Color as a Material, not an Optical, Property

Commentary on

Byrne & Hilbert's "Color Realism and Color Science"

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Abstract

We argue that color, in the sense most behaviorally relevant for humans and other animals, includes much than reflectance. For all animals color is an indicator of the substance and state (including internal state) of objects, for which purpose reflectance is just one among many relevant optical properties. Further, linguistic evidence shows that for humans color includes optical (and nonoptical) properties of objects more closely related to the material of the object than is reflectance. Rather than attempting to reduce color to a simple physical property, it is more realistic to embrace the full phenomenology of color experience.

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What's Real About Color?

Evidence from ethology and linguistics suggests that, in *reality*, there is much more to color than reflectance, and therefore that defining color in terms of reflectance is an *unrealistic* narrowing of the concept. The target article does discuss the ecological approach to color, but the authors are more concerned with whether it contradicts physicalism than with what it can tell us about the function of color vision and the reality of color. What, then, are the functions of color vision in humans and other animals?

Certainly, for nonhuman species, abstract color and reflectance have little ecological relevance. With rare exceptions, such as the parrot Alex (Pepperberg 2002), nonhuman animals are not required to make abstract judgments such as "Is this green?" or "What color is this?" Rather, I will argue that color is primarily relevant only insofar as it is correlated with the substance and state of an object.

In an evolutionary sense, one of the primary functions of color vision is to separate objects from the background. Typically an object of interest (such as a prey species or edible plant) is of a different material than the background, and therefore it will affect light differently. Some, but not all, of this difference is a result of reflectance.

Another important function of color vision is *recognition*: determining the behaviorally relevant kind of an object (food, predator, nest, etc.). For this purpose, the animal needs optical properties that are correlated with the kind of object and independent of irrelevant environmental factors, such as illumination and distance. Therefore the nervous system constructs invariants, such as color and size constancy. Certainly, reflectance is among the invariants extracted by color vision, but there is no reason to suppose that it, as opposed to ecologically more relevant properties, is salient for most animals. (This is one reason that it is so difficult to test for color vision in nonhuman species; e.g., McFarland 1987, pp. 76-77.)

A third important function of color vision is to determine the (behaviorally relevant) state of an object (Is the fruit ripe? Is the water potable? Is the mate receptive?). In many of these cases the primary relevance of the surface state is as an indicator of the internal state of the object. Again, reflectance is irrelevant except as a component of a wider range of optical properties correlated with the ecologically relevant state of the object.

The foregoing is not intended to be an exhaustive list of the functions of color vision, but it should show that color vision is used to extract a range of optical properties correlated with the substance and state of an object. Certainly, color is real, but there is much more to it than reflectance.

It is also important to keep in mind that most ecologically-relevant categories (such as EDIBLE-BANANA) will be multimodal, integrating visual, olfactory, tactile, kinesthetic, and other sensorimotor properties. This suggests that it may be a mistake to consider the visual aspects of color in isolation from the nonvisual.

But is it Color?

One might object that although many optical properties are relevant to animals, they are not, properly speaking, color. However, I will argue that for humans, as for nonhuman animals, there's much more to color than reflectance. The authors state their intention to treat color realism as "primarily a problem in the theory of perception, not a problem in the theory of thought or language," but this begs the question of whether color, in any important sense, can be so treated. They distinguish the problem of color realism from the investigation of color as a folk category, but the possibility remains that the folk category is the only (ecologically) real category. To see this, we can look at the prescientific use of words for color and for particular colors.

I apologize for spending so much space on ancient color terms, but there are advantages to looking at languages that are not our own and at early color terms, whose meanings are uncontaminated by assumptions about a linear color spectrum.

For example, the Latin word *color*, which means appearance and complexion as well as color, comes from an Indo-European root that means to cover or conceal and also gives us such words as "hall," "hull," "helm," "occult," and "cell"; that is, *color* originally refers to "that which covers" an object (Watkins 2000, s.v. kel-^{2}). Further, the primary meaning of the ancient Greek word *chrôma* is skin, and only secondarily complexion and color (Liddell, Scott & Jones 1968, s.v.). It comes from the Indo-European root *ghrêu-*, which means to rub or grind; one form gives Greek *chrôs* (Watkins 2000, s.v. ghrêu-), which means skin, flesh, body, and only secondarily the complexion and color of the skin (Liddell, Scott & Jones 1968, s.v. chrôs); *chrôma* also derives from this form. Again, we see that the concept of color refers to surface appearance, especially as an indicator of internal state (as in complexion). Similar observations apply to words for specific colors.

Ancient Greek color terminology is notoriously complex (vol. 1 of Maxwell-Stuart 1981 is devoted to one word, *glaukos*). Consider *porphureos*, commonly translated "purple"; it is famous as the royal color, the unauthorized use of which could be interpreted as treason (Gage 1993, p. 25). But what color is it? In addition to purple, lexicons list as its meanings dark red, crimson, and russet (Liddell & Scott 1889, s.v.). Therefore we can see why Homer uses it to describe blood, but why is the stormy sea *porphureos* (*Iliad*, I.482)? And why the rainbow (*Iliad*, XVII.547)? As Liddell & Scott (1889, s.v.) remark, "the word does not imply any definite color." Rather, for Homer's audience, the word referred first to the gleaming, glancing play of light on disturbed water, and by extension to any shimmering, lustrous, lurid, or glittering play of color; "royal purple" had this quality (Cunliffe 1924, s.v.; see also Gage 1993, pp. 16, 25-26, for more on *porphureos*).

Another, but especially informative, example is the Greek word *chlôros*, nominally translated "green." We are not surprised that wood and seawater may be described as *chlôros*, but why is it applied to sand, people, cheese, fish, flowers, fruit, gold, tears, and blood (Liddell, Scott & Jones 1968, s.v.)? Some of these usages can be explained by assuming that the range of hues includes pale green, greenish yellow, yellow, and perhaps any pale color. However, the core meaning is revealed by its Indo-European root *ghel-*^{2}, which means to shine and by extension any bright material; from this root we also get such words as "yellow," "gold," "gleam," and "gloaming" (Watkins 2000, s.v.). However, in ancient Greek the meaning is further extended in a way that is easy to understand, for we use "green" similarly: to describe something that is moist (as in green wood), living, fresh (or unsalted), freshly cut or picked, blooming, unripe, etc. (Liddell, Scott & Jones 1968, s.v. chlôros). Thus we understand how cheese, fish, flowers, fruit, and blood can be *chlôros*.

Here we come close to the crux of the matter: these supposed color terms have semantic fields that refer to a range of ecologically relevant appearances (correlated with underlying properties, such as freshness), which correspond only loosely with reflectance types. If we try to reduce the meanings of such terms to a narrow physical property, such as reflectance, we will be ignoring much of their meaning.

It's the standard bait-and-switch: replace a complex concept by a simpler one, explain the simpler, and claim (or leave to be inferred) that you have explained the more complex. I don't claim that the target article is attempting to mislead us in this way, for the authors are quite clear and explicit about their intentions. Nevertheless, I think that they have sold color short.

Conclusions

One may assume that color is primarily a simple, abstract physical property, such as surface spectral reflectance and that all the rest is inessential complication, connotation, association, and other psychosocial baggage, but I think the evidence points in the opposite direction. Color is fundamentally concrete, material, and deeply embedded in the lives, ecologies, and evolutions of the organisms that perceive it. Abstraction comes later, if at all, from an attempt to give a simple scientific description of the phenomena. This is the reason that color does not enter into any fundamental physical theories: it is not a physical, but a psychobiological category.

Much of the difficulty with color arises from trying to reconstruct a folk concept as a scientific or philosophical concept. This is unnecessary. We have or can define the scientific concepts that we need, such as surface spectral reflectance and productance. Further, the attempted reconstruction is counterproductive, for it diverts us from the interesting and important task of elucidating the rich and concrete phenomenology of color as it is actually experienced by humans and other animals.

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