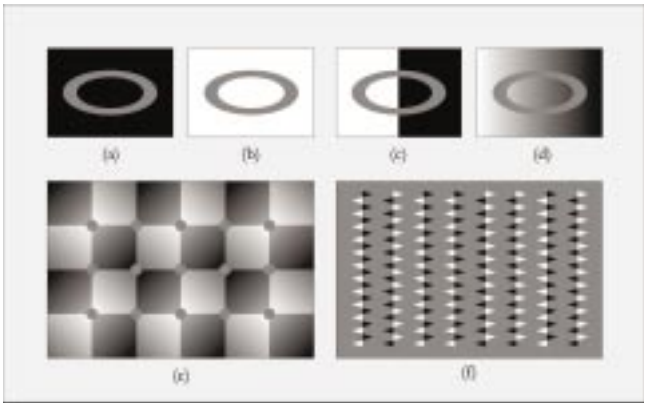

Figure 1 (Todorović). (a,b) *Simultaneous lightness contrast.* The two gray elliptical rings are physically identical but look different. (c) *The Koffka-Benussi ring.* The same ring set on a bipartite background looks different in the two parts, at least when one compares the extreme left and right ends. (d) *The gradient background effect.* The physically real black-to-white background gradient induces an oppositely directed illusory gradient in the physically uniform ring (McCourt 1982). (e) *The gradient chessboard effect.* The figure contains two types of squares, one type involving a black-to-gray gradient, and the other a white-to-gray gradient, in different diagonal orientations. All disks have the same reflectance, but some look dark gray, some medium gray, and some light gray. For related gradient effects, see Logvinenko (1999). (f) *The shimmering effect.* The figure consists of black and white triangles, distributed over a physically uniform background. However, the background interspaces between different triangle columns have different perceived shades of gray. For related effects involving backgrounds, see Adelson (1993) and Pinna et al. (2001).

whereas if the physical comparison yields equality and the perceptual comparison yields difference, or the other way around, the percept is nonveridical (see Todorović, in press, for extending this type of analysis to perceptual constancies). Appropriately elaborated, such an approach to perceptual truth and error, based not on cross-domain (physical-phenomenal) comparisons, but on relations of intradomain comparisons (physical-physical vs. phenomenal-phenomenal), should allow for assessment of perceptual veridicality without endorsing realism in the authors' sense.

Beautiful red squares

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Abstract: The reflectance types that Byrne & Hilbert identify with colors count as types only in a way that is more dependent on, and more relative to color perceivers, than their account suggests. Their account of perceptual content may be overly focused on input conditions and distal causes.

Byrne & Hilbert (B&H) defend the external physical reality of colors as mind-independent properties of ordinary physical objects against the objections of those who would deny their existence altogether, or psychologize them and drive their reality mentally inward. In their view, the redness of a tomato is as real a property of the tomato as its shape. They hold that from the facts about color perception and perceivers, "it does not follow that the colors themselves are in any interesting sense dependent on, or relative to, perceivers or mental events" (sect. 1.3.3). Though there is a sense in which the properties that B&H identify with colors do not strictly depend on perceivers for their existence, there seem to be other interesting and important respects in which the reality of such colors is relative to, or dependent upon, the specific causal structure and dispositions of color perceivers.

B&H identify colors with reflectance types (at least in the primary case of opaque objects and surfaces). Any such type will include many specific reflectances, and the crucial issue is the basis on which they all count as belonging to one and the same type. The specific reflectances will differ physically not only in their underlying realization, but in their particular reflectance profiles – the proportions of light at various wavelengths and intensities that they respectively reflect and absorb. They count as one type only in so far as they are treated as equivalent by human color perceivers. The problem of metamers makes this especially clear, but even in more ordinary cases, the relevant reflectance types will embrace a diversity of more specific reflectance profiles which count as belonging to the same only by virtue of their psychophysical equivalence, either relative to the response curves of some set of cones or, more likely, relative to the computations of the opponent process system.

The fact that any given object O has a reflectance of the relevant type GR – for example, that identified by B&H with unique green – is independent of the existence of any actual perceivers, in the sense that if all such perceivers were to cease to exist, or even if they had never existed, it would still be true that O would have the power to produce the relevant response in such perceivers if any were to come into existence. Despite being perceiver-independent in that strict sense, the sense in which the relevant reflectances count as being of a single type does seem *interestingly relative to a class of perceivers.* Consider an admittedly artificial parallel. Imagine that someone – call him Adam – makes a list that consists of the following four properties: being made of sulfur, of iron, of table salt (sodium chloride), or being spherical. Being categorically inclined, he deems all objects that satisfy one of the four conditions to be of a single type – call it the "Adam's list" type or type AL. The AL type is, at one level, a list-independent type for the reason that, if Adam and his list were to cease to exist or even if they had never existed, the bar magnet on my desk and the salt crystals in my shaker would still be of type AL. However, it is equally clear that things of type AL have no interesting commonality other than their shared inclusion in Adam's list.

Do the reflectance types that B&H identify with colors, similarly count as types solely on the basis of their shared relation to color perceivers? They may not be quite as heterogeneous as the AL type items, but they are nonetheless diverse and there are likely no laws, causal explanations, or natural regularities into which they enter other than those that involve their interactions with color observers, as B&H more or less acknowledge.

In that respect, the relevant reflectance types are very much unlike the shapes of objects. In rejecting dispositionalism about colors, B&H ask rhetorically why those who suggest we identify colors with the dispositions to produce color experiences (under the relevant conditions) are not equally inclined to do the same for shapes, since an object's being square will dispose it to look square under the appropriate range of conditions. The obvious answer is that shapes, unlike colors, enter into a great many causal regularities not involving shape perceivers. The objective reality of shapes is anchored largely by their nonperceptual causal roles. Though the specific reflectances collected within a reflectance type may individually have some such nomic nonperceptual roles, it is unlikely that the reflectance types themselves enter into such regularities. In that sense, the reflectance types that B&H identify with colors, owe their integrity as types to perceiver-involving relations far more than do shapes. This of course does not imply the truth of dispositionalism, which identifies colors with dispositions or powers rather than with their categorical bases. However, it does seem to imply that B&H's reflectance types cohere *as types* in a way that is parasitic on their dispositional roles. An object's being red thus may be more like its being beautiful than its being square.

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One might dispute the analogy between reflectance types and AL types by arguing that the former and not the latter are perceptually detectable. The fact that they are actually detectable is of course dependent on the existence of the relevant sorts of color perceivers. AL types are in principle perceivable, and indeed we could extend our imagined scenario so that Adam constructs a set of robots to search for and collect AL type objects using sensors and post-sensor analyzers that reliably produced AL representations when and only when an AL type object was present. Given the right sort of story, it would be fair to say that AL types were perceivable relative to the robots. Thus, in terms of perceptibility, AL types differ from reflectance types at most in *actual, in practice* perceptibility, which does not seem to undercut the analogy to any significant degree.

Let me mention one other difficulty which cannot be developed here at any length. B&H are concerned with experiential content and the properties that objects appear to have in perceptual experience. Their focus is on the distal causes of the relevant experiences and thus it is not surprising that they appear sympathetic to covariational accounts of content. However, mental content, including that associated with perceptual experience, is unlikely to be determined by input relations alone. Surely two creatures – two perceivers – could have detectors that detected exactly the same features of the external environment but which appeared to them quite differently. To one creature the detection of those features might make the relevant object appear nutritious and food-like, while to the other those same features would appear as noxious. The same distal tracking conditions would hold, but the content of the perceptual experience would surely differ.

Some may find it difficult to accept that objects can look nutritious or noxious, as opposed to being inferred to be such. I have no such difficulty but if you do, then shift from vision to olfaction, where it seems obvious that such properties can be smelled and where two creatures might differ drastically in the content of their perceptual experience despite the exact coincidence of their tracking and detection profiles. Insofar as perceptual content is not determined solely by input relations, the content of color experience may be determined by inner factors over and above the relevant facts about their distal causes on which B&H focus.

Confusion of sensations and their physical correlates

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Abstract: The authors favor a "color realism" theory that considers colors to be physical properties residing in objects that reflect, emit, or transmit light. It is opposed to the theory that colors are sensations or visual experiences. This commentary suggests that both theories are correct, and that context usually indicates which of these dual aspects is being considered.

As the authors recognize, their position that colors are physical properties of objects, rather than the products of sensory evaluation of optical stimuli, is not held by the majority of color scientists. There is good reason for those doing experimental work in vision research to consider that color does not reside in objects or light rays, but rather in the visual response of color by viewers.

After many experiments with prismatic separation of colors and the nonadditive effects of mixing colored lights and pigments, Newton (1730/1952) also came to the conclusion that colors are sensations or visual experiences rather than physical properties. He stated that,

> For the Rays to speak properly are not coloured. . . . so Colours in the Object are nothing but a Disposition to reflect this or that sort of Rays more copiously than the rest; in the Rays they are nothing but their Dispositions to propagate this or that Motion into the Sensorium, and in the Sensorium they are Sensations of those Motions under the Forms of Colours. (Newton 1730/1952)

Newton also wrote, "And if at any time I speak of Light and Rays as coloured or endued with Colours, I would be understood to speak not philosophically and properly, but grossly, and accordingly to such Conceptions as vulgar People in seeing all these Experiments would be apt to frame."

I humbly differ from Newton on one point: It is not only "vulgar people" who fail to make the distinction between the stimulus serving as the physical correlate and the sensation it produced. Because it is the vital function of sensory input to allow us to evaluate accurately and respond appropriately to external conditions and events, it is not surprising that aspects of sensation are interpreted in terms of their external physical correlates (see my target article in this journal [Warren 1981] on the physical correlate of sensory intensity).

The distinction between a stimulus and the sensory/perceptual response that it produces applies to hearing, as well. Tones are in some respect similar to color: Changing the frequency or wavelength of the stimulus produces qualitative changes in the sensations that are evoked. According to the "official" definition of tones by the American National Standards Institute (ANSI 1973), a tone is both (1) a "sound wave" and (2) a "sound sensation." This acknowledgment of dual usage of the term has caused no apparent concern or dissention among those working in audition: They readily make the proper distinction based upon context. As Newton observed, it is much simpler to refer to both a stimulus and its sensory correlate by the same term, while recognizing the distinction; for example, to describe both the pigments of a tomato and its appearance as red, or both the sound of a tuning fork and the pitch it produces as a tone.

In section 1.3.4 entitled "Subjective, objective phenomenal, and physical color," Byrne & Hilbert (B&H) state that "nothing but confusion can come from using color terms to 'denote sensations.'" On the contrary, it appears that emphasis on reserving color terms for the inherent "physical" color of objects, such as a ripe tomato, can make understanding color appearance more difficult. An example of such a difficulty is the shift in color observed by Purkinje while seated in a garden in the gathering twilight. He noted that the red flowers seemed black, while the blue flowers seemed gray. We now understand the basis of the "Purkinje shift" in terms of the consequences of switching from cone to rod receptors in the retina. But, if a blue flower appeared gray in the twilight, what was its "true" color at that time? Posed in this manner, the question cannot be answered: Although the physical nature of the flower's pigments is unchanged, its color to an observer is no longer blue.

In their Abstract, B&H present their view that colors are physical properties of objects and the light they reflect, rather than the subjective responses they produce when being seen. Perhaps it is not necessary to choose between these views. The acousticians may have the right laissez-faire approach: Use the same term to describe both the stimulus and the sensory/perceptual response, and allow the context to make it clear which aspect is being considered.

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