ballroom, knife protruding from his back) had some person or other not murdered him. (2) We have no trouble understanding how someone could be the murderer of Professor Plum without our having decisive evidence of his guilt. Here, belief (1) creates a presumptive prejudice to the effect that Professor Plum was murdered, and belief (2) explains away potential counter-considerations engendered by our lack of evidence about specific individuals. This combination of beliefs, then, leads us to think that there is a fact of the matter about who murdered Plum, even if that fact of the matter is beyond our ken.

Contrast the case of the wanted independent standard for color perception. Here our general background beliefs both fail to establish a presumptive prejudice in favor of an independent but possibly unknown standard, and fail to override the counter-considerations engendered by our lack of evidence. Indeed, the failure of several hundred years of systematic efforts directed at articulating standards of this kind establishes a presumptive case *against* their existence. (The history of these efforts is recounted in Hardin 1993, pp. 67–82; see also Cohen 2003.) As such, B&H's view that there is an epistemically unavailable standard strikes me as a piece of unwarranted optimism.

Suppose that, as I suspect, there is no well-motivated independent standard to arbitrate between the two representations of C1's color. Must we, then, endorse color eliminativism? Like B&H, I hope to avoid this outcome: Eliminativism amounts to such a radical revision of our pretheoretical views about the world that it should be regarded as a position of last resort. (As usual, Hume [1762/1986] is eloquent on this point: "Philosophy scarce ever advances a greater paradox in the eyes of the people, than when it affirms that snow is neither cold nor white: fire hot nor red" [letter to Hugh Blair of 4 July 1762, printed in *Mind,* October 1986].)

Luckily, there are noneliminativist ways of accepting the absence of a perceiver-independent standard for C1's color. Namely, we can hold that the alternative representations of C1's color (the way it looks to you, the way it looks to your colleague) are *both* veridical. There are a number of ways of fleshing out this suggestion, but one of the most popular is to construe colors as relativized to perceivers. (The dispositionalist view B&H consider [and reject as unmotivated] in section 2.2 is one account of this type, although there are a number of others. Consequently, the point I am pressing is one way of providing the motivation for such views that B&H think is lacking.) In the case at hand, this would amount to saying that C1 exemplifies both of these color properties: unique green to you, and bluish green to your colleague. This view both frees us from having to answer the otherwise pressing, but apparently unanswerable, question of whether C1 is unique green or not, and explains why past efforts to answer it have failed (namely, according to this view, there is no nonarbitrary reason for preferring either choice over the other). This is all to the good: Hard cases make bad law.

The view I am recommending is a species of realism, in that it insists that colors are real (not merely apparent) properties of objects. (A number of authors have objected that such views unacceptably preclude erroneous color attributions [e.g., see Hilbert 1987, p. 8, and Matthen 2001]. For a response to this objection, see Cohen 2000; 2003.) However, unlike B&H's preferred form of realism, it accomodates the data about perceptual variation without requiring either hard choices or unwarranted optimism. As such, I believe this view is a more attractive alternative for those in the market for a realist account of color.

True color only exists in the eye of the observer

Frans W. Cornelissen,[a] Eli Brenner,[b] and Jeroen Smeets[b]

[a]*Laboratory of Experimental Ophthalmology, School for Behavioral and Cognitive Neurosciences (BCN), University of Groningen, 9700 RB Groningen, The Netherlands;* [b]*Department of Neuroscience, Erasmus Medical Center, 3000 DR Rotterdam, The Netherlands.*
f.w.cornelissen@med.rug.nl brenner@fys.fgg.eur.nl smeets@fys.fgg.eur.nl http://www.eur.nl/fgg/neuro/people/smeets

Abstract: The colors we perceive are the outcome of an attempt to meaningfully order the spectral information from the environment. These colors are not the result of a straightforward mapping of a physical property to a sensation, but arise from an interaction between our environment and our visual system. Thus, although one may infer from a surface's reflectance characteristics that it will be perceived as "colored," true colors only arise by virtue of the interaction of the reflected light with the eye (and brain) of an observer.

Color vision evolved as a means for organisms to gain information about the world from the light reflected (and occasionally emitted) by surfaces. Color vision enables organisms to detect and recognize objects on the basis of spectral as well as intensity (luminance) differences. Reflectance characteristics can provide useful information about an object, such as whether a banana is ripe or not. If it looks yellow, the banana is likely to be ripe. But is the banana really yellow? In a sense it must be, because we are very consistent in categorizing surfaces by their color. On the other hand, we are known to misjudge reflectance properties when the illumination is unusual, or in the case of metamers. This supports the notion that the goal of visual processing is to provide fast and adequate, and not necessarily the best (Brenner & Smeets 2001), estimates of physical properties. In the case of color vision, the estimate should be sufficiently reliable for judging whether, for example, bananas are ripe under natural lighting conditions.

The segregation of reflectance properties into colors is not an arbitrary association between surface reflectances and color names that is learned during development (Brenner et al. 1985; 1990; Di et al. 1987), but is determined by the spectral sensitivity of the cones and the way their outputs are combined during subsequent neural processing. Most of the variance in natural reflection and illumination spectra can be accounted for by using a set of only three basis functions (for an overview, see Lennie & D'Zmura 1988). Thus, crude sampling with three adequate types of sensors (the cones) would allow us to discriminate between most of the different spectral reflectances present in our environment. In the course of evolution, our ancestors presumably acquired cones with spectral sensitivities that were suitable for the existing visual environment and their own behavioral needs (Regan et al. 2001). In our opinion, the colors that we perceive are the outcome of the way that our visual system uses the signals of the three cone types to make order of the spectral (and in particular, the reflectance) information present in the environment. Thus, we can agree with Byrne & Hilbert (B&H) that colors are related to physical properties (i.e., reflectance spectra), but not in the way they propose, because we will argue that colors only exist in connection to an observer.

For our visual system, a fundamental problem that occurs when estimating a surface's properties is that the spectral composition of the light reaching the eye is the product of the surface's reflectance and the spectral content of the illuminant. For spectral information to be useful, one must be able to distinguish surface properties from those of the illumination. Humans and many other animals can somehow recognize colors under a wide range of illuminations (Arend & Reeves 1986; Bauml 1999; Cornelissen & Brenner 1995, Dorr & Neumeyer 1996; Foster & Nasciamento 1994; Foster et al. 1997; Ingle 1985; Land & McCann 1971; Lucassen & Walraven 1996; Troost & De Weert 1991; Werner et al. 1988). That they are able to do so, can be attributed to the ingenuity of their color vision systems, which, in many ways, can be understood to be a collection of "tricks." Cone adaptation is a trick that reduces the sensitivity to longer-term spectral biases in the visual environment (Von Kries 1905). An emphasis on the ratio between the stimulation of different kinds of cones (color opponency), rather than on the cone responses themselves, is a trick that makes color vision independent of the level of illumination (Brenner & Cornelissen 1991; Foster et al. 1997; Jameson & Hurvich 1961). Comparisons between the stimulation at different spatial locations (spatial opponency) is a trick that makes color vision less dependent on the chromaticity of the illumination (Brenner & Cornelissen 1991; Brenner et al. 1989; Walraven et al. 1987).

Relying on such tricks has its consequences. For example, biases in the chromatic content of neighboring surfaces influence a surface's apparent color by chromatic induction (Brenner et al. 1989; Cornelissen & Brenner 1991; Walraven 1973). Perhaps that is why the influence of the color of neighboring surfaces is reduced if the scene is very colorful (Brenner & Cornelissen 2002). The use of tricks such as those mentioned above means that not only the cones themselves, but also the subsequent connectivity, will influence the way that the spectral composition of the light reaching the eye is transformed into perceived colors.

In the target article, B&H argue that colors are real physical surface properties. We maintain that the colors that we perceive arise from interactions between our visual system and the spectral information in the environment, and therefore cannot be physical properties of the surfaces alone. B&H (section 3.4, para. 10) in a way come close to this conclusion when they point out that we have no unbiased and independent means to determine an object's "physical color" because only human (and perhaps animal) responses can be used to determine it. This ultimately reduces the idea, that objects are colored, to an untestable belief. We are less pessimistic about the possibilities of studying the perception of surface colors, because we see color vision as a systematic interaction between our visual system and the light that reaches our eyes when reflected from surfaces in our surroundings. Thus, bananas are yellow (at least for human observers) because our visual system responds to them in a certain way.

To provide an analogy somewhat akin to one presented by B&H (sect. 1.1, para. 4), we point out that whether a specific substance can be considered to be "food" depends on whether the organism in question can digest it. Grass is food to a cow, because its stomach and intestines can digest it. For us, grass is not food, because we cannot digest it. Thus, being food is not a property of the grass. There is no food without an organism that can eat it. *Color is like food in this respect.* Whether a particular reflectance spectrum becomes a color depends on the presence of an organism with a suitably equipped visual system. Colors can therefore only arise by virtue of an eye and brain of an observer. Whether this implies that colors should be considered to exist only "in the mind" is a matter of taste.

ACKNOWLEDGMENT
The authors are supported by Grant 051.02.080 of the Cognition Program of The Netherlands Organisation for Scientific Research (NWO).

Orange laser beams are not illusory: The need for a plurality of "real" color ontologies

Lieven Decock[a] and Jaap van Brakel[b]
[a]*Faculty of Philosophy, Tilburg University, 5000 LE Tilburg, The Netherlands;* [b]*Institute of Philosophy, University of Leuven, 3000 Leuven, Belgium.*
l.decock@uvt.nl Jaap.Vanbrakel@hiw.kuleuven.ac.be

Abstract: Reflectance physicalism only provides a partial picture of the ontology of color. Byrne & Hilbert's account is unsatisfactory because the replacement of reflectance functions by productance functions is ad hoc, unclear, and only leads to new problems. Furthermore, the effects of color contrast and differences in illumination are not really taken seriously: Too many "real" colors are tacitly dismissed as illusory, and this for arbitrary reasons. We claim that there cannot be an all-embracing ontology for color.

Byrne & Hilbert's (B&H's) color realism, grounded in reflectance physicalism, only provides a partial picture of the ontology of color as we know it. Many aspects of human color vision are neglected or sidestepped in their account. This sort of critique is not new, but B&H's responses to earlier critiques (e.g., Campbell 1993) are not satisfactory.

Since reflection is not the only physical process underlying color perceptions, what the authors call "productances" are introduced to modify surface reflection functions into more general functions, so that processes like absorption, emission, and so forth. (Nassau 1983) can be taken into account. However, the idea of productance functions remains sketchy. At no point in the target article is the precise relation between productance and color given. If, as B&H say, "productances are always *relative to an illuminant*" (sect. 3.1.2, emphasis in original), prima facie color is no longer an independent property or disposition of a surface. If the productance of a surface is relative to the illuminant, it becomes unclear what the color of the surface is. Is it to be equated with the productance function or with the productance function relative to an illuminant? If the productance function is presented as $p(\lambda, I)$, that is, a binary function taking as domain pairs of wavelengths and illuminants, and as range the positive real numbers (since values larger than 1 are possible), then it is not clear whether the color of the surface should be identified with the binary function $p(\lambda, I)$ with variable I, or with the simple function $p(\lambda, I_a)$ for a given illuminant I_a. On the first horn of the dilemma, the direct correspondence between physical color and perceived color is broken, because in a given situation, one would not perceive "the" color of a surface, but only one aspect of the color of a surface. On the second horn, some surfaces no longer have a unique color, because for each illuminant I_a, the simple function $p(\lambda, I_a)$ will be different. With this option, the relation between perceived and physical color is restored, but at a high cost. The advantage of reflectance physicalism over the wavelength conception of color (Hilbert 1987, p. 7) would be that overall illumination could be neglected, because of color constancy. But if illumination plays an essential role in how the color of a surface is perceived, we may as well take the light that reaches the eye as the "real" physical base on which color perception supervenes.

Also the role of contrast effects is underestimated. In section 3.1.3, B&H discuss related and unrelated colors. They reject the objection that brown cannot be a surface color, because unrelated colors that are seen under laboratory conditions are less normal than related colors. However, the problem of contrast effects is much more serious. Even if a surface is presented in a surrounding containing all the other colors that are normally necessary for its perception, still its perceived color can change dramatically by local changes in the colors surrounding it. By means of contrast effects one can make any surface look like almost any color (Whittle 2002). Hence, it may be more appropriate to regard the color of a surface as being a relation between its reflectance function and the reflectance functions of the background and surrounding surfaces, again undermining B&H's basic ontological claim that a perceived color can be identified with the surface reflectance or productance function of an isolated object.

And there are other limitations. Sometimes, perceived colors are totally unrelated to the reflection function of the surface or volume one is looking at. Take, for example, the color of an orange laser beam. It has a very vivid color. However, if we interpret this phenomenon according to B&H's theory, the object one is looking at is a cylinder of air. But the reflectance function of this cylinder is totally unrelated to the perceived color. Hence, B&H would have to say that the vivid orange is, in fact, an illusory appearance. A more appropriate way of regarding this case is by claiming that one is seeing the color of the laser beam rather than the color of a cylinder of air. A similar case is the projection of a film on a white screen. Again, the perceived colors are totally unrelated to the normal reflection function of the screen. Should we therefore conclude that one does not see colored figures on the screen? Again, the troublemaker in these examples is the assumption that colors