that we have genuine perceptual acquaintance with the spatial character of our world.

1. Introduction

During the Early Modern period, many philosophers, impressed by the discoveries of the scientific revolution, argued that colors were unreal. According to these color eliminativists, all of our perceptions of color are illusory, representing the objects we perceive as having properties that no physical object actually has. The eliminativists were swayed by the following principle, emerging from the then-current scientific zeitgeist:

> *Non-Instantiation*: No properties other than geometrical properties (and, in particular, no secondary qualities like colors) are instantiated by any physical objects in our universe.[2]

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[1] Such a view has been defended by David Chalmers under the label 'shape functionalism' (see Chalmers 2012, Chapter 7; and forthcoming).

[2] Galileo and Descartes would likely have endorsed such a version of the principle, while Locke—though he sometimes suggests something along these lines—was less committal about which specific

Recently, though, many philosophers of perception have been swayed by another, more intuitive, idea:

> *Veridicality*: Our color perceptions are not all illusory; that is, the properties attributed to objects by our color perceptions are (at least sometimes) properties the objects causing those experiences actually have.

Some of the advocates of *Veridicality* have, like the eliminativist faction, been impressed by the evidence in favor of *Non-Instantiation*.[3] And so they have been led to adopt an account of the *contents* of our color perceptions (an account of the way in which those perceptions attribute properties to objects) that can reconcile the two propositions. According to (one version of) this view, a perception of an object as, say, red, is to be counted as veridical if and only if the object in question instantiates the property—*whatever* property it turns out to be—that typically causes such experiences. *Non-Instantiation* is no threat to *Veridicality* on such a view, since the content of a color experience includes a kind of 'placeholder,' rather than a determinate specification of a property that science has (allegedly) revealed not to feature in physical reality. That placeholder is then (through elaborate empirical investigation) to be filled in by a scientifically-respectable property, with which we identify the property of redness: for Locke (who, in some of his moods, was an early advocate of this kind of view), this property turns out to be a particular 'texture'; for modern versions of the account, it turns out to be a particular spectral-reflectance profile.[4]

Early Modern theorists did not, generally speaking, apply this story about the contents of our perceptions of colors—the story involving a placeholder in the specification of the perceptual content—to *primary* qualities like shape. This was because a natural, pre-theoretical account of the contents of shape perceptions—an account that did not include any placeholders—could accommodate both *Non-Instantiation* and a shape-centered version of *Veridicality*. Since squareness, unlike redness, is itself a geometrical property—one of the properties the science of the Early Modern period was willing to grant to physical objects—a perception of squareness could attribute that very determinate property to an object *veridically* (that is, the experience's content could include the determinate, geometrical property *squareness*, without any need to insert a placeholder, and still represent the object accurately).

The science of the Early Modern period, then, challenged the pre-theoretical conception of the colors of objects, but not the conception of their shapes; and, as a result, philosophers proposed revisionary accounts of color—but not shape—*experience*. Later revolutions in science, however, might seem to have moved us beyond this traditional divide. In particular, on some interpretations, the Einsteinian revolution of the twentieth century called into question the scientific respectability of the primary qualities, in much the same way that the science of the Early Modern period called into question the scientific respectability of the secondary qualities. Consider Minkowski's famous claim that, given Einstein's special theory of relativity (henceforth, 'STR'), 'space by itself, and time by itself are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality'.

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properties physical objects instantiate (he sometimes suggests that they may be properties that are simply unknown to us).

[3] For contemporary theorists, *Non-Instantiation* will take a modified form, since the list of properties regarded as 'scientifically-respectable' has changed (it is no longer limited to geometrical properties). But contemporary scientific theories do—at least on many interpretations—still entail that objects never instantiate irreducible *color* properties. See (Mackie 1976, p. 18).

[4] For an interpretation of Locke as holding this kind of view, see (Campbell 2002); for defenses of the modern version, see (Chalmers 2006) and (Thompson 2010).

On this picture, a *spatial* property like squareness is no more scientifically legitimate than a color property was for the Early Moderns; both are 'doomed to fade away into mere shadows'.

This line of thought has generated much debate about how our conception of the spatial features of the universe might need to be revised in light of scientific theory.[5] Until recently, though, there has been little discussion of whether the Einsteinian revolution should also lead us to revise our conception of spatial *experience*.[6] As described above, the Early Modern challenge to our conception of the colors, combined with a commitment to *Veridicality*, led many to adopt a placeholder account of color experience. The Einsteinian challenge to our conception of spatial features, then, would seem to augur a parallel revision in accounts of *shape* experience. And, indeed, some philosophers of perception have recently suggested that, in order to preserve *Veridicality* for our shape experiences, we must include a placeholder, rather than a determinate spatial property, in specifying their contents.[7] On this account of shape perception, the property attributed to an object by an experience of that object as square is just *whatever* property in fact typically causes such experiences; and, given what we have learned from Einstein, the property in question will not turn out to be a purely spatial property—a kind of property that nothing in our universe actually has—but rather some arcane property of the spatiotemporal manifold (Minkowski's 'union' of space and time, whose independent existence is all that remains on the Einsteinian picture).

In the case of traditional primary qualities like shape, however, any such placeholder account of the contents of our perceptual experiences faces a problem. The problem arises when we try to combine *Veridicality* and *Non-Instantiation*—two theses the 'placeholder' account of *color* perception was designed to accommodate—with a third feature of our conception of shape, which has no analogue in the case of color. This third feature comes into view when we note that shape properties, unlike color properties, feature in our conceptual scheme in a variety of ways, some of which are not tied to our perceptual experiences at all. In particular, we reason about shape properties in the *a priori* domain of Euclidean geometry, and the property of squareness referenced, for example, in Hippocrates's proof of the quadrature of the lune *is* a 'purely spatial' property (rather than a property of Minkowski's space-time manifold). Furthermore, it seems that it is *this very property*—the property about which Hippocrates proved some crucial propositions, which we might call 'Euclidean squareness'—that shows up in the contents of our shape experiences. It is Euclidean squareness that we attribute to the objects we perceive when we perceive them to

[5] See, e.g., (Reichenbach 1958), (Horwich 1978), (Friedman 1983). (DiSalle 2006) provides a useful historical overview of the scientific and philosophical literature.

[6] (Strawson 1966) and (Hopkins 1973) are important exceptions, though both of their discussions are focused on a narrower Kantian conception of experience, and on difficulties raised for such a conception by Einstein's *general* theory of relativity (GTR). By contrast, my focus here will be on issues raised by *S*TR, since, despite philosophers' tendency to focus on GTR in discussing Einstein's discoveries, it seems to me that a more fundamental question about the instantiation of spatial properties in our universe arises already in STR (on this point, I am in agreement with Tim Maudlin (see his (2012), pp. 127-128)).

[7] (Thompson 2010, p. 170) and (Chalmers 2012, p. 334) explicitly acknowledge being motivated by considerations stemming from Einsteinian physics in proposing a placeholder account of spatial experience, though many who advocate this type of view are more centrally motivated by general externalist leanings. The arguments I present here are, in part, supposed to provide a way to resist some of the moves made by proponents of a broadly externalist account of perceptual content.

be square. The problem, then, is that we can combine these observations with *Veridicality* and *Non-Instantiation*[8] to generate a set of three incompatible theses:

> *Commonality*: The property we reason about in doing *a priori* geometrical proof, Euclidean squareness, is the same property that we attribute to objects in shape perception.
>
> *Veridicality*: Our perceptions of squareness are not all illusory; that is, the property we attribute to objects in perceptions of squareness is a property the objects causing those perceptions (at least sometimes) actually have.
>
> *Non-Instantiation*: Euclidean squareness is not instantiated by any physical object in our universe.

We are now faced with a puzzle, since each of these three mutually inconsistent propositions is independently plausible.[9]

Some might choose to resolve the puzzle by rejecting *Veridicality*. This would be to see the Einsteinian revolution as an extension of the eliminativist project of the scientific revolution: the science of the Early Modern period revealed the unreality of the secondary qualities, and Einstein's theory completed the project by revealing the unreality of the primary qualities.[10]

The kind of universal error such a view ascribes to our perceptual experiences is not terribly appealing, however, and it does not cohere very well with our actual practice (those familiar with Einstein's theories do not generally take themselves to be permanently suffering from spatial illusions). So another option, one that many advocates of a placeholder account of shape perception endorse (at least implicitly), is to reject *Commonality*. The lesson of the Einsteinian revolution, on this picture, is that we do not—from the perspective of perceptual experience itself—have a direct grasp on the particular contents of our spatial experiences, any more than we do in the case of color. In both cases, we have only a kind of placeholder, a promissory note that *whatever* determinate property our perceptions attribute to the world around us, that very property is the property that has typically caused those perceptions. We might have hoped that we had a better grip on the contents of *shape* perceptions—in particular, we might have thought that the properties attributed by such experiences were the very properties we reason about in doing *a priori* geometrical proof—but Einstein revealed that that could not be the case if we want to avoid ascribing universal error to our shape experiences. In light of Einstein's discoveries, this view insists, we need to *bifurcate* our spatial concepts: the property of squareness we attribute to objects in perception is *not* the property of Euclidean squareness about which we reason in doing geometrical proof (instead, it is a property of Minkowski's space-time manifold).

In recent work, David Chalmers has defended such a placeholder account of shape experience. He argues, in part on the basis of considerations from STR, that the property

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[8] Each suitably modified to apply to our *shape* perceptions and the scientific picture that emerged from the Einsteinian revolution. In what follows, I focus on the particular case of squareness for ease of exposition, but analogous points can be made for any shape property.

[9] Note that an analogous puzzle cannot be generated in the case of color because there is nothing analogous to Euclidean squareness—no pre-theoretical, non-experiential conception of redness to which we are committed—that can be used in formulating a version of *Commonality* for redness. This leaves us free to identify the property of redness that we attribute to objects in perception—the property mentioned in the formulation of *Veridicality*—with a property that is *not* ruled out by *Non-Instantiation* (this property might turn out to be a texture, or a spectral-reflectance profile).

[10] This would seem to be Minkowski's view, judging by the above quotation.

attributed by our perceptual experiences of squareness is not one on which we have a determinate, *a priori* grip. Instead, squareness is to be picked out in terms of the role it plays in generating our experiences: *whatever* property in fact typically causes our experiences of squareness will be the property represented by those experiences. And, given what we know from STR, that property will not be Euclidean squareness.[11]

Though it allows us to escape the puzzle, the move to a placeholder view in the case of shape experience has heavy costs. The idea that we have an *a priori* grasp of space and spatial structure, and that it is our *a priori* spatial concepts that we apply in experience, is deeply intuitive. More importantly, it is only *because* the spatial concepts we apply in experience are the familiar concepts of Euclidean geometry that we have any real grip on the spatial features of our world. To perceive an object as square just is to perceive it as having a quadrilateral surface with four equal sides joined at four right angles—to perceive it as instantiating Euclidean squareness. If the spatial properties represented in our experience turned out *not* to be these familiar Euclidean properties, we'd have no real understanding of the contents of our own spatial perceptions. And, as Kant famously observed, our representation of the spatial features we perceive seems to play a unique role in our capacity to form a conception of the mind-independent objects of the empirical world; thus, severing the connection between our *a priori* spatial concepts and the features represented by experience threatens to leave us without any determinate conception of the world we perceive.[12]

I want to suggest that we can avoid these costs, by resolving the puzzle in a different way: we can reject *Non-Instantiation*, and thereby dissolve the pressure that Einstein's theory supposedly puts on *Commonality*. In what follows, I will address Chalmers's argument in support of a placeholder account of the contents of our shape perceptions, suggesting that his picture rests on a faulty analogy between the relativity of spatial properties revealed by STR and the variability of experiential content revealed by classic philosophical thought experiments involving colors. I will then show how the challenge that *Non-Instantiation* poses to *Veridicality* and *Commonality* hinges on a key ambiguity in spatial terms like 'Euclidean squareness'. Einstein's theory does show that a certain kind of *absolute* spatial property—what we might call '*absolute* Euclidean squareness'—is not instantiated in our universe. Spatial properties that are absolute in this sense are properties objects instantiate independent of reference frame—independent, that is, of any temporal facts. But there is another way

[11] In Chalmers's words, his view is one on which 'we do not have any "direct" grip on the basic nature of spatial properties' represented in experience (Chalmers 2010, p. 492). Chalmers does think, however, that we have a determinate concept of a *different* property, which he calls 'Edenic squareness', and which seems equivalent to the property I have labeled 'Euclidean squareness'. But contemporary physics, according to Chalmers, has shown that Edenic squareness is not instantiated in our universe (Chalmers 2006, p. 443; 2012, p. 333; and forthcoming, p. 22); and yet we still take our squarish experiences to be veridical. This suggests that the property represented by our squarish experiences is not Edenic squareness (Chalmers 2012, p. 326 and forthcoming, p. 22). Thus, Chalmers favors precisely the kind of 'bifurcation' of our spatial concepts described in the preceding paragraph: in light of contemporary scientific discoveries, Chalmers thinks we should reject *Commonality* in order to hold on to *Veridicality*.

[12] Chalmers himself actually embraces something like this consequence: he holds that the contents of our experience (and our associated 'everyday' beliefs about the objects we perceive) do not in themselves differentiate between a world in which we perceive material bodies and a world in which our experiences are generated by a computer hooked up to our envatted brains. (Chalmers does allow that we have 'metaphysical' beliefs 'about the underlying nature of reality' that differentiate between material and computer-generated worlds (Chalmers 2010, p. 459); but these beliefs do not show up at the level of the *perceptual* contents available to the subject on Chalmers's view.) Though Chalmers stresses the alleged epistemological benefits of this picture (Chalmers 2010 and forthcoming), the radical opacity of perceptual contents it embodies seems like a cost we would do well to avoid.

to think about spatial properties that does *not* require them to be absolute: we can delineate a set of genuinely spatial properties by assigning shapes to objects *relative to* a specified frame of reference. The objects we perceive do have spatial properties in this second sense, and those spatial properties are *Euclidean* spatial properties.[13] So our perceptions of shape can attribute the very properties about which we reason in geometry to the objects around us, without misrepresenting those objects. Properly understood, Einstein's theory is compatible with both *Veridicality* and *Commonality*, and with the intuitive idea that we do indeed have a direct grasp of the contents of our spatial perceptions.

2. Chalmers's Argument Against Shape Presentationalism

Consider a visual experience of the type you have when you view a square surface head-on. Following Chalmers, we can call this type of experience, specified in terms of its intrinsic phenomenal character (that is, in terms of what it's like to have the experience), a 'squarish' experience.[14] We might wonder what the *content* of a squarish experience is; that is, we might ask what property such experiences attribute to the objects perceived, and what form the attribution takes.[15] Chalmers describes two possible views, corresponding to the 'placeholder' and 'presentationalist' options I described above:

> *Shape functionalism* (Chalmers's term for the 'placeholder' view) holds that the property represented by a particular kind of shape experience is 'whatever normally causes the relevant shape experiences'; on this view, 'shapes such as squareness are picked out in virtue of their role in causing our experiences of shape'.
>
> *Shape presentationalism* holds that 'all squarish experiences represent the same property: squareness'. (Chalmers forthcoming, p. 21)

An important implication of shape functionalism is that *different* determinate properties can be represented by squarish experiences in different contexts, if different properties in fact typically cause those experiences in the respective contexts.[16] This contrasts with shape

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[13] At least as far as STR is concerned. It's true that the spatial properties objects have according to *G*TR will not be perfectly Euclidean; I briefly address this worry below (see fn. 50).

[14] Chalmers uses terms of the form '*X*-ish' to pick out experiences with a particular type of intrinsic phenomenal character, namely, the character of those experiences we typically have when we perceive *X*s. I will follow his usage throughout the paper. There may be a worry about whether it is even possible to individuate experiences in terms of their intrinsic phenomenal character (independent of the objects that cause those experiences); some versions of 'naïve realism' or 'disjunctivism' (see Campbell (1993), Martin (2004)) and some versions of 'strong representationalism' (see Dretske (1995), Tye (2000), Lycan (2001)) have the implication that it is not. I will not be directly addressing this kind of worry, or the views on which the talk of '*X*-ish experiences' is illegitimate, here.

[15] Some question whether experiences *have* contents—whether they attribute properties to the world—*at all* (see, for example, Travis (2004), Brewer (2006), Papineau (2013)). Siegel (2010) presents a sustained argument in favor of what has been called the 'Content View' of perceptual experience—the view that perceptual experiences do indeed have representational contents. I will not enter into that debate here, but will simply assume for the sake of my argument that Siegel is right, and that it makes sense to ask what content a perceptual experience has.

[16] Or, at least, such a possibility is not *ruled out* by shape functionalism; there may be some facts external to the basic theory of shape perception itself that make such a case impossible.

presentationalism, on which there is a single determinate property attributed to objects by all squarish experiences.[17]

One way to decide between these views, then, is to ask whether we can generate an example of two subjects whose squarish experiences represent different determinate properties. The inverted spectrum has often been used in this way to argue for a placeholder account of *color* perception: subjects who are spectrum inverted relative to each other represent two different color properties[18] when having the same type of color experience (or so the argument goes).

In the contemporary literature, such arguments are often framed in terms of 'Twin Earth' cases. Putnam's original Twin Earth example can be seen as providing an argument in favor of a placeholder account of the contents of *water* perceptions.[19] Since Oscar's and Twin Oscar's 'waterish' experiences are both veridical, despite the fact that they are caused by different determinate chemical-composition properties (H_2O and XYZ, respectively), there can't be any *single* determinate property that all waterish experiences attribute to the liquids perceived. Instead, we should think of a given subject's waterish experiences as representing *whatever* determinate chemical-composition property has in fact typically caused such experiences in that subject's environment.[20]

Chalmers's strategy in arguing for a placeholder account of shape perception is to construct a series of cases involving shape experience that he takes to be relevantly analogous to Putnam's Twin Earth.[21] Before getting to the specifics of Chalmers's argument, it will be helpful first to consider the general structure of Twin Earth arguments.

In order to formulate a Twin Earth argument in support of a placeholder account of some feature *X*, we need a pair of subjects (the 'twins')—one on Earth, one on an alien planet—who are both having *X*-ish experiences. We then need to identify two distinct properties—the *Earthly property (EP)*, and the *alien property (AP)*—such that: (a) due to

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[17] Shape presentationalism goes very naturally with a commitment to *Commonality*: if all squarish experiences represent a single, determinate property, it is reasonable to think that that property will be Euclidean squareness, since that is the property with which we seem to be acquainted in having squarish experiences. But shape presentationalism is compatible with a denial of *Commonality*: one could hold that all squarish experiences represent the same determinate property, but deny that the property represented is Euclidean squareness. The appeal of such a combination of views is not immediately obvious, but I will address a possible motivation for this type of position at length in §4.

[18] Where these color properties are to be identified with particular textures or spectral-reflectance profiles.

[19] In his original paper (Putnam 1973), Putnam himself is focused on the contents of *language*, rather than those of mental states, and he argues only for *semantic* externalism on the basis of his Twin Earth example. Others, such as Tyler Burge (Burge 1979), later extend this type of argument to include the contents of *propositional attitudes*, like belief. The kind of 'placeholder' analysis of *perceptual* contents discussed here, and the argument for that analysis on the basis of Twin Earth-style cases, is developed by writers such as Ned Block (Block 1990) and Chalmers (Chalmers 2006), though it is at least suggested by Putnam's own later work (Putnam 1981). Block's Inverted Earth case is a version of the inverted spectrum argument that makes use of the contemporary Twin Earth paradigm; Block's argument can be seen as a defense of a 'placeholder' account of color perception.

[20] We might question whether perceptual experiences really attribute 'high-level' natural kind properties—like the determinate chemical composition H_2O—to the objects of perception *at all* (see (Siegel 2010)). It won't matter much for my purposes whether they do, since the shape properties I am concerned with are paradigms of *observational* properties, and so they will feature in the contents of perceptual experience on any view that allows that perceptual experiences do indeed have contents.

[21] (Thompson 2010) also constructs such a case—which he, following (Hurley 1998), calls 'El Greco World'—in defending a placeholder account of shape perception. (Burge 1986), (Davies 1993), and (McGinn 1989) also discuss related cases, though to somewhat different ends. I'll focus on Chalmers's argument here, since his version gets most directly at the issues raised by STR.

differences in the twins' local environments, the typical cause of the Earthly twin's *X*-ish experiences has been *EP*, while the typical cause of the non-Earthly twin's *X*-ish experiences has been *AP*; and (b) we intuitively judge that each twin's *X*-ish experiences are veridical when, and only when, the perceived object instantiates the property that has typically caused *X*-ish experiences in that twin's own environment.

What I want to flag is that, in a Twin Earth scenario, features of each twin's *historical environment* play a crucial role in fixing the target referent for that twin's *X*-ish experiences. Our judgment that Twin Oscar perceives veridically when he has a waterish experience of XYZ is driven by the fact that XYZ is the drinking liquid he knows and loves; it is the liquid with which he has a past history. By contrast, if *Oscar* travels to Twin Earth, has a waterish experience of XYZ, and reports that he has found water, he is mistaken—his experience has misled him. Lacking any *previous* causal interaction with XYZ, Oscar does not have perceptual states that represent it; his waterish experiences represent H_2O.[22] A Twin Earth argument works by revealing that what counts as a veridical *X*-ish experience depends on what *has*, in a given subject's *past*, caused *X*-ish experiences in that subject.

We can now turn to Chalmers's Twin Earth argument against shape presentationalism, which he employs in the course of defending a 'thoroughgoing spatial functionalism' (Chalmers forthcoming, p. 22). Chalmers begins by imagining that there is a planet just like Earth—where that means the planet contains a 'doppelganger' of each Earthly object and person—traveling past us in a uniform direction at 87% the speed of light. Call this planet 'Lorentz Earth'. One of the surprising results of STR is that objects moving past a given observer at close to light speeds will undergo 'Lorentz contraction' relative to the observer's frame of reference; a meter stick will be less than a meter in length, a circle will be 'squished' into an elongated ellipse. So objects on Lorentz Earth, when considered from Earth's reference frame, will be contracted in the direction of Lorentz Earth's motion relative to us, by a factor of two. For example, a 2'-by-2' square object on our planet, if it were placed on Lorentz Earth, would become a 2'-by-1' rectangle relative to our frame.

Now suppose that an Earthling named Albert is in Fenway Park in Boston, looking directly down at third base[23] (call this object 'Third Base$_E$'). Albert will be having a squarish experience of the 15"-by-15" object[24] he is looking at. His twin on Lorentz Earth, Twin Albert, will also be looking down at *his* third base (call this object 'Third Base$_L$'), in Lorentzian Fenway Park. Though the object Twin Albert is looking at is a 15" by 7.5" rectangle relative to Earth's reference frame, it is square relative to *Lorentz* Earth's reference frame, so Twin Albert will have a squarish experience of it.

Chalmers suggests that this Lorentz Earth scenario is relevantly similar to Putnam's Twin Earth, and he uses it in formulating an argument against shape presentationalism. We can reconstruct his argument as follows:[25]

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[22] At least, Oscar will not *initially* have states that represent XYZ. It is plausible that if Oscar lives on Twin Earth for an extended period, he will, after suitable 'adaptation' to his new planet, have waterish experiences that represent XYZ. This phenomenon is sometimes referred to as 'slow-switching'. What is crucial here is that, in Twin Earth arguments, historical context sets the veridicality conditions for a subject's 'pre-adaptation' experiences.

[23] Perhaps he is Albert Pujols, having just uncharacteristically hit a triple in a game against the Red Sox, and he is pausing to enjoy the rare opportunity to observe third base from his unfamiliar vantage point.

[24] See Rule 1.06 of Major League Baseball's *Official Baseball Rules* <http://mlb.mlb.com/mlb/downloads/y2014/official_baseball_rules.pdf>.

[25] See (Chalmers forthcoming, pp. 19-20). A closely related argument appears in (Chalmers 2012, pp. 327-328). Note that Chalmers's full argument in favor of shape functionalism involves extending the conclusion from the Lorentz Earth case to two further cases ('Absolute Lorentz Earth' and 'El Greco

1) Albert has a squarish experience of Third $Base_E$ and Twin Albert has a squarish experience of Third $Base_L$.
2) Albert's experience veridically represents the shape of Third $Base_E$ iff Twin Albert's experience veridically represents the shape of Third $Base_L$.[26]
3) Albert's experience veridically represents the shape of Third $Base_E$: that is, the shape property represented by Albert's perceptual experience is the shape property Third $Base_E$ actually has.[27]
4) So Twin Albert's experience veridically represents the shape of Third $Base_L$: that is, the shape property represented by Twin Albert's perceptual experience is the shape property Third $Base_L$ actually has (2,3).
5) The shape property instantiated by Third $Base_E$ is **squareness**; the shape property instantiated by Third $Base_L$ is **2:1-rectangularity**.
6) The shape property represented by Albert's experience is **squareness** (3,5).
7) The shape property represented by Twin Albert's experience is **2:1-rectangularity** (4,5).
8) **Squareness** and **2:1-rectangularity** are not the same property.
9) So not all squarish experiences represent the same property (1,6,7,8).
10) If shape presentationalism is true, then all squarish experiences represent the same property.
11) Thus shape presentationalism is false (9,10).[28]

Note that Chalmers's argument depends on several key uses of shape terms in steps (5) through (8) (the relevant instances are highlighted in bold). These instances of shape terms are supposed to *express* the idea of, as Chalmers puts it, 'ordinary squareness' (and other

World'). Since I will be arguing that Chalmers's initial conclusion based on the Lorentz Earth case should be rejected, I won't explicitly address his consequent arguments about the other cases, which depend on that conclusion.

[26] This premise is based on symmetry considerations inherent in STR: since there is no privileged reference frame, it would be arbitrary to attribute illusory perceptions to just *one* of the two observers. Thus, we should count Twin Albert's experience as veridical if (and only if) we are prepared to count Albert's as veridical.

[27] This premise is an expression of *Veridicality*: since this is a typical shape experience of a competent perceiver of shape, we should assume that it is veridical.

[28] Here, I have stated the conclusion of Chalmers's argument as the denial of shape presentationalism, a thesis about the contents of shape experience. But Chalmers's explicit statement of the argument's conclusion is that the *word* 'square' is 'Twin-Earthable'; he explicitly states a parallel claim about the contents of squarish *experiences* only after his discussion of the 'Absolute Lorentz Earth' case (Chalmers forthcoming, pp. 21-22). Still, the *premises* of Chalmers's argument concern the veridicality of the twins' shape experiences (not the truth of their utterances), and so the argument only makes sense if Chalmers is assuming that perceptual and linguistic contents are to be given a unified analysis. Thus, the conclusion of Chalmers's argument can reasonably be taken as a claim about the contents of squarish experiences (as I have here) and not just as a claim about the 'Twin-Earthability' of the word 'square'. Indeed, given that Chalmers's premises are framed in terms of the veridicality of experiences, to the extent that there is a significant gap between the conclusion about the word 'square' and that about squarish experiences, only the *latter* would be supported by the argument. In what follows, I will be assessing the argument's force as an argument about the contents of shape experience (addressing corresponding issues about the reference of shape terms only in passing). Note that the version of the argument given in (Chalmers 2012) is spelled out entirely in terms of the reference of spatial expressions; it is, however, introduced to address a question about the possibility of shape *illusions* (Chalmers 2012, pp. 328). Again, this move—from a question about the veridicality of shape experiences to an argument about the contents of spatial expressions—only makes sense if Chalmers is assuming that the two kinds of content are to be given a unified analysis.

'ordinary' shape properties) in Earth English (as opposed to *mentioning* terms of Earth or Lorentz English). Ordinary squareness is thus supposed to be the *referent* of our term 'square' and, relatedly, the property represented by squarish experiences of Earthly subjects (see step (6)). The key question I now want to press is: What property is ordinary squareness; what, on Chalmers's view, is the property represented by our squarish experiences here on Earth?

One way to resist the argument would be to take ordinary squareness to be a property Chalmers labels 'rest-squareness': the property an object has if and only if it is square relative to its own reference frame.[29] This would undermine steps (5) through (9) of the argument, since rest-squareness is a property that *both* twins' bases have: Third Base_L is, like Third Base_E, square relative to its own reference frame. So, if we were to take rest-squareness to be ordinary squareness (that is, take it to be the referent of our ordinary term 'square'), the crucial claim—in premise (5) of Chalmers's argument—that Third Base_L is *not* square (but rather a 2:1 rectangle) would be false.

Chalmers considers the proposal that ordinary squareness is rest-squareness, but he rejects it on the grounds that it is inconsistent with the use of spatial vocabulary in STR. In particular, Chalmers points out that we describe objects as 'contracting' when they accelerate in STR, even though their *rest*-shapes remains constant; he takes such statements to be inconsistent with the proposal that the referent of our ordinary term 'square' (and, correspondingly, the property represented by our squarish experiences) is rest-squareness.[30]

This leaves us with the question of what, on Chalmers's shape functionalist picture, ordinary squareness—the property represented by our squarish experiences on Earth—turns out to be. Chalmers is not very explicit in answering this question,[31] but we can see what he might have in mind if we recall that his argument is supposed to be a shape analogue of Putnam's original Twin Earth argument. So, as noted above, for the argument to work, we need to find a pair of *distinct* properties, *EP* and *AP*, such that: (a) Albert's squarish experiences have typically been caused by instances of *EP* (and not *AP*), while Twin Albert's have typically been caused by instances of *AP* (and not *EP*); and (b) we intuitively judge that these historical differences fix the contents of the twins' respective squarish experiences, so that Albert's experiences represent *EP*, while Twin Albert's represent *AP*. "Ordinary squareness" is Chalmers's term for the property represented by Albert's squarish experiences. The question of what ordinary squareness amounts to, then, is just the question of what plays the role of *EP* in Chalmers's argument. And, given STR, a natural thought is that *EP*—the property that has typically caused squarish experiences on Earth, but not on Lorentz Earth—is the property of *squareness relative to Earth*, while *AP* is the distinct property of *squareness relative to Lorentz Earth*.

Given the argumentative context, however, these expressions—'squareness relative to Earth' and 'squareness relative to Lorentz Earth'—do not provide a particularly helpful way of picking out the properties in question, since they both *use* spatial terms, and the question at issue concerns how the reference of our spatial representations is fixed. Is 'square', as it appears in the expression 'square relative to Earth', to be given a *presentationalist* analysis, or a *placeholder* analysis? Answering *this* question would seem to require antecedently settling the question at issue. The argumentative context also presents a further difficulty. I am assessing

[29] Standard scientific jargon suggests this property should be labeled 'proper squareness', on analogy with 'proper length' (where 'proper' does not mean 'correct' but rather 'relative to *one's own* frame').

[30] See (Chalmers 2012, p. 329; forthcoming p. 20). Chalmers's reliance here on the use of spatial vocabulary in STR is a somewhat curious move, given that his *own* account of the reference of ordinary spatial terms also seems to deviate from standard STR usage (see fn. 39 below).

[31] He says only that ordinary shape terms pick out 'relativistic properties in a relativistic universe' like ours (Chalmers 2012, pp. 325-326); but this leaves open *which* relativistic property 'square' picks out.

shape functionalism as a way to resolve the puzzle described in §1 by accepting *Non-Instantiation* and rejecting *Commonality*. But the use of terms like 'square relative to Earth' might suggest that we are, contrary to *Non-Instantiation*, attributing 'purely spatial' properties to objects; so using such terms might seem inconsistent with the shape functionalist's position.

To avoid these difficulties, we can frame Chalmers's argument in accord with Minkowski's claim about 'space by itself' fading into shadow. On Minkowski's picture, the only underlying physical properties that objects in our universe have are spatio*temporal* in nature; thus, the properties generating our squarish experience will not be *spatial* properties, like squareness (relative to Earth), at all. The underlying *spatiotemporal* property that Third Base_E has (call it 'ST_E') will be the real referent of our term 'square' and the property represented by our squarish experiences (since it is the property causing those experiences). ST_E is, then, the property playing the role of *EP* in Chalmers's argument.[32]

The shape-functionalist picture that now emerges is the following: In Albert's historical, Earthly environment, squarish experiences have been caused by a particular, determinate *spatiotemporal* property, ST_E. In Twin Albert's historical Lorentzian environment, squarish experiences have been caused by a *different* spatiotemporal property (call it 'ST_L'; this is the property that plays the *AP* role in the argument). The particular, determinate spatiotemporal property with which each twin has interacted, in turn, is fixed as the property represented by that twin's squarish experiences: for Earthlings like Albert, squarish experiences represent ST_E; for Lorentzians like Twin Albert, squarish experiences represent ST_L.[33]

The problem with this proposal is that, although ST_E and ST_L are indeed properties we can identify as distinct causes of squarish experiences in the two twins' respective historical environments—they satisfy condition (a) in setting up the Twin Earth scenario—it is *not* plausible that those different historical interactions *fix the contents* of the twins' squarish experiences in the manner proposed—ST_E and ST_L don't satisfy condition (b). We do not intuitively judge that an Earthling like Albert has veridical squarish experiences when, and only when, he perceives an object that instantiates ST_E.

In order to bring this out, we can consider the shape perceptions of observers who happen to be moving relative to Earth but who have (unlike Twin Albert) *grown up* on Earth. Suppose that Albert has a normal (non-Putnamian) twin, raised alongside him on Earth, who—instead of pursuing a promising baseball career—elected to enroll in an experimental

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[32] What property, exactly, *is* ST_E? It is the underlying property of the Minkowski space-time manifold that 'grounds' squareness-relative-to-Earth, in something like the way that H_2O 'grounds' water. This property won't be one that has a neat specification in terms of the Minkowski space-time geometry itself: it will have to be a property instantiated by objects that are square relative to Earth, but not by objects that are square relative to Lorentz Earth, even though there is no *intrinsic* difference between those objects in terms of their Minkowskian features (the two objects' space-time 'worms' or 'world-volumes' will occupy congruent regions of Minkowski space-time). Instead, ST_E will have to be a kind of *relational* property of the spatiotemporal manifold: an object will instantiate it in virtue of (a) the space-time region occupied by the object's world-volume and (b) the angle between the object's world-volume and the world-volume of Earth ('angle' here corresponds to two objects' velocities relative to each other; for an object at rest on Earth, like Third Base_E, the two world-volumes will be parallel, so the angle will be (by convention) equal to zero). See (Sattig 2015, p. 222) on the relation between objects' Minkowskian world-volumes and their shapes. The important point is that the analysis in terms of world-volumes can be spelled out purely in terms of the *spatiotemporal* features of the situation; this gives us a way to think about ST_E that does not itself rely on concepts of spatial properties, whose analysis is under dispute.

[33] Though it is a natural way to develop the shape functionalist position, this proposal is not explicitly endorsed by Chalmers (who, as noted above, is simply silent on the question of which specific properties the twins' experiences represent (see fn. 32)).

space-flight program; call him 'Astronaut Albert'. Astronaut Albert is on his first space mission, zooming past Earth in his spaceship at near-light speed (we can imagine that he is moving, relative to Earth, in the same direction and at the same speed as Lorentz Earth). As he zooms along, he is staring down at a base (call it Third Base_A) that he has brought on his spaceship as a reminder of his baseball-playing brother.

Astronaut Albert will be having a squarish experience of Third Base_A; the crucial issue is what the shape-functionalist account we are now considering implies about the contents and the veridicality of this experience. Since Astronaut Albert's squarish experiences have, until now, occurred on Earth, their content will, on the shape-functionalist view, be fixed by the property that has typically caused those experiences in his Earthly environment: namely, ST_E. But, since Astronaut Albert is moving relative to Earth, the base he is looking at will instantiate a *different* spatiotemporal property. In fact, given that Astronaut Albert is currently in the same state of motion as Lorentz Earth, his base will instantiate the same spatiotemporal property as *Twin* Albert's base: ST_L. So Astronaut Albert's squarish experience will represent Third Base_A as instantiating ST_E, when it does not—that is, Astronaut Albert will be suffering an illusion.

This verdict is simply not a plausible one, given the way STR is typically understood. In standard STR examples, we have two *Earthling* observers—one on Earth, one flying past Earth at near-light speeds—in precisely the situation of Albert and Astronaut Albert. In such scenarios, each subject will judge that the objects around him have their 'normal' shapes, while the objects in the other observer's frame are 'compressed'. Albert will have a squarish experience of Third Base_E, but he will not have a squarish experience of Third Base_A; and *vice versa* for Astronaut Albert.[34] A key idea in STR is that neither observer in these cases is 'more right' in his perceptions than the other. But if we accept the shape-functionalist claim that the squarish experiences of Earthling subjects represent the particular determinate property ST_E, we would have to conclude that Albert is getting things right, while Astronaut Albert is misled: his squarish experience of the base on his ship and his experiences of objects on Earth as contracted are *illusory*, rather than accurate perceptions of the metaphysical facts.

Those metaphysical facts are strange, to be sure: according to STR, the objects of Earth *actually are contracted* relative to Astronaut Albert's reference frame. But, in order to capture the truly revolutionary nature of the theory, we need to acknowledge that it indeed concerns the spatial properties of *objects themselves*. If we suppose that Astronaut Albert is simply misperceiving the true shapes of objects, we make it seem as though STR merely describes a certain kind of *perceptual error* that befalls subjects who accelerate out of their native reference frames. But similar perceptual effects already occur in non-relativistic contexts: an astronaut accelerating to merely very fast—but non-relativistic—speeds would misperceive the shapes of objects on Earth, because those objects would look blurry and stretched. STR is not a theory about such perceptual effects; it is a theory about how the spatial properties of objects themselves are different, relative to different reference frames.

[34] Strictly speaking, Astronaut Albert won't have *experiences* of objects on Earth as contracted, since those objects will be moving past him at far too great a speed for his visual system to discern their shapes at all. As Tim Maudlin emphasizes, talk of subjects' 'observations' of objects in different reference frames in STR is *not* meant to line up with 'literally what the observer would *see* if she opens her eyes' (Maudlin 2012, p. 103). But the key point here is that Astronaut Albert's 'observations' of the shapes of objects on Earth (effected via sophisticated measuring devices) will represent those objects as compressed; and, on the view we're now considering, both those observations and Astronaut Albert's (literal) visual experiences of objects on his own ship would be ruled inaccurate.

One final case brings out just how counterintuitive the consequences can get if we take Earthlings' historical interactions with ST_E to fix the contents of their squarish experiences. Suppose Astronaut Albert has flown off in his spaceship and then switched off his engines, in order to enjoy a weightless meditation session in space, no longer in view of Earth. Astronaut Albert might be moving at near-light speeds relative to Earth, or he might not; he has lost track of how many times he has fired his engines, and he has not been tracking the Earth's movements. He now looks at Third $Base_A$ and has a squarish experience. If ST_E is fixed as the property represented by Earthlings' squarish experiences, whether Astronaut Albert's experience is veridical will depend not only on the intrinsic properties of the object, nor on how he is related to it, but on his state of motion relative to a planet halfway across the galaxy.[35]

Clearly, something has gone wrong here. At base, the shape-functionalist picture runs off the rails when it loses sight of the *symmetry* that lies at the heart of STR. We do not take one of the two twins in typical STR examples to be suffering from illusions; we emphasize that each has an *equally accurate* take on the spatial properties of the objects in the scenario.[36]

Chalmers himself emphasizes this symmetry in describing the Lorentz Earth scenario (as noted above in fn. 27), and he even uses spatial terms (presumably in 'ordinary English') in the standard way when he writes: 'From an objective point of view, the situation is completely symmetrical…. Twin Albert is compressed relative to Albert's reference frame, while Albert is compressed relative to Twin Albert's reference frame' (Chalmers forthcoming, p. 19). This is all correct, but it is inconsistent with the way in which (as I've just argued) Chalmers's *own view* requires our 'ordinary' spatial terms to be tied to the specific properties that have played the relevant role in our *Earthly* environment. 'Compressed' is an 'ordinary' spatial term that, on Chalmers's picture, refers to the determinate property of the spatiotemporal manifold that has generated experiences of compression on Earth. So Albert's objects are not compressed, while Twin Albert's are, by Chalmers's own lights. And, when we consider two *Earthling* observers moving very rapidly relative to each other, the symmetry recedes even further: now, we must convict one of the subjects, but not the other, of widespread *perceptual* and *judgmental* error.

So it seems the Lorentz Earth scenario cannot be used as a Twin Earth argument in support of Chalmers's shape-functionalism: our judgments about the veridicality of Earthling space-travelers' perceptions—the judgments that correspond to the most natural

[35] Another difficulty for this view comes out at the level of *language*: STR examples often invoke a pair of spaceships moving relative to one another, where *neither* is specified as being at rest relative to Earth. In these cases, if we were to take our historical interactions with objects on Earth to fix the reference of our spatial *terms* along with the contents of our spatial *experiences* (as Chalmers suggests we should), we would always need to know how the objects described were moving *relative to Earth* in order to know how we should apply those terms, and whether one (or both) of the observers (assuming them to be Earthlings) should count as making false claims about objects' shapes. Similarly, in considering a standard example where a meter stick is accelerated to near-light speeds, we would need to know whether it is accelerating *out of* Earth's frame, or instead *into* Earth's frame (that is, whether it is at rest relative to Earth at the *beginning* or at the *end* of its acceleration) in order to know whether we should say that the stick undergoes Lorentz *contraction* (which is what we would say in the former case) or rather Lorentz *expansion* (the verdict we would reach in the latter case). This is out of step with the way that spatial concepts, and spatial terms, are actually employed in STR, and with Chalmers's own claim that his account of the meaning of 'ordinary' spatial terms is supported by the language of 'Lorentz *contraction*'.

[36] Note that the kind of symmetry in question here is not the complete qualitative matching of two subjects' mental lives typical of Twin Earth cases. It is the more mundane symmetry of inertial reference frames (and of the perspectives of observers within those frames, whether or not the observers are qualitative duplicates) that is invoked when discussing STR in physics.

interpretation of STR—reveal that we do not take the historical environment of a given subject to fix the contents of her squarish experiences. One of the conditions for a successful Twin Earth argument—condition (b)—is not met.[37]

At this stage, one might object that Chalmers does not require such a tight analogy between Lorentz Earth and Twin Earth for his argument to work. The failure of the analogy stems from the way in which, unlike in the case of natural kinds like water (where we take a subject's *historical* circumstances to fix the contents of her waterish experiences), we take the contents of a subject's shape experiences (given STR) to depend on features of her *current* environment (specifically, on her current state of motion). So perhaps, in the case of shape experience, we can weaken the conditions needed for a standard Twin Earth argument by jettisoning the reference-fixing role of the historical environment. Instead, we might analyze the Lorentz Earth case in light of a modified version of shape functionalism, one on which a given squarish experience represents the property that plays the relevant role in generating squarish experiences in a subject's *current* environment.[38] For an Earthbound subject like Albert, this property will be ST_E, and so his squarish experience will be veridical; for Astronaut Albert, on his spaceship, this property will be ST_L (the very property his base instantiates), so his experience will be veridical as well. We can thus recover our intuitive judgments about the symmetry of the situation and the veridicality of *both* twins' experiences.

The reference-fixing role of the historical environment is not, however, an optional extra in developing the kind of placeholder account of perceptual content Chalmers defends. Without it, the placeholder view will fail to set any substantive constraints on the relevant perceptual contents; virtually all experiences will count as veridical. Take the present proposal about shape experience: a given squarish experience represents whatever property plays the role of causing squarish experiences in a subject's *current* environment. Now suppose we have a subject—Fun Albert—who enters a funhouse. He sees a rectangular object that, due to the funhouse's distorting mirrors, causes a squarish experience in him. Given that Fun Albert is *currently* in the funhouse environment, rectangularity is the property that plays the relevant role in generating squarish experiences in his current environment. So his experience will count as a veridical perception of the object's rectangularity. But surely experiences in funhouses are paradigms of illusions: the experience in question is not veridical. Even more troublingly, consider how the present proposal would have us assess the squarish experiences of a recently-envatted brain. Another subject—Vat Albert—is walking along on Earth, when he is suddenly snatched away and his brain is suspended in an evil scientist's vat; he is fed inputs that match those that he used to get from square objects on Earth. Since Vat Albert is *currently* in the vat environment, where a certain kind of electrical signal plays the relevant role in generating squarish experiences, his experience will count as veridically representing that electrical-signal property.[39]

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[37] I've argued that Lorentz Earth does not provide Chalmers with a suitable analogue of Twin Earth, and so cannot be used in defending shape-functionalism, but I have yet to say where Chalmers's argument itself (as spelled out on p. 9) goes wrong. That will have to wait until I have developed my own account of shape perception in STR; see below, p. 24.

[38] This would make spatial content a sort of *indexical* content: the properties picked out by a token state's spatial contents would depend on the circumstances in which *that token* is instantiated. Thanks to an anonymous referee for this suggestion.

[39] As an anonymous referee points out, this version of the placeholder view will also have trouble accommodating the intuitive truth of statements Astronaut Albert, while on his ship, makes about the shapes of objects he observed *in the past*, when he was back on Earth (e.g., 'That *was* square', in reference to an earlier encounter with Third $Base_E$): if Astronaut Albert's term 'square' refers to ST_L when he is on his ship, such statements will have to be regarded as false.

What these examples illustrate is that a placeholder view that does not take perceptual contents to be historically fixed is, in an important sense, *empty*. It places no real constraints on what counts as veridicality for a particular experience; and so it does not allow us to recover our intuitive judgments about everyday (or fantastical) instances of illusion. In trying to assess the question raised by STR—the question of how our shape experiences represent the objects we perceive—such a view is not a serious contender.[40]

So, to sum up: Twin Earth arguments, as employed in defense of placeholder accounts of perceptual experience, require us to see the contents of the relevant experiences as *historically anchored*. Such arguments work by revealing that the content of each twin's experience is *fixed* by the features present in that twin's own past environment. But such historical anchoring seems to be absent in STR. In standard Einsteinian relativity cases, reference to shape properties shifts immediately: whatever a subject's history may be—even if she is an Earthling enjoying her very first space voyage in a non-Earth reference frame—the veridicality of her shape perceptions depends only on the shapes objects have relative to her *current* state of motion.[41] Having acknowledged the lack of historical anchoring of shape contents in STR, a proponent of a *placeholder* view cannot hope to salvage the account by jettisoning the historical-anchoring requirement. On a *presentationalist* view, there would be no need to appeal to historical context: according to the presentationalist, squarish experiences *in themselves* represent a single, determinate shape property, so a squarish experience comes with determinate content 'built in'. But on a placeholder view, a squarish experience has no built-in determinate content. Historical anchoring is the only way for the placeholder view to set substantive veridicality conditions; abandoning the historical-anchoring requirement amounts to stripping the view of any real content.

3. Shape Presentationalism in a Relativistic Universe

What then, should we say about the contents of shape perception in a relativistic universe? Recall the puzzle from the introduction: Euclidean squareness is the property we reason about in doing geometry, but (according to *Non-Instantiation*) that property is not instantiated by any physical object in our universe. So if Euclidean squareness were the property represented by our squarish experiences (that is, if *Commonality* were true), all those experiences would be illusory. Chalmers's shape functionalism was supposed to be a way of assigning contents to our shape perceptions without implying this kind of universal error. Such a view would allow us to maintain *Veridicality* for our shape perceptions, but only by divorcing their contents from the Euclidean shape concepts we employ in *a priori* geometrical reasoning: the determinate property represented by our squarish experiences would turn out to be the spatiotemporal property ST_E, rather than Euclidean squareness. Having rejected Chalmers's argument, we are now free to avoid this bifurcation of our empirical shape concepts and our *a priori* ones; that is, we are now free to accept *Commonality*.[42] But does holding on to *Com-*

[40] Note that the placeholder view Chalmers himself endorses is not empty in this way. Chalmers emphasizes that *temporary* illusions are possible on his picture, because the content of a particular experience is fixed by facts about the *historical environment* of the subject. For example, in explaining why a *recently*-envatted brain suffers illusions, even though, on his view, an *always*-envatted brain does not, Chalmers writes, 'my conception of external reality is anchored to the reality in which I have lived most of my life' (Chalmers 2010, p. 474).

[41] That is, STR cases do not exhibit the 'slow-switching' characteristic of genuine Twin Earth cases (see fn. 23).

[42] Of course there might be *other* reasons to reject *Commonality*, given STR. (Peacocke 1989), for example, presents a kind of *transcendental* argument for an externalist account of spatial perception, on

monality mean that we will have to give up *Veridicality* and accept an error theory for shape perception?

I want to suggest that it does not. We can have our *Commonality* and our *Veridicality*, too. In order to see how, we need to examine more closely the threat of *Non-Instantiation* that STR supposedly raises for any such view. The idea was that STR dislodges the separation between space and time, between spatial properties and temporal ones. In Newtonian space-time, the spatial dimensions are in a strong sense separable from the temporal dimension. An object's being square has nothing to do with its (or anything else's) state of motion (where motion is a matter of how the object's spatial position changes over *time*); an object can be said to be square *absolutely*. But in the kind of space-time we have in STR, Minkowski space-time, there is no clean separation of space and time. We cannot specify a set of spatial properties that apply to an object irrespective of which inertial frame—which state of motion, which way of progressing spatially through *time*—is regarded as 'at rest'.[43] This forces us to see the spatial properties of the object as tied inextricably to its temporal properties. And that was supposed to rule out the possibility that Euclidean squareness—a purely spatial property—could actually be instantiated by physical objects in our universe.

But we are not, in the end, forced to abandon spatial notions altogether within STR; we do not need to accept *Non-Instantiation*. We simply need to distinguish two ideas of 'objective' space (space that has 'an independent reality', in Minkowski's terms), only one of which is ruled out by STR. STR *does* entail that no objects in our universe instantiate a property that a certain pre-theoretically intuitive picture would ascribe to them. Chalmers calls this property 'perfect' or 'Edenic' squareness; we might call it 'absolute Euclidean squareness'. And it is the *absoluteness* of the property that really rules it out as a property that objects in our relativistic universe could have. If an object is square relative to its own reference frame, it will not be square relative to a frame moving with respect to it; so we can't say that an object is *absolutely* square, in the sense that it is square relative to every reference frame (or square irrespective of reference frame), given STR.[44]

We *can*, however, *specify* a reference frame, and *then* make a claim about an object's shape: we can say, for example, that, relative to Earth's reference frame, Third Base_{E} is square. This claim, though it is explicitly acknowledged to be non-absolute (in that it mentions a particular reference frame that is relevant to its interpretation), is genuinely a claim about a spatial property of the object, in a perfectly *objective* way. That is: the claim is not 'true' in a weak, relative sense, where that means the statement could correctly be

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which the geometry of the environment fixes the spatial content of experience. If we were to combine such a view with *Non-Instantiation*, we would be forced to deny *Commonality* (though Peacocke himself actually seems to endorse a version of *Commonality* similar to that advanced below, which suggests that he instead denies *Non-Instantiation* (Peacocke 2015, p. 382)).

[43] This is just to make the familiar point that there is no unique 'foliation' of the Minkowski space-time manifold into a series of spatial simultaneity slices (or 'three-planes').

[44] The sense in which I am here using the term 'absolute' corresponds to one half of the contrast that Michael Friedman labels 'absolute-relative' (as opposed to 'absolute-relational' or 'absolute-dynamic'). Friedman defines absoluteness, in this sense, in the following way: 'an absolute element of the spatio-temporal structure is one that is well-defined independently of reference frame or coordinate system' (Friedman 1983, p. 62). My point is that, given STR, squareness is not a property that is absolute in this sense. (It is a further question whether squareness is absolute in Friedman's other two senses; it seems to me that it is, in both of these other senses, but I will not go into those issues here.) My use of 'absolute' also corresponds to the kind of absoluteness denied to space and time by Paul Horwich's 'Relativist Thesis G': 'Space and time are relative [i.e., not absolute] in the sense that certain magnitudes such as duration and distance vary from one frame of reference to another' (Horwich 1978, p. 400).

evaluated as true by one assessor, false by another.[45] Even within STR, it is *objectively* true that Third Base_E is square, relative to Earth's reference frame.

Indeed, it is *only* through the use of these specifications of reference frames that we can make sense of the canonical claims of STR. When we say that STR reveals that a moving rod contracts, we are employing spatial notions, and those notions can only be employed within a framework that has room for the idea of space (as opposed to the indissoluble space-time fusion that is the 'absolute' manifold of STR). Our attributions of squareness to objects within STR make use of our spatial concepts in an intelligible way, despite Minkowski's claim that 'space by itself' would fade into the shadows under Einstein's theory. And, crucially, the *spatial* manifold we pick out by defining a set of coordinates on Minkowski space-time (by specifying what inertial reference frame is to be considered at rest) is a *Euclidean* space.[46] The concepts of length and shape we use in talking about the theory—for example, the shape concepts we use when we say that a moving sphere will be compressed into a flattened ellipsoid—are our familiar Euclidean spatial concepts. It is this fact that allows us to make sense of the theory in the first place; we describe the results of STR in terms of the Euclidean spatial properties objects have relative to various frames of reference because such properties are the only genuinely *spatial* ones on which we have an intuitive grasp.

I think we now have the tools to defend a version of shape presentationalism that is consistent with both *Commonality* and *Veridicality*. Squareness, as it shows up in the contents of our squarish experiences, is the very Euclidean shape property we employ in doing geometrical proofs. As such, it is *not* picked out in virtue of the role it plays in generating our experiences; it is picked out by the determinate, *a priori* geometrical definition 'having a quadrilateral surface with four equal sides joined at four right angles'. We have a more direct grasp on this property than Chalmers's placeholder analysis—on which squareness is '*whatever* property in fact plays the relevant role in causing our squarish experiences'—would suggest. This means that we do not have to wait on the findings of empirical science to reveal what determinate property a squarish experience represents; we know, as *Commonality* insists, that it is the very property of Euclidean squareness—a property on which we have an *a priori* grasp—that features in the contents of our perceptions of squareness. The one addition we must make to our account (if we are to hang on to *Veridicality*) is that the

[45] See MacFarlane (2014) for a development of this kind of relative notion of truth. The point I am making about the objectivity of non-absolute claims about the shapes of objects in STR is that such claims are *not* 'assessment sensitive' in MacFarlane's sense.

[46] This is an expression of the fact that Minkowski space-time is *pseudo*-Euclidean. One might worry that once we move to the General Theory of Relativity (GTR), according to which the space-time of our universe is pseudo-*Riemannian*, we will no longer have even frame-relative Euclidean spaces, and so our spatial concepts (if they are indeed Euclidean) will not veridically apply to the objects we perceive. While I do not want to go into too much detail on the implications of GTR, as opposed to STR, for accounts of our spatial cognition, I will say briefly: Even within GTR, we can (and *must*, at the theoretical limit) define *local* areas of space-time that are roughly Minkowskian, and we can determine spatial coordinate systems within those areas. All of our actual experience of the world takes place within such roughly Euclidean spaces, so we can regard our attributions of Euclidean spatial properties to the objects around us as veridical because, relative to a set of coordinates defined within a local pocket of our pseudo-Riemannian universe, and allowing for a degree of indeterminacy (to accommodate the fact that space on these scales is only *roughly* Euclidean) that will have to be acknowledged in any case in order to allow for veridical perception in *any* domain (see (Stazicker 2011 and forthcoming)), objects instantiate such Euclidean spatial properties. See (Hopkins 1973) for an insightful discussion of how our experiential attributions of shape properties (our 'visual geometry') can be seen as consistent with the *slight* divergence from Euclidean geometry that, according to GTR, we encounter in our actual spatial environment.

intuitive, *a priori* property of Euclidean squareness must be supplemented by an extra 'parameter'—a specification of a reference frame—if it is to be a property instantiated by objects in our universe.[47] Once that parameter is filled in—by specifying the current reference frame of the observer having the perceptual experience in which the property of squareness features—the property attributed by the experience will be one the object perceived can genuinely have. This extra parameter, though it is not itself a part of the *presentational* content of squarish experiences (since it does not show up *explicitly* in those experiences themselves), allows our experiences to veridically present Euclidean squareness.

This move away from what might be seen as the *fully* intuitive, pre-theoretical analysis of the contents of our shape perceptions—an analysis in terms of *absolute* Euclidean squareness—does not give us reason to reject shape presentationalism, or to deny that it is Euclidean squareness we attribute to objects, in favor of a placeholder view, on which the property *we* attribute to objects when we have squarish experiences is a different property from that attributed by Lorentzians when *they* have squarish experiences. Albert attributes Euclidean squareness to Third Base_{E} (relative to his reference frame); Twin Albert attributes *the very same property*, Euclidean squareness, to Third Base_{L} (relative to *his* reference frame). There is an implicit parameter that varies between the two observers, but the *property* attributed by each—the property that features in the contents of both of the twins' squarish experiences—is the very property that features in our *a priori* geometrical reasoning.

It might be objected that, on the account just sketched, it is *not* the same property that is represented by Albert's and Twin Albert's experiences, since 'Euclidean squareness (relative to Albert)' is a *different relational property* from 'Euclidean squareness (relative to Twin Albert)'. So (the objection goes) the account is not really defending presentationalism (the view that all squarish experiences represent the *same* property) at all.

Suppose, for the moment, that we were to grant that there are indeed two distinct properties here. We can still insist that there is a single *relation* represented by both observers' squarish experiences—the relation of *being square relative to the observer.*[48] And, crucially, 'squareness', as it appears in the formulation of that relation, does not allow for the possibil-

[47] How we should understand the role of this reference frame 'parameter' will be the subject of §4.

[48] On the view that the twins' experiences represent the same *relation*, are we compelled to accept that those experiences represent different *properties*? We might take Albert's experience to represent *squareness-relative-to-Albert*, and Twin Albert's to represent *squareness-relative-to-Twin-Albert*. Since Albert and Twin Albert are different objects, this would indeed suggest that there are two different relational properties in play. This, in turn, would suggest that there is a narrow sense in which we might think of squarish experiences as 'Twin-Earthable': the squarish experiences of the twins, while representing a single common relation, would be associated with two different relational properties (note, though, that this narrow sense of Twin-Earthability does not in any sense support—and may not even be compatible with—a placeholder view of shape experience (see fn. 53 below)). But we can also understand the idea of *squareness-relative-to-the-observer* by thinking of the observer as the 'center' of a centered world. The idea then would be that the contents of shape perceptions are to be evaluated relative to *centered* possible worlds. On this proposal, Albert's and Twin Albert's squarish experiences will both represent the same centered-world property. This proposal seems well-motivated, given that the commonality of perceptual contents across subjects (or within a subject at different times) already requires analyzing those contents in terms of centered worlds. For example, Chalmers notes that on a presentationalist (or, in his earlier terminology, a 'Russellian') account of *location* contents, 'the location property [represented in an experience] must be a relative location property: the property of being a certain distance in front of the perceiver at a certain angle, for example' (Chalmers 2006, p. 386). In order for this 'relative location property' content to be shared across subjects, as Chalmers intends it to be, 'the perceiver' will have to be understood as the center of a centered world. Andy Egan develops an account of perceptual content using centered worlds (Egan 2010), though he has a much broader understanding of what can qualify as a 'centering' feature (for issues raised by STR, a subject's path through space-time will suffice).

ity that different particular properties might, in different circumstances, be picked out by *that* term. It maintains its standard, Euclidean meaning, and the relation represented by all squarish experiences centrally involves the property of Euclidean squareness.[49]

In order to see that it is not particularly problematic to take the content of squarish experiences to include a determinate *relation*, or 'parameterized property', we can compare the case of experiences of left and right. Chalmers (forthcoming) considers a view on which a single particular relation, 'being to the left of', can be represented by each of two different 'leftish' experiences had by two different subjects, even if those subjects are facing each other (and so two different directions in (absolute?) space are being picked out). According to Chalmers, such a view—on which the same relation, but not the same absolute property, is represented by all experiences of a certain type—would count as a presentationalist view. That is essentially the kind of view I am proposing in the case of shape experience. For we could frame the presentationalist view about the contents of leftish experiences in terms of an implicit parameter of the kind I am proposing for our shape experiences: all leftish experiences can be seen as representing the same property, leftness; but that property then needs to be supplemented by filling in an implicit parameter that specifies the orientation of the observer's body in order to pick out a particular spatial direction.

It might now be objected that, while it is plausible to claim that all leftish experiences represent a single particular *relation* or parameterized property (even though they don't represent a single *direction* in space), it isn't plausible to make a similar claim about squarish experiences representing a single relation or parameterized property. According to this objection, leftish experiences seem, *on their face*, to be representing some sort of relation (leftness is *transparently* a relation); but squarish experiences, on their face, seem to be representing a non-relational (i.e., *intrinsic*) property. We discovered the relational aspect of shape properties only through incredibly sophisticated scientific theorizing; so it is not plausible to suggest that all along we somehow represented the relational nature of shape properties in our perceptual experiences of shapes (shapes that seemed to us to be perfectly intrinsic[50]). A presentationalist view that says experiences of a certain type represent a particular relation is only plausible if that relation shows up *as a relation* in experience; this condition is met for leftish experiences, but not for squarish ones.

I agree that the relational nature of squareness (or, the need for an implicit parameter) is not apparent from within experience itself, the way it (plausibly) is for leftness. But I deny that we can only attribute relational contents to experiences if the relationality shows up *transparently* in those experiences. We can be aware of certain aspects of the contents of our experiences (and concepts), without realizing that more is needed in order for those contents (and concepts) to pick out particular phenomena in the world. When we discover that there is a need for an extra parameter (or, that there is a relational aspect to the phenomenon represented), we do not thereby discover that those concepts fail to have the determinate

[49] In §4, I argue that the view I'm defending does *not* require us to concede that squarish experiences represent a relation, rather than a property. But for now, the point I'm stressing is that, even if we did make such a concession, the resulting account would be a version of shape *presentationalism*, not a placeholder view. Indeed, a *placeholder* version of this proposal—an account that parses 'square' as it appears in the relation 'square relative to the perceiver' as 'whatever normally causes squarish experiences'—is the view that squarish experiences represent whatever normally causes them in a given perceiver, without tying that content to the perceiver's *historical* context ('normally' would instead mean 'normal in the perceiver's *current* environment'). So a placeholder version of this view collapses into the *empty* view discussed at the end of §2.

[50] David Lewis emphasizes this point about the seemingly non-relational nature of shape properties (Lewis 1986); I discuss his claims at length in §4.

content we took them to have—we do not, that is, discover that the contents in question are non-presentational.

An example of another property with a 'hidden parameter' will be helpful here. Consider Mona, who has lived her whole life in a single city, and has never realized that there are different time zones across the surface of the Earth. Mona has acquired a concept of noon (the time of day when, characteristically, the sun is directly overhead), not realizing that that description could pick out different 'absolute' times, depending on one's location on Earth.[51] When Mona discovers that the sun is not directly overhead at the same time in all locations, she will realize that an additional parameter (or a relativizing term) needs to be included with the proposition 'It's noon' in order to make a determinate temporal claim: 'It's noon (in New York)' is true if and only if it's the time of day when the sun is directly overhead in New York, while 'It's noon' (with no further parameter filled in) fails to make a determinate claim—one assessable for truth—at all. But, crucially, in learning that her concept of noon needs to be supplemented by an additional parameter, Mona does *not* learn that her concept previously failed to pick out a particular property—that it failed to have the determinate content she took it to have. Similarly, we do not need to propose a placeholder analysis of Mona's previous 'noonish' *experiences*—we do not need to suppose they merely represented *whatever* property in fact caused such experiences in her environment—in order to understand how she could have been representing a property that has a 'location parameter'. All along, Mona's noonish experiences represented the determinate property of its being the time of day at which the sun is directly overhead. What Mona realizes when she discovers that there are different time zones is that her noonish experiences, in *presenting* her with that determinate content, also included a *non-presentational* element: unbeknownst to her, those experiences included an *implicit* parameter, which was filled in by her own location.

Similarly, when we discover that, in our universe, squareness is a property objects can have only relative to a particular reference frame, we do not thereby learn that we had no determinate grip on the property of squareness, or that we failed to pick out any particular phenomenon in the world with our attributions of squareness to objects. We simply learn that there is a further parameter to be filled in, which is needed in order for the very property on which we already had a grip—the property of having a quadrilateral surface in a Euclidean plane with equal sides joined at equal angles—to be applicable to the objects we perceive. That is how, even in a relativistic universe, we can hold on to *Commonality* and *Veridicality*: our squarish experiences, with the reference-frame parameter implicitly filled in, can attribute the same geometrical property of squareness that we reason about in Euclidean proof to the objects we perceive, while at the same time attributing to them a property they genuinely have.

4. Is Shape Intrinsic?

I now want to consider one final objection, which focuses on my claim that the account just sketched—on which all squarish experiences represent Euclidean squareness, relative to the observer—vindicates *Commonality*. According to this objection, we can grant that the view I've proposed counts as a presentationalist one, in that a single *relation* is represented by all squarish experiences. But, the objection goes, this isn't enough to save *Commonality*. What *Commonality* demands is that the property represented by squarish experiences be the same

[51] The scare quotes on 'absolute' are a way of registering that I am here ignoring the fact that, given STR, *times* are themselves non-absolute (in the sense discussed in fn. 48). The case of Mona will work perfectly well for my purposes if we imagine her living in a Newtonian universe.

property as that about which we reason in doing *a priori* Euclidean proof. And this latter property is surely *not* relational: there is no 'hidden parameter' involved in the property of squareness that appears in Hippocrates's proof. Squareness, as it features in *a priori* geometrical reasoning, is *intrinsic*; the property of squareness that I've argued is represented by our squarish experiences is *relational*. So the two simply can't be the *same* property; thus, on my own view, *Commonality* turns out to be false.[52]

In order to respond to this objection, it will be helpful first to consider another puzzle about the nature of shape properties: the problem of 'temporary intrinsics'.[53] The problem can be spelled out in terms of David Lewis's classic example. At noon, Lewis is standing up straight; but earlier, he was bent over tying his shoes. Being bent and being straight are two incompatible shape properties; nothing—including Lewis—could be both bent and straight. So we need a way to understand how both of these shape properties can be instantiated by the same object without running into contradiction.

We might propose to do this by noting that Lewis is not *simply* straight and bent; he is, rather, straight-at-t_1 and bent-at-t_2 (where t_1 and t_2 are different times). While being straight and being bent are incompatible, being straight-at-t_1 and bent-at-t_2 are not. They are compatible *relational* properties.

According to Lewis, this solution to the problem of temporary intrinsics cannot work because it implies that,

> contrary to what we might think, shapes are not genuine intrinsic properties. They are disguised relations, which an enduring thing may bear to times. One and the same enduring thing may bear the bent-shape relation to some times, and the straight-shape relation to others…. This is simply incredible…. If we know what shape is, we know that it is a property, not a relation. (Lewis 1986, p. 204)

Lewis's claim here is that shape properties are *essentially* intrinsic, while the properties attributed to an object according to the proposal under consideration—straightness-at-t1, bentness-at-t2—are *relational*. So, if we accept this proposal, it turns out that the properties we attribute to objects are not *shape* properties at all.

We may suppose that Lewis would agree that shape properties, as he conceives of them, are the ones we reason about in Euclidean geometry (which are not relational); his claim, then, is that those properties, in their very nature, are intrinsic, and thus no relation could be Euclidean squareness. This means that no view that analyzes the contents of squarish experiences in STR in terms of relational properties could be one on which *Commonality* turns out to be true. And so, even if the view I've sketched preserves some form of *presentationalism*, it cannot save *Commonality*.

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[52] This objection can allow that there is *some* connection between the monadic *is-square* predicate that features in Euclidean geometry and the dyadic *is-square-in* predicate that relates objects to reference frames in STR; but it denies that the two predicates pick out the *same property*, since one is monadic, and the other dyadic. On a view that allows for predicates of *variable arity* (or 'multigrade predicates'), the fact that Euclidean squareness, as it features in our *a priori* reasoning, is expressed by a monadic predicate, would not rule out that that very same property could be instantiated in a relativistic universe *relationally*. That is, we could take a single *is-square* predicate, *Q*, to express the very same property of Euclidean squareness in *a priori* geometry (where it appears in monadic form: *Q(o)*) *and* in attributions of squareness to physical objects, relative to a reference frame, in our universe (where it appears in *dyadic* form: *Q(o,r)*). For an argument that we should allow for such multigrade predicates, see Oliver and Smiley (2004). I will not here take a stand on whether we should allow for multigrade predicates; instead, I hope to show that such predicates are not needed to understand shape perception in STR, since Euclidean squareness is represented in our experiences *non-relationally*.

[53] See (Lewis 1986), (Johnston 1987), (Lowe 1988), (Haslanger 2003), and (Sider 2007).

The key claim in Lewis's objection takes the form of a conditional: 'If we know what shape is, we know that it is a property, not a relation'. I have, in effect, been insisting that the antecedent of this conditional is true: we *do*, contrary to what the placeholder view implies, know what squareness is. If the placeholder view were true, then Lewis's claim would pose no threat to the thesis that squareness is a relation, since the antecedent of the conditional would be false. According to the placeholder view, we *don't* know what shape is: we have only a 'placeholder' understanding of the property we ascribe to objects in taking them to be square. We know squareness as 'that property, whatever it turns out to be, that plays the relevant role in generating our squarish experiences'. And that kind of 'knowledge' of shape in no way rules out that squareness could be a relation; indeed, as we saw above, it does not rule out that squareness could turn out to be a completely unfamiliar property of the Minkowski space-time manifold.[54] But what I emphasized in the Introduction is that our knowledge of shape is not like this: while it is plausible that we have only a kind of place-holder concept of *color* properties, we know—from the perspective of experience itself—which determinate property *squareness* is, which specific property our squarish experiences attribute to the objects we perceive. As *Commonality* insists, it is the very property of Euclidean squareness about which we reason in doing *a priori* geometrical proof. In trying to vindicate both *Veridicality* and *Commonality*, then, what we need is an account that allows us to say that it is the property of squareness on which we have an *a priori* grasp—the property that shows up *unrelativized* in Euclidean proof—that our perceptual experience veridically attributes to objects.

My claim is that the account I've proposed can achieve this. In order to see how, we can first consider what has been called the 'abverbial' response to the problem of temporary intrinsics.[55] Lewis's challenge is that, in order to avoid contradiction in attributing shape properties to an enduring object like a person—in order to avoid the conclusion that a single object is both bent and straight—we would need to introduce some extra *things*, over and above the object and the properties: namely, the *times* at which the object has the properties. This would require us, by Lewis's lights, to insert an extra *argument place* in our attributions of shapes to objects: it is not that an object, *o*, is square (which we could formalize, using *Q* as the predicate 'is-square', as '*Q(o)*'); it is that *o* bears the square-at *relation* to a further thing, a time *t* (thus, what we really have is '*Q(o, t)*'). The is-square predicate *Q* turns out to be two-place; the is-square property turns out to be the is-square-*at* relation.

The adverbial response to Lewis's challenge is that we needn't understand the temporal modifier 'at *t*'—in a sentence like 'Lewis is bent at noon'—as introducing an additional *object*, a time *t*, to which the subject bears some relation. Instead, we can see 'at *t*' as expressing the *manner* in which the shape property is *instantiated*; we can, in the words of E.J. Lowe, take '"at *t*" at its face value as having adverbial (or predicate modifier) status' (Lowe 1988, p. 73). Temporal modifiers, on this account, have an *adverbial* role: a sentence like 'Lewis is bent at noon' is to be parsed as 'Lewis is-noonly bent'.[56]

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[54] The sense in which we don't know *what squareness is*, on the placeholder view, is that we lack *acquaintance* with it. We don't know *which* property squareness is (at least prior to doing a lot of empirical research), if we only know that it is *whatever* property in fact typically generates squarish experiences. See (Campbell 2011), (Johnston 1996), and (Evans 1982) on the significance of this type of acquaintance, or 'knowledge which'; the *locus classicus* is of course (Russell 1912).

[55] See (Johnston 1987), (Lowe 1988), (Haslanger 2003).

[56] This is a somewhat awkward construction, but there are other temporal modifiers for which the explicitly adverbial rendering is more natural: we can say 'Lewis is-presently bent' and 'Lewis is-formerly straight', giving us two felicitous (and transparently non-contradictory) sentences. Compare (Johnston 1987, p. 128): 'Temporal qualification has to do with the ways individuals have properties.

I do not want to take a stand on whether the adverbial response is the best solution to the problem of temporary intrinsics. What I do want to suggest is that we can apply a version of the adverbial response to a parallel problem raised by STR. Recall how we described Third Base_L, the rest-square object on Lorentz Earth: relative to Lorentz Earth, it is square; relative to Earth, it is 2:1-rectangular. Being square and being 2:1-rectangular are incompatible properties; so, if we take them to be *intrinsic* properties of Third Base_L, we seem to have a contradiction. We might, then, think that we are forced to acknowledge that the shapes of objects are *not* intrinsic: STR reveals that we need to introduce another *thing*, a reference frame, relative to which objects have shapes. Third Base_L can then be seen as having two compatible relational properties: it bears the square-in *relation* to Lorentz Earth's frame, and the 2:1-rectangular-in relation to Earth's frame. In general, objects bear the square-in relation to frames; they do not instantiate the intrinsic property of *Euclidean* squareness.[57] This is just another way of drawing out the idea that, given STR, we are forced to reject *Commonality*.

My response to this challenge should by now be apparent: Reference frames are not additional *things* to which objects bear some relation (they do not fill an additional argument place in uses of the 'is-square' predicate). Instead, the role reference frames play in STR is to determine different *ways* in which spatial properties can be *instantiated* by objects in our universe. The properties themselves are not relations between reference frames and objects; a shape property like squareness remains the very same intrinsic property about which we reason in Euclidean proof.

On this picture, Third Base_L instantiates squareness in the *Lorentzian manner*, and it instantiates 2:1-rectangularity in the *Earthly manner* (we might say that it is-Earthwise 2:1-rectangular, and it is-Lorentzwise square). These two properties—2:1-rectangularity and squareness—are the same intrinsic properties (expressed by the same monadic predicates) as those that feature in Euclidean proof.

Turning to the question of shape *perception*, we can see that this picture provides a natural account of the contents of squarish experiences. Perception is, in its nature, first-personal. When a subject *S* has a squarish experience, then, the manner of instantiation of squareness that sets veridicality conditions for her experience is the one determined by *her own* (current) state of motion: *S* represents the object she perceives as instantiating Euclidean squareness *S-wise*.[58] On this picture, a squarish experience presents a subject with Euclidean

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Unproblematically Sam may have the property of being fat in the *t** way and have the property of being thin the *t* way. Temporal qualifiers are often adverbs. Sam is presently fat. But he is *t*ly thin'.

[57] (Skow 2007) argues, based on considerations entirely independent of STR, that objects do not have intrinsic shape properties. I will not be addressing his argument here.

[58] On this picture, perceptions are veridical if and only if they represent the perceived object as having the shape it instantiates relative to the perceiver's current reference frame. We thus get the intuitively correct veridicality judgments about the shape experiences of Astronaut Albert, in the cases discussed in §2. When we widen our gaze and consider non-perceptual shape contents, we can also see how this account allows for a natural understanding of the common locutions of STR. Once we are familiar with the theory, we can *make explicit* the manner of instantiation of spatial properties that we wish to discuss. Even while on Earth, we can *say* 'Third Base_L is square in Lorentz Earth's frame'; here, we make the claim that Third Base_L instantiates squareness *Lorentzwise*. The flexibility of our language—a flexibility that is absent in the domain of perception, where contents are necessarily first-personal—allows us to flag that we are discussing different manners of instantiation of shape properties, while holding constant the meaning of our shape terms themselves. When, in more mundane circumstances, we describe an object as square without specifying a reference frame, we should interpret our statements as making claims about the shapes objects instantiate in the manner that is most relevant contextually (namely, the manner of instantiation associated with the speaker's current reference frame; this explains why Astronaut Albert *speaks truly* when he says 'Third Base_A is square'). This

squareness—Euclidean squareness is the *presentational* content of such experiences. In a relativistic universe like ours, the contents of such experiences *also* include a further, *non*-presentational element—a specification of the *manner* in which that property is instantiated, determined by the subject's state of motion.

With this account onboard, we can now (finally) put our finger on where Chalmers's argument against shape presentationalism (from §2) goes wrong. Chalmers claims (in step (4) of the argument) that Twin Albert's squarish experience of Third Base_L represents the shape property that Third Base_L actually has. Since (by (5)) that property is 2:1-rectangularity, Chalmers concludes (step (7)) that Twin Albert's squarish experience represents 2:1-rectangularity; and so we have a case in which a squarish experience represents something other than squareness (step (9)), thereby providing a counterexample to shape presentationalism. But if objects can, as I've been suggesting, instantiate *multiple* shape properties—even incompatible shape properties—in different *manners*, there is a failure of reference in the claim, in step (4), that Twin Albert's squarish experience of Third Base_L represents *the* shape property that the base actually has. Third Base_L instantiates *both* 2:1-rectangularity (Earthwise) *and* squareness (Lorentzwise); there is no *unique* shape that is *the* shape it has. The veridicality of Twin Albert's experience thus does not imply that his experience represents 2:1-rectangularity; it only implies that his experience represents *some* shape property that Third Base_L has.[59] And, given that perceptual experiences represent the properties that are instantiated in the first-personally-relevant manner, Twin Albert's squarish experience will represent the shape property Third Base_L instantiates Lorentzwise—namely, *squareness*. Twin Albert's squarish experience is therefore not a counterexample to shape presentationalism.

Importantly, I am not claiming that we were getting *nothing* wrong in our conception of shape properties before Einstein. Prior to STR, we did think that Euclidean squareness was instantiated by objects *absolutely*—without any adverbial modification[60]—as it would be in a Newtonian universe. So we learned that we were getting something wrong when Einstein revealed that the universe is non-Newtonian. And this seems quite correct: Einstein's theory would not have been as revolutionary as it was had it not revealed an error in our ordinary thinking. But what STR reveals is simply that the *manner* of instantiation of shape properties is different from what we took it to be; the properties themselves, instantiated by objects in this novel way, are the very Euclidean properties with which we were already acquainted. On this account, we can understand why we describe STR in the terms we do, using ordinary Euclidean shape terms (in statements like 'a square object moving relative to us will, relative to our reference frame, be an elongated rectangle'). We do not have to convict our perceptual experience of radical error (allowing us to hold on to *Veridicality*), and we can (as *Common-*

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account thus captures the intuitive idea that the meaning of 'square' does not shift when we say, in everyday life, 'Chessboards are square', and then, in a discussion of STR, 'Third Base_L is square relative to Lorentz Earth'.

[59] Strictly speaking, Chalmers need not claim that Third Base_L instantiates only one shape property; what he needs for his argument to go through is the claim that, whatever shape properties Third Base_L *does* instantiate, the property represented by *Albert's* squarish experience—squareness—is not among them. Modifying the argument to include only this less demanding premise, though, does not remove the problem. There is now a crucial ambiguity in the modified premise 'Third Base_L does not instantiate squareness'. It is true that Third Base_L does not instantiate squareness *Earthwise*; but false that it does not instantiate squareness *Lorentzwise*. In moving from the true premise 'Third Base_L does not instantiate squareness [Earthwise]', via the veridicality premise, to the conclusion, 'Twin Albert's squarish experience does not represent squareness', the argument would thus be equivocating (since it is the *Lorentzwise* instantiation of squareness that is relevant to the truth of the conclusion).

[60] Or, perhaps, in the 'absolute manner', as the adverbial phrasing suggests.

ality urges) understand the contents of our shape experiences in terms of the very unrelativized, Euclidean shape properties on which we have an intuitive, *a priori* grasp.

5. Conclusion

According to Thomas Reid, there is a genuine distinction between primary and secondary qualities, in that:

> our senses give us a direct and a distinct notion of the primary qualities, and inform us what they are in themselves: But of the secondary qualities, our senses give us only a relative and obscure notion. They inform us only, that they are qualities that affect us in a certain manner, that is, produce in us a certain sensation; but as to what they are in themselves, our senses leave us in the dark. (Reid 1785, 2002; Essay II, Chapter XVII, Section I, p. 201)

On this Early Modern picture, experience provides us with only a placeholder conception of the *secondary* qualities; but, because perception includes 'a direct and a distinct' representation of the *primary* qualities, we are not left *entirely* 'in the dark' about the nature of the empirical world.

An intuitively appealing way of spelling out Reid's idea is the following: experience provides us with direct and distinct representations of primary qualities because it presents objects as instantiating the Euclidean spatial properties of which we have an *a priori* understanding.[61] The Einsteinian revolution, however—by calling into question the applicability of our *a priori* spatial concepts to the physical universe—threatened to undermine the traditional distinction between primary and secondary qualities: if the objects we perceive do not in fact instantiate Euclidean spatial properties, we might feel compelled—in order to preserve *Veridicality*—to retreat to a placeholder account of *every* aspect of perceptual content, and to accept that our experience does leave us utterly in the dark about the nature of the world.

Fortunately, though, Einstein's theories do not force us to accept a placeholder account of spatial perception. The objects we perceive do, even within STR, instantiate the very shape properties of which Reid had 'a direct and a distinct notion'. What STR reveals is that these Euclidean shape properties are instantiated in our universe not *absolutely*, but in a *manner* that Reid could not have foreseen—namely, *relative to particular frames of reference*. Understanding STR in this way allows us to hold onto the crucial Early Modern idea that, in virtue of our spatial experience, we are indeed acquainted with a central aspect of the world we perceive.

[61] Reid himself would have been pleased to acknowledge some *a priori* element at work in our perception of the primary qualities; but he would not have accepted that it is *Euclidean* geometry that is represented in *visual* experience. Indeed, Reid is credited by many with the invention of *non-Euclidean* geometry, precisely as a theory of the 'geometry of visibles'. Reid did hold, however, that *tactual* geometry is Euclidean (see (Van Cleve 2002)).

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