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THEORETICAL NOTE

Empirical Evidence for Perspectival Similarity

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When a circular coin is rotated in depth, is there any sense in which it comes to resemble an ellipse? While this question is at the center of a rich and divided philosophical tradition (with some scholars answering affirmatively and some negatively), Morales et al. (2020, 2021) took an empirical approach, reporting 10 experiments whose results favor such perspectival similarity. Recently, Burge and Burge (2022) offered a vigorous critique of this work, objecting to its approach and conclusions on both philosophical and empirical grounds. Here, we answer these objections on both fronts. We show that Burge and Burge's critique rests on misunderstandings of Morales et al.'s claims; of the relation between the data and conclusions; and of the philosophical context in which the work appears. Specifically, Burge and Burge attribute to us a much stronger (and stranger) view than we hold, involving the introduction of "a new entity" located "in some intermediate position(s) between the distal shape and the retinal image." We do not hold this view. Indeed, once properly understood, most of Burge and Burge's objections favor Morales et al.'s claims rather than oppose them. Finally, we discuss several questions that remain unanswered, and reflect on a productive path forward on these issues of foundational scientific and philosophical interest.

Keywords: shape, perspective, constancy, representation, philosophy

Figure 1 contains three images of wooden "coins": A circular coin viewed head-on, an elliptical coin viewed head-on, and a circular coin rotated at an angle. Consider the following question: Is there any relevant sense in which the rotated circular coin "looks elliptical"? More precisely: Does the circular coin, when rotated, share any aspect of its appearance with the elliptical coin—an aspect it does not share when viewed head-on?

This seemingly innocent question is at the center of a rich and divided philosophical tradition, tracing at least to the 17th century (if not further; see Burnyeat, 1979) and continuing to the present day. Among the many answers on offer, one class of views embraces *perspectival similarity* (Lande, 2018), holding that the rotated circle and head-on ellipse do indeed share some aspect of their appearance that is not shared by the head-on circle. Contemporary philosophers who defend perspectival similarity include Peacocke (1983), Noë (2004), Schellenberg (2008), Cohen (2010), Lande (2018), and others. Though these and other theorists differ on the nature of this similarity—how and why it is that the rotated circle and head-on ellipse look similar, or what grounds this similarity in their appearance—they accept perspectival similarity in some form, agreeing that there is some relevant sense in which the rotated circular coin looks elliptical.

However, another class of views rejects perspectival similarity. For example, Schwitzgebel (2006) writes of a rotated coin: "I'm inclined to say it looks just plain circular, in a three-dimensional space—not elliptical at all, in any sense or by any effort I can muster." Similarly, Smith (2002) writes: "the suggestion that pennies, for example, look elliptical when seen from most angles is simply not true—they look round."[1] Here, too, there is disagreement about what (if anything) *does* change about the coin's shape appearance when it is rotated in depth.[2] Nevertheless, defenders

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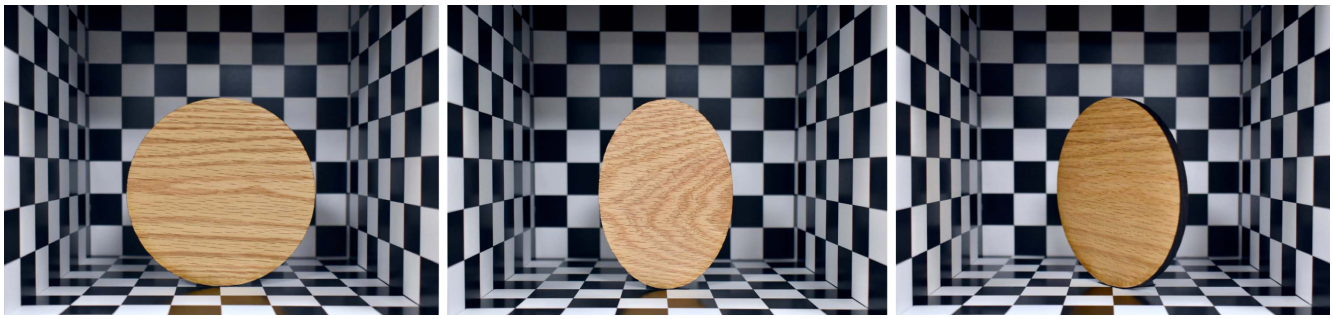
[1] Smith continues, nearly designing a psychophysics experiment of his own: "I am not even inclined, the tiniest bit, to take the [tilted penny] to be elliptical, or to react to it as to an elliptical—one can even say elliptical *looking*—object. If set to perform discrimination tests, I should naturally and unthinkingly class together, on the basis of their visual appearances, what I see when I look at the titled penny with *round* objects seen full on." Other theorists who reject perspectival similarity (or at least come very close to doing so) include Briscoe (2008), Hopp (2013), and Siewert (2006). For example, Hopp holds that, when perceived accurately, "round objects tilted away do not look elliptical."

[2] For example, one can deny perspectival similarity while still embracing *perspectival variation*. This view would accept the (less controversial) claim that a rotated circular coin looks different from a head-on circular coin, while still denying the (more controversial) claim that there is some sense in which the rotated circular coin looks elliptical.

Figure 1
Three Wooden "Coins"



Note. A head-on circular coin, a head-on elliptical coin, and a rotated circular coin. See the online article for the color version of this figure.

of this view hold that there is *no* sense in which a rotated coin looks elliptical—that is, no sense in which a circular coin, when rotated, comes to share some aspect of its appearance with a head-on ellipse.[3]

Saliently, most of these discussions about shape appearance and visual perspective tend to keep some distance from empirical data. For example, neither Peacocke and Schellenberg (in embracing perspectival similarity) nor Schwitzgebel and Hopp (in rejecting perspectival similarity) discuss or cite any experimental results on shape perception. It is hard to blame them: Though there are of course mountains of empirical work on the perception of 3-D shape, there has not (to our knowledge) been an empirical study, using the tools of vision science, directly aimed at this philosophical debate—that is, aimed at the question of shared appearance between head-on ellipses and rotated circles.[4]

To begin filling this gap, we ran a series of such studies (Morales et al., 2020, 2021). To acquire experimental evidence of shared appearance between head-on ellipses and rotated circles, we asked whether subjects who must locate a head-on ellipse in a display containing an additional nonelliptical object would be "distracted" by rotated circles more so than head-on circles, on account of their putatively shared appearance. This general approach and explanatory pattern is common in visual cognition research. For example, consider that it is harder to find a red square among red triangles than to find a red square among blue triangles (as reflected in slower search times). The canonical explanation of this pattern is that, even though red squares and red triangles look very different in some respects, they also share some aspect of their appearance (namely, their color). This shared aspect makes them harder to distinguish—especially under time pressure—than pairs of stimuli that do not share this or other aspects of their appearance (here, red squares and blue triangles). We reasoned that the same logic could hold here, if head-on ellipses and rotated circles look similar in a way that head-on ellipses and head-on circles do not.

In nine experiments reported in Morales et al. (2020), as well as a tenth reported in Morales et al. (2021), we indeed found this predicted slowdown: A head-on ellipse is harder to locate when displayed next to a rotated circular coin than a head-on circular coin. On the basis of this and similar results across many variations of presentation and context (including several variants in which the coins sat in front of subjects for seconds or even minutes), we concluded that:

> An elliptical coin is harder to distinguish from a rotated circular coin (vs. a head-on circular coin) because the two objects *appear to have something in common*. More precisely, when subjects see the rotated

[3] Vision scientists also weigh in on this question; though their views may not cleanly map onto these philosophical positions, it is not difficult to find passages sympathetic to one or the other class. Beyond the sources cited in our original article, antiperspectivalist views are often attributed to Attneave, who had a "sandbox in the head" theory of both perception and imagery: "These 'sandbox in the head' theories (Attneave, 1972) propose that depth is encoded directly in perceiving and imagining, and that no special status is afforded to the picture plane or any other two-dimensional surface" (Kerr, 1993). An oft-quoted passage from Palmer (1999) states that, under conditions of perceptual constancy, "people veridically perceive the constant, unchanging properties of external objects *rather than* the more transient properties of their retinal images" (emphasis added by Weksler, 2016; see also Schulte, 2021); another passage asserts that, when there is sufficient depth information, "shapes at a slant look the same as they do in the frontal plane" (though other passages seem to embrace certain aspects of perspectival appearance). More recently, Erdogan and Jacobs (2017), writing in *Psychological Review*, present a model (also referenced by Burge and Burge) that seems aligned with such views in both the content and format of the representations involved, holding that "shape representations code information about an object's three-dimensional structure, not the two-dimensional structure of its retinal image" and that "shape representations code shape properties in an object-centered coordinate system, not a viewer-centered coordinate system." This is not to say that such theories could not accommodate perspectival similarity or account for empirical evidence in its favor (nor that there aren't other, contrasting scientific accounts), but rather that perspectival similarity is neither assumed nor actively predicted by these models. (Note that *viewpoint-dependency* in such models is not the same as perspectival similarity; viewpoint-dependency is the behavioral phenomenon whereby object recognition is better from some views than others, whereas perspectival similarity concerns shared appearance). For the sake of precision, and to avoid misrepresentation, the rest of our discussion focuses more on philosophical expressions of these views than scientific ones; however, we think many classical and contemporary scientific accounts express broadly similar theoretical positions.

[4] Many scholars have acknowledged this lack of relevant experimental work. For example, Schwenkler and Weksler (2019) note the traditional view that "the dispute belongs to the realm of phenomenological, conceptual, and metaphysical analysis," rightly asserting that the debate has so far "proven recalcitrant to the methods of philosophy." Reacting to this traditional view, they propose an experimental approach, and they (also rightly) consider the very idea of an experimental approach to be a new and different inroad to these issues (see also discussion in Green, 2021; Kelly, 2008). An intriguing exception might be Thouless (1931a, 1931b; see also Epstein & Park, 1963; Epstein et al., 1977); in some ways our project is a continuation of this old but inspiring work. (For related studies on perspectival size and distance, rather than shape, see Carlson, 1962; Gilinsky, 1955; Gogel, 1969; McCready, 1985; Rock & Brosgole, 1964).

> circular coin and the head-on elliptical coin, it can be said that they bear a representational similarity to one another.

Our follow-up publication refined this view further: "Our claim is that frontal ellipses compete with rotated circles because of some shared aspect of their appearance, where this aspect is shared from certain perspectives but not others" (Morales et al., 2021). In other words, we take these results to favor perspectival similarity, and thereby to oppose the view that there is not "any sense" in which a rotated circle looks similar to a head-on ellipse.

Recently, Burge and Burge (2022) issued a critique of this work, arguing that it "provides no empirical support for any claims regarding either perspective or the perception of shape," because of defects in our characterization of the philosophical and scientific views we discuss, flaws in our experiments (which, in their view, were "poorly controlled and poorly conceived"), and patterns in our data that allegedly undermine our conclusions. More specifically, Burge and Burge give three empirical arguments: (a) the reaction-time differences we focus on are also accompanied by accuracy differences, in ways that undermine our claims; (b) rotating a coin introduces new "uncontrolled differences" between it and the ellipse that could account for our results differently; and (c) the cues for discriminating distal circles from distal ellipses are weaker and less reliable when the distal circles are rotated.

This critique rests on a series of misunderstandings—of our experiments, claims, and, critically, the literature we are engaged with. Here, we respond to these objections on both philosophical and empirical fronts. In the first section ("The Evidence"), we directly address Burge and Burge's empirical arguments and evaluate their success against our claims; not only do we find them unsuccessful, we show that many of them favor our account rather than oppose it (though we agree that the relevant issues are not fully decided or resolved). In the second section ("Perspectival Similarity Without 'A New Entity'"), we further clarify our position and address charges that we misrepresent the philosophical literature on this question. We show that, to the contrary, it is Burge and Burge's philosophical discussion that is problematic, in ways that directly relate to their subsequent mischaracterization of our claims (which we detail and correct). This section also suggests that Burge and Burge's positive view places them in much friendlier intellectual territory than their discussion suggests; it only seems otherwise because they ignore a prominent rival view that our own work was responding to (and that both our position and their position opposes). Finally, in the third section ("Moving Forward"), we point to future empirical directions on these philosophical issues, and reflect on ways to productively advance this literature.

The Evidence

Our research question is whether there is any shared appearance between a rotated circle and a head-on ellipse that is not shared between a head-on circle and a head-on ellipse. We test this question in 10 experiments that find impaired search for head-on ellipses flanked by rotated circles compared to head-on circles (with some variations using squares and trapezoids). Burge and Burge raise three empirical objections against our experiments. Here, we proceed through these arguments and assess their quality.

Argument 1: Accuracy Differences and Alleged Dissociations

The primary measure we report in our article is the difference in reaction time (RT) between the head-on-circle condition and the rotated-circle condition. Burge and Burge observe another pattern: In addition to an RT difference (faster with head-on-circular distractors than rotated-circular distractors), there is also an accuracy difference, such that subjects answer correctly more often in the head-on-circle condition than the rotated-circle condition. They refer to this pattern as "unreported data"[5] and suggest that it undermines our arguments and conclusions.

However, this objection gets things backward; the correlation between speed and accuracy *complements* our results, and in no way undermines them. As Burge and Burge correctly note, speed and accuracy are joined at the hip; they are always correlated, except in very unusual circumstances—and so the question in any given case is only whether this correlation is positive or negative. The problematic pattern for our conclusion of shared appearance would have been a *negative* correlation between accuracy and speed: slower response times and *greater* accuracy in the rotated condition than the head-on condition. This pattern is known in psychophysics as a "speed–accuracy tradeoff," and it makes RT differences difficult to interpret, because slower responses might not reflect increased difficulty or stimulus competition but rather strategic behavior by subjects to prioritize accuracy at the expense of speed.

But what Burge and Burge highlight is not a speed–accuracy tradeoff; it is the opposite pattern—a difference in accuracy that is in line with the RT slowdown. This is the pattern that visual cognition researchers *hope* to see in their data; it is a confirmation of the performance differences suggested by the RT results. That's why visual search papers so often include phrases like "faster and more accurate" in their results sections; that phrase does not mean "faster and more accurate (and therefore uninterpretable)"; it means "faster and more accurate (and so especially compelling)." (For examples of this canonical pattern of reasoning, see Kimchi, 1994; Waters & Lipp, 2008; Wolfe et al., 2011; there are many others.)

Indeed, Burge and Burge imply as much when they write that "there is nothing surprising" about this accuracy difference, whose relationship to speed "has been known for decades." We agree. What is surprising is Burge and Burge's suggestion that this undermines our arguments or conclusions. Recall: Our view is that there is some sense in which circles, when rotated, come to visually resemble head-on ellipses (relative to when the circles are viewed head-on). With this view in mind, note that an equivalent way of stating the accuracy difference is that subjects searching for ellipses under time pressure are more likely to respond to rotated circles than to head-on circles. This is exactly what one would expect on our view.

To see this another way, consider our earlier analogy to finding a red square among red triangles versus a red square among blue triangles. The results one would expect from such a task are straightforward: There would be an RT slowdown for finding a red square among red triangles than among blue triangles, and there would also be an accuracy difference consistent with this effect. Its interpretation would

[5] Readers are advised that every data point from every one of our experiments—along with our code, stimuli, and analyses—is permanently and publicly available at https://osf.io/thj6y/, and has been since publication. Any reader is welcome, and indeed invited, to conduct any further analyses they wish.

be straightforward as well: The reason there would be slower responses and more mistakes for finding a red square among red triangles than among blue triangles is that red squares share an aspect of their appearance with red triangles that they do not share with blue triangles. The same logic applies in our actual experiments.[6] Perspectival similarity predicts the RT differences and the accuracy differences. But, recall, some prominent positions deny perspectival similarity, holding that there is *not any sense* in which a rotated circle comes to share its appearance with an ellipse. So, while everyone agrees that red triangles are more distracting than blue triangles when looking for red squares, some views may *not* agree that rotated circles should be more distracting than head-on circles when looking for head-on ellipses. Our experiments disconfirm that hypothesis.

Why did Burge and Burge think this very ordinary result was a problem for our claims? As their text clarifies, it's because they read us as claiming a dissociation between speed and accuracy, since we noted that our RT differences emerged even when "performance was at ceiling" (e.g., Experiments 8 and 9) and indeed even when subjects were "not confused at all about the true shapes of the stimuli." But this is no claim of a dissociation between speed and accuracy. Of course, it is true that even in Experiments 8 and 9 performance was never literally 100%, and we are happy to accept Burge and Burge's clarification that a subject who answers incorrectly on a given trial is in some weak sense "confused" about what they were looking at (though this same weak sense would apply equally to the red squares and triangles case, and so is no problem for our view). But once again these differences only further support, and do not in any way refute, our central claims. The only reason we mentioned high accuracy was to convey that the task was easy and the objects were trivial to distinguish (like red squares and red triangles). For example, in the strongest and most naturalistic experiment from our first publication (real-world objects with unconstrained viewing; Experiment 9), accuracy was 98.4% in the head-on condition and 97.2% in the rotated condition—extremely good (approaching "ceiling") performance, especially in light of the time pressure.[7] If accuracy had been poor (say, 70%), then perhaps an argument could be made that we had ineffectively displayed our stimuli. But 98.4% and 97.2% accuracy, under time pressure, is remarkably good, suggesting that the objects were easily seen for what they were—circles and ellipses presented at various orientations—and thus that our RT results arose even in conditions where accuracy was high. All of these results straightforwardly support our account, and in no way undermine it.

Argument 2a: New Uncontrolled Differences

Burge and Burge's other arguments concern what they call "uncontrolled differences" in our two experimental conditions (head-on circular distractor and rotated circular distractor). There are two variants of this argument in their text, so we address them separately here.

First, Burge and Burge note that, when a coin is rotated, other visual differences come along with this manipulation, such as increased visibility of the coin's rim, a change in its specularity and shading, and so on. They suggest that, rather than reflecting perspectival similarity, results in the rotated-circle condition (i.e., worse/slower performance) could have arisen because "subjects could identify the distal circle as the stimulus with the darker shading, or with the visible edge, among other cues." On this worry, the more such differences there are, the less interpretable our experiments are. For example, our real-world experiments further amplify the problem, because "these experiments introduced more uncontrolled cues (binocular disparity & motion parallax)."

But this objection too gets things backward; it is the opposite of the argument Burge and Burge need to make to undermine our claims. It is plainly true, of course, that rotating the circle introduces many new differences between the circle and the ellipse. (Most of these differences would more ordinarily be called cues to 3-D shape.) But these new differences—differences between the coins that are *added* in the rotated-circle condition—should make our result more compelling, not less compelling. To reiterate: Our finding is that locating the head-on ellipse is more *difficult* in the rotated-circle condition than the head-on-circle condition—it produces slower responses (and less accurate ones, as Burge and Burge note). Our explanation of these performance differences is that a rotated circle and a head-on ellipse look similar in a way that a head-on circle and a head-on ellipse do not, and that this makes the rotated-circle condition harder than the head-on-circle condition. If Burge and Burge's objection is to succeed, it needs to give an alternative account of why that condition is difficult. Pointing to new or additional differences between the stimuli in the rotated-circle condition seemingly does the opposite of what Burge and Burge need to do; each additional difference on their list is a difference that would tend to aid performance in that condition, not impair it. The newly visible rim (on one coin but not the other), the new differences in shading and specularity between the coins (when they previously were matched along these dimensions), and so on, are all features that make targets and distractors more discriminable from one another, not less (since, e.g., anytime a subject sees a rim, they could reject that shape as their target).

To see this another way, consider Burge and Burge's observation that removing all low-level differences between the coins in the rotated-circle condition would have made the task impossible. That is surely correct. But this reasoning extends in the other direction too: Just as removing differences between the coins in the rotated-circle condition would have made the discrimination even harder (and eventually impossible, if all differences were removed), the presence of those differences should tend to *assist* the discrimination (barring some independent reason to think that shading/specularities/disparities/etc. of one kind but not the other impair discriminations). And so the presence of those additional differences between the coins does not immediately provide an alternative explanation for why the rotated-circle condition is the *harder* condition. It is possible that, for the claims Burge and Burge imagine

[6] Note that we are not committed to the view that the perspectival ellipticity of a rotated coin has the same status as the red color of a triangle. Our analogy serves only to illustrate that, when attempting to locate an object based on its visual appearance, objects sharing aspects of that appearance will tend to distract. (See also a brief discussion in the final section, "Moving Forward").

[7] Burge and Burge mistakenly describe the data from our real-world experiments as "filtered." While this was true of our computer-based experiments (where we applied an 80% accuracy exclusion criterion to ensure data quality, though all results remained the same even without this filtering), it was not true of our real-world experiments, where every subject in all three of these experiments performed well enough that not a single subject would have even approached that accuracy cutoff. Additionally, all subjects passed a screening procedure that required 100% shape identification performance without time pressure.

we are making (see next section), this objection would be more powerful or effective. But for our claims of perspectival similarity, their objection is pointing in the wrong direction.

Argument 2b: Unreliable Cues to Distal Shape

Burge and Burge's final argument may be their strongest one (in part because it is the only one whose upshot would be a problem for our view). This argument is also based on differences in the head-on versus rotated condition. Here, Burge and Burge argue that "Distal circles and ellipses that generate retinally projected shapes with matched aspect ratios force subjects to rely more on other cues (e.g., shading, specularities, edge visibility)," and that these other cues "are as a group weaker and less reliable." Since "Less informative, less reliable cues tend to cause slower response times and less accurate discriminations," it is possible that the slowdown we observed occurred only because it is harder to recover the distal shape of the rotated circle (in ways that allow for discrimination from distal ellipses) than the distal shape of a head-on circle. This concern is related to Linton's (2021) worry, namely, that distal shape was more difficult to recover in the rotated condition.

If that difficulty explains our results, this would indeed be a challenge to our interpretation. What do we make of this argument? First, we note that Burge and Burge's rendition of this objection is difficult to evaluate as written, in part because they offer no sourcing or evidence for their claims—both their claim that the cues available in the rotated case are, *as a group*, weaker and less reliable than in the head-on case, and their claim that these cues tend to cause slower response times.[8]

Nevertheless, we can consider it. And indeed we did. This general concern motivated nearly half of our experiments, which address it from multiple angles:

- Experiment 6 introduced a delay in responding, such that subjects had to view the stimuli for a full second before being permitted to give a response (with those responses thus arriving over 1.5 s after exposure to the stimuli). Even if there are differences in the strength of the cues to distal shape in each condition (whatever the direction of these differences might be), subjects in this experiment had extra time to recover distal shape. But if perspectival similarity persists in experience even after shape constancy is achieved, we might still predict an impact on search behavior. That in fact is what we found.

- Experiments 8 and 9 used real-world objects in full-cue conditions, and the objects remained in front of subjects for nearly half an hour. The coins were visible throughout the entire session (including before the first trial), under more than adequate illumination, with no masking. In other words, the setup was just an array of easily visible wooden objects, located right in front of the subjects. Unsurprisingly, 100% of subjects in those experiments passed a screening procedure requiring them to say which shapes were which, perfectly, without time pressure. Still, our effects remained.

- Finally, in response to Linton's (2021) related objection, Experiment S1 (reported in our follow-up publication; Morales et al., 2021) replicated the setup of Experiments 8 and 9, but at a viewing distance that has been shown in other work to be optimal for shape constancy from binocular disparity (Johnston, 1991). It is hard to imagine better and more ecologically valid conditions for perceiving the distal shape of an object; it seems to us that the most plausible reason for a slowdown under these conditions is that the two objects look similar to one another.

Burge and Burge briefly discuss these experiments, but only to dismiss them on the basis of the other, flawed arguments reviewed earlier. For example, of Experiment 6 (delay), Burge and Burge write "these results also exhibit accuracy differences"; and of Experiments 8, 9, and S1 (real-world), they write "But these experiments introduced more uncontrolled cues (binocular disparity & motion parallax). And, here too, there are accuracy differences between hard and easy conditions." As we have seen, these objections are not, and cannot be, decisive. Accuracy differences are expected whenever there are RT differences, and they are most definitely predicted on our account; appealing to them again here does not undermine these experiments as answers to the "unreliable cues" objection. And Burge and Burge's concern about uncontrolled cues again goes in the wrong direction: The *addition* of differences in the rotated-circle conditions ("these experiments introduced more uncontrolled cues") is no objection at all when the rotated-circle conditions are the harder conditions.

Of course, we do not mean to say that our results fully decide this issue; we think they are highly suggestive when considered together, and in conjunction with our six other experiments, which included an experiment where height and width were varied independently of shape (Experiment 2), an experiment that further explored the role of rotation, noncanonical views, specularity, and edge visibility (Experiment 3), and an experiment that matched projected aspect ratios, but not projected shapes, in all conditions (Experiment 4). We are also very much open to other approaches and sources of evidence (see final section). But Burge and Burge need new responses to these experiments.

Perspectival Similarity Without "A New Entity": Do We (Dis)agree About Visual Perspective?

Its tone aside, one of the more surprising aspects of Burge and Burge's article is that it eventually expresses a view that sounds quite congenial to our own. In a passage that arrived unexpectedly following their vigorous discussion, Burge and Burge write: "we are commonly aware of some elliptical shape corresponding to the

[8] The objection is also given by Burge and Burge in a way that seems to concede an important aspect of our claim. Why do "distal circles and ellipses that generate retinally projected shapes with matched aspect ratios force subjects to rely more on other cues"? The task in our experiments is not to make a same/different judgment; it is to tell which of the two objects is a distal ellipse, where our finding is that rotated distal circles are more tempting lures under these conditions. And retinally projected shape is, of course, not determinative of distal shape: As Burge and Burge well know, underspecification of the distal environment by the retinal image entails that two objects with different retinal projections can have the same distal shapes, two objects with the same projections can have different distal shapes, distal circles can have elliptical retinal projections, distal ellipses can have circular projections, and so on. In other words, while we, the experimenters, know that the object with a circular projection was in fact a head-on circular object, the naive subject's visual system must discover this fact independently: the circular projection of the head-on circle is perfectly consistent with a cleverly angled noncircular object.

projection cast by a rotated dinner plate." This statement sounds very much like our own claims, and Burge and Burge's efforts to distinguish the two are subtle indeed:

> [P]rojected shape is merely sensed, but not perceived. The elliptical-shape-awareness depends causally on this mere sensing. It is an open empirical question at what processing stage—mere sensory, perceptual, or post-perceptual—this conscious awareness emerges and what psychological capacities it requires. We think it likely that conscious mere sensing of retinally projected shape occurs at the perceptual stage of processing.

So: For Burge and Burge, the elliptical aspect of the rotated coin is sensed but not perceived (not in itself an unusual view on this question), yet the awareness that derives from this nonperceptual sensing likely arises at the "perceptual stage of processing" (as opposed to the "mere sensory" stage), and is consciously accessible. That is more than sufficient for our purposes as laid out above. Whether the coin's ellipticity is visually apparent, visually perceived, seen, or consciously-sensed-at-the-perceptual-stage-of-processing, all such formulations disfavor views that reject perspectival similarity and favor views that embrace perspectival similarity—and so are well in line with the overall aim of our project.

What, then, explains our apparent disagreement? We think the answer lies in another surprising aspect of Burge and Burge's discussion: It does not actually engage with (or even mention) the philosophical views that our article was responding to—namely, the class of views that reject perspectival similarity. Note, for example, that the philosophical sources we rely on most heavily in our original article—the work by Schwitzgebel and Smith reviewed above, which are the only pieces of contemporary philosophy quoted *in extenso* in our text, appear immediately before we present our empirical approach, and hold that the rotated coin looks "not elliptical at all, in any sense"—are not discussed at all in Burge and Burge's own piece. They do not attempt to show that we have misunderstood these views, nor those of any other philosopher whose work we discuss. Indeed, their article does not once cite these pieces of work that were so central to our project.[9]

We think this omission matters, because it leads Burge and Burge to misinterpret our claims and criticize views we do not hold. Instead of reading us as other scholars have (e.g., Cheng, 2022; Cohen, 2021; Daoust, 2021; Hill, 2022; and especially Green, 2021, who reviews the same sources and context and then characterizes our views accurately and as intended: "visual experiences of the slanted circle and head-on ellipse are similar in some respect"), Burge and Burge exoticize our claims, attributing to us the proposal that "a new entity" should be introduced into the science of perception and interpreting this entity as being located "in some intermediate position(s) between the distal shape and the retinal image." This is not our claim. It is possible that some philosophers conceive of perspectival appearance along these lines (perhaps, e.g., in Hill, 2016's discussion of "Thouless properties"; though even Hill suggests that what we are aware of are viewpoint-dependent relational properties *of the perceived object*, not some intermediate, separate entity located between the perceiver and the object). In any case, we are not among them. Our text does not defend this conception. Indeed, in an effort to be cautious and conservative about this general issue, we wrote:

> To be even more precise, the results here indicate such representational similarity even without specifying the dimension of such similarity, or the specific features that ground this similarity. For many philosophical issues at stake here, it may be important to distinguish between interference caused by matching perspectival shapes vs. by persisting retinal images themselves vs. by independent representations of ellipticity [Lande, 2018]. Our results here cannot adjudicate between these extremely subtle options; but all imply some notion of representational similarity, which is what we take our results to demonstrate.

In other words, we are explicitly *un*committed to the view Burge and Burge attribute to us.[10] Of course, we could have been even clearer about this, and we acknowledge Burge and Burge's concern that we sometimes expressed "ambiguous, unclear theoretical positions" (though we also note that many other scholars interpreted us correctly despite this ambiguity, and we are aware of no scholars who read us as Burge and Burge did; see especially Cheng et al., (2022), who explore this misinterpretation in detail). In any case, we hope we have now clarified that our work is engaged with the (unresolved) debate over whether there is perspectival similarity in visual appearance.[11]

[9] For their part, Burge and Burge bring a similar charge against our discussion, asserting that "Morales et al. barely discuss philosophy that utilizes science's treatment of perspective in perception" and offering instead the following five publications: Burge (2010, 2014a, 2014b), Lande (2018), and Rescorla (2014). In fact, our article discussed or referenced nearly two dozen works of philosophy, among them the following publications that are substantively engaged with the science of perception (in general) and visual perspective (in particular): Bennett (2012, 2016), Briscoe (2008), Cohen (2010), Green and Schellenberg (2018), Hill and Bennett (2008), Noë (2004), Weksler (2016), and Wojtach (2009). Burge and Burge's charge may be related to their surprising dismissal of work by several leading philosophers of perception cited in our article. For example, they assert or imply that Cohen's (2010) discussion is "not scientifically informed"; this criticism is simply misplaced, and we invite any reader to see for themselves that Cohen's article is remarkably well-integrated with relevant scientific literature. Moreover, Burge and Burge's list of alternative references is misleading on this score: Most items on it (Burge, 2014a, 2014b; Rescorla, 2014) are contributions to an author-meets-critics exchange that neither cite nor discuss any relevant empirical work on visual perspective as it relates to shape perception (though some are empirically engaged in other ways); indeed, Burge (2014b) contains no references to any scientific work at all. Burge (2010) is the second author's monograph exploring objectivity in perception and cognition; we agree that it is a relevant source, though it is engaged in a much broader project than the narrower issues we consider here. Lande (2018) is by far the most relevant work on Burge and Burge's list, and it was accordingly cited multiple times in our article.

[10] Burge and Burge quote this passage too, but use its cautiousness against us. They write that we "clearly distinguish perspectival shape from the retinal image" and so they take license to attribute to us a much stronger view in which perspectival shape is separated from any retinal or projective properties. But in fact we distinguish these views precisely to clarify what we are *not* claiming, since we are aware that some philosophers *do* argue for perspectival properties conceived along these lines. We do not conclude that our results support an intermediate entity located between the perceiver's eyes and the world; we go out of our way not to draw this conclusion.

[11] Burge and Burge's mishandling of our views complicates other aspects of their discussion. For example, they report that they contacted multiple vision scientists whose work we quote in our article and found that "In each case, they hold views very different from the present authors' portrayals." This was already a somewhat puzzling statement given that only one of the works of vision science quoted in our main text has any living authors. (Indeed, the maximum number of quotations that Burge and Burge could be referring to is two: the passage from Murray et al.'s (2006) neuroimaging study, where Burge and Burge agree that our reading is "perhaps invited by some of Murray et al.'s terminology," and a passage from a textbook appearing in a footnote.) And Burge and Burge provide no details about the questions they asked or the answers they received. In any case, given their misconstrual of our aims, it is not clear what to make of their reporting. (Regrettably, we were not among the scholars Burge and Burge contacted for this sort of clarification.)

Importantly, on an accurate reading of our claims, Burge and Burge not only express sympathy toward them but seem to actively endorse them. They write: "If the authors were to claim merely that there is a viewpoint-dependent shape similarity in how distal shapes are perceptually represented (or in how they appear), the authors would be stating something that is already well-appreciated." But this *is* our claim. (Again: "Our claim is that frontal ellipses compete with rotated circles because of some shared aspect of their appearance, where this aspect is shared from certain perspectives but not others.") Burge and Burge are simply incorrect, as a matter of scholarship, that perspectival similarity in perception (or appearance) is "already well-appreciated," if by well-appreciated they mean uncontroversial, widely accepted, or any meaning in that vicinity. As we have shown in our original publications and again here in this discussion, many prominent contemporary scholars hold views that reject this supposedly well-appreciated claim, in clear writing that has been widely interpreted in the literature along these lines.[12] These are the same views and sources that Burge and Burge omit from their critique. If Burge and Burge find our claim obvious, so be it; this means only that our experiments were not designed for them. If anything, they or anyone else with that feeling could see our results as complementary to their views, providing additional empirical support for a position they accept but that others reject (as in Green, 2021).[13]

Moving Forward

Our experiments are in no way the last word on this deep, long-standing, and foundational issue about the nature of visual perspective. Indeed, one could even say they are among the first words in a new empirical conversation about this question (one perhaps started by Kelly, 2008, and Schwenkler & Weksler, 2019). How might that conversation productively move forward, both philosophically and empirically?

Critical Experiments and Scientific Tractability

One issue that remains unclear (both in Burge and Burge's discussion, and in the literature more generally) is the extent to which the present questions are ultimately empirical, or at least can be informed by experimental data. For some issues, Burge and Burge seem to suggest not. For example, when discussing our paradigm, they not only note the presence of uncontrolled low-level image properties (though, as we argue above, these are characteristics that favor our interpretation rather than oppose it) but also insist that the stimuli were "uncontroll*able*"—that no other version of this approach *could* have succeeded in generating relevant data for these questions. The support they provide for this claim is the principle that "Psychophysics attributes performance differences to a factor only if that factor has been isolated," where they further clarify that successfully isolating a factor would require that "all low-level image features were matched" across the critical conditions.

It is far from obvious that this follows. Of course, we agree that many low-level features constitute important confounds that must be ruled out (and we consider a wide array of them across our 10 experiments). But Burge and Burge's requirement that "all low-level image features" must be matched before inferences can be made about the cause of performance differences is far too strict as stated. First, not every unmatched low-level feature provides an *alternative* explanation for a given effect; as we note above in response to Argument 2a, some unmatched low-level features will tend to work against the hypothesized effect, such that their being unmatched is neutral or even favorable to the relevant high-level interpretation.[14] But second, the standard Burge and Burge give above is simply out of step with mainstream perception research, and would close the door to many valuable research programs in perceptual psychology. Burge and Burge seem to be saying that only a single critical experiment without any possible confounding factors can support inferences of the sort we are after. But many substantive views about perception (and many other topics, for that matter) are adjudicated not by a single critical result but rather by triangulating results from different studies with disjoint sets of alternative explanations (see, e.g., a related discussion in Morales et al., 2022). Rather than looking for a perfect experiment, such hypotheses are evaluated by how they cohere with an overall body of evidence, most individual pieces of which will necessarily be incomplete and imperfect—but not, just for this reason, irrelevant.

For example, a wealth of empirical evidence suggests that visual processing attributes "objecthood" to certain stimuli: We perceive not just features and locations but also cohesive bounded wholes (e.g., Feldman, 2003; Peterson, 2001; Scholl, 2001; an approving discussion of such work also appears in Burge, 2010, 2011). But any study of visual objecthood—say, one in which objects are contrasted with nonobjects—will inevitably be confounded in Burge and Burge's sense, if only because such studies require lower level cues to allow the visual system to segment the object from its background (at minimum, some kind of visual discontinuity, somewhere in the image, to indicate the object's boundary). Indeed, every study that has ever

[12] Our interpretation of Schwitzgebel's and Smith's views and their place in the literature is mainstream, shared by multiple scholars writing before and after us (e.g., Cohen, 2021; Green, 2021; Schwenkler & Weksler, 2019). For example, Green (2021), reviewing this work, describes perspectival similarity as an active, "controversial" question in the literature and characterizes these authors' views as follows: "[T]he slanted circle does not appear similar in any relevant respect to the head-on ellipse (Smith, 2002; Schwitzgebel, 2006, 2011; Hopp, 2013). […] This account does not predict any similarity between experiences of the slanted circle and the head-on ellipse." Similarly, Cohen (2021) describes the work of these same three authors as arguing that we see "roundness exclusively" when we look at rotated circular coins. We read these sources as Cohen and Green do.

[13] Despite this agreement on the question of *whether* there is viewpoint-dependent (i.e., perspectival) similarity in these cases, there may be differences in how we, Burge and Burge, and other scholars understand the nature or basis of this similarity. For example, their use of the terms "perception" and "perceptual representation" seem to be heavily informed by the framework developed, most prominently, in Burge (2010)—that is, as a process of "objectification" marked by perceptual constancies. Suggested in their response too is a distinction between *what* is represented in perception and *how* it is represented, which has philosophical origins in the Fregean notion of "modes of presentation." We briefly revisit this issue in the following section ("Moving Forward"). However, we do not further pursue these distinctions here because they are secondary to our own question of whether there is perspectival similarity in the representation of distal shape (where both we and Burge and Burge answer yes, while other scholars answer no).

[14] It is also possible to design studies in which different low-level features are present to greater or lesser degrees across different stimuli within a set, which allows for a modeling approach that regresses out the contribution of each feature to estimate the influence of the core variable of interest. Though this would not apply to our own designs, it is a common approach in other literatures (e.g., number perception; DeWind et al., 2015) and stands in contrast to Burge and Burge's purported psychophysical principle that all low-level features must be matched across conditions.

explored visual objecthood has had to include some low-level cue of this sort—including even creative approaches in which such cues are temporally delayed (e.g., Gao & Scholl, 2010) or when the boundaries are illusory contours produced by lower level cues elsewhere in the display (e.g., Moore et al., 1998), etc. Burge and Burge's standard would undermine the received interpretation of this entire body of work, because it is not possible to manipulate objecthood across conditions without introducing *some* unmatched low-level feature—and so any given study could not (according to the standard that "all low-level image features" be matched across conditions) implicate objecthood itself over and above the low-level features that cue it. It is perhaps not surprising, then, that Burge and Burge's presentation of this standard as a core assumption in psychophysics is given without any sourcing or argumentation; it is simply unworkable, at least as rendered in their text.[15]

If, in their view, no experiment like ours could provide "any evidence" bearing on these questions, then what kind of result would? (Burge and Burge do propose one experiment in a certain species of fish; but this seems to rest on some of their earlier misunderstanding of our claims.) In any case, we do not share Burge and Burge's pessimism about the scientific tractability of these questions. At the very least, we believe our more modest claims about perspectival similarity are amenable to empirical investigation—including, but not limited to, our own methodological approach.

Empirical Optimism and Future Directions

Where might this literature proceed next? One future direction could be to experimentally distinguish the different proposals for what grounds perspectival similarity in shape appearance. As noted earlier, Burge and Burge eventually come to embrace perspectival similarity (in line with our own conclusions, but contra many other scholars working in this literature), but they argue that awareness of the elliptical aspect of the rotated coin derives from "how" the object is represented, rather than "what" is represented. Though only a brief part of Burge and Burge's discussion, the view they gesture at resembles one developed by Lande (2018), who holds that the perspectival character of perception derives from the "structure" of perceptual representation, rather than from any represented perspectival properties. This account of perspectival similarity contrasts with the views of Hill (2016) and Noë (2004), among others, who hold that perception positively represents "appearance properties," including the elliptical aspect of the rotated coin. Can these two sorts of views be distinguished?

Here, too, we find ourselves more optimistic than Burge and Burge (who say of the views of Cohen, Hill, and Schellenberg that "no scientifically acceptable philosophical defense is possible"). One approach could be to ask whether the rotated coin's apparent ellipticity can "attach" to other stimuli, along the lines of illusory conjunctions (Treisman & Schmidt, 1982). When two or more items, such as a red square and a green triangle, are shown quickly and/or peripherally, visual processing sometimes exchanges their features, such that we may occasionally and illusorily experience a green square or a red triangle. If the elliptical aspect of a rotated coin is a proper visual feature, then perhaps it could become bound to the wrong object, such that subjects might incorrectly attribute ellipticity to some other nearby stimulus. But if the elliptical aspect of the rotated coin derives from the structure of perceptual representation without being a feature or property of its own, then one might predict against this sort of effect occurring. (One could also imagine a similar design for manipulations of size and distance.) Either outcome would be consistent with perspectival similarity (and so not inconsistent with the more general conclusion we ourselves draw), but certain results could perhaps tease apart different notions of what is responsible for such perspectival similarity.

Another approach might explore connections between perspectival appearance and mechanisms of perceptual grouping. When stimuli appear near each other in space, visual processing tends to group them together, in ways that are amenable to psychophysical investigation. Intriguingly, Rock and Brosgole (1964) demonstrated that grouping by proximity is driven more by "phenomenal proximity" (what we might call here "perspectival proximity") than by physical proximity. But proximity is only one of many grouping cues; another, grouping by similarity, arises when stimuli are seen to share visual features. For example, a square grid of uniformly spaced dots will appear to be organized into discrete rows if each member of the row is the same color (and a different color from the rows above and below it). In that case, another potential approach, so far unexplored to our knowledge, could ask whether perspectival shape can serve as a grouping cue. If several objects of different distal shapes are placed so that they have the same elliptical perspectival shape, does this similarity drive grouping processes? Here too, neither outcome would undermine broader claims of perspectival similarity, but may bear on more specific disputes about the explanation for such similarity.

Encouragingly, our own optimism about the empirical tractability of such questions appears to be echoed elsewhere in this literature. For example, Kelly (2008) reports pilot data from a priming experiment asking whether viewing rotated circular objects facilitates subsequent recognition of drawn ellipses. Complementarily, Schwenkler and Weksler (2019) propose an experiment to adjudicate perceptual versus postperceptual interpretations of perspectival representation (rather then sensory vs. perceptual interpretations), by varying working memory demands in tasks that ask subjects to report perspectival shape properties. Linton (2021), even while criticizing our work, shares a creative design using an elliptical cloud of points whose shape is visually distorted in different ways under monocular and binocular viewing conditions. Cheng (2022) outlines a neuroimaging approach based on repetition suppression, and Stewart et al. (2022) invoke perspectival appearance to explain similarity judgments in a mental rotation paradigm (see also Morales & Firestone, 2022). Still other empirical work could more directly explore the role of conscious awareness in these phenomena and results, which we discuss only briefly in our own work but which merits independent investigation (see, e.g., discussion in Cohen, 2021; Green, 2021; Morales, 2021).

Notably, each of these latter directions seems productive—and, especially, constructive. Regardless of whether these directions arise from researchers who broadly share our views, express some skepticism, or are genuinely undecided, they reflect an open-minded

[15] We do not foreclose the possibility of some nearby principle applying generally enough; but the one articulated by Burge and Burge—which is consistently presented using variations of the "all low-level image features" formulation—cannot be it. For an excellent discussion of these issues, including experimental strategies for implicating high-level properties even when they are "recognitionally coextensive" with corresponding low-level properties, see Block (2014; and even Burge, 2014a).

attitude toward the sorts of empirical approaches we have promoted ourselves, and they point forward in ways that will surely enrich a philosophical debate that has at times risked becoming stale and intractable. We hope the present discussion finds a similarly constructive course.

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