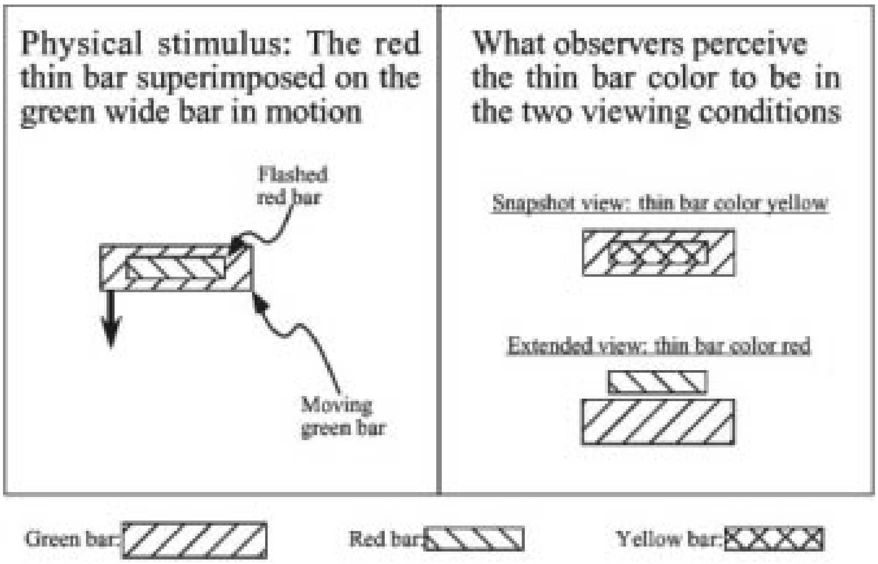

Figure 1 (Nijhawan). The left panel shows the physical stimulus at the instant the thin bar is flashed. The bold arrow shows the direction of motion of the green bar. The right panel shows what the observers perceive in the "snapshot" and the "extended" views. For simplicity, the background, which was black in the actual experiment, is shown as white.

the flashed red bar appears off the stationary green bar, in a position shifted in the direction of pursuit, and the color of the shifted bar is seen as red instead of yellow (Nijhawan et al. 1998).

The authors may argue that the above results are based on flashed objects, which are highly unnatural stimuli. Consider, however, stimuli with the time profile of a brief flash (abrupt onset followed quickly by offset) more generally; such stimuli are common for the tactile system, and have contributed to its evolution. It has been suggested that visual systems with image forming eyes have evolved from the more primitive touch based systems (Gregory 1967; Sarnat & Netsky 1981). This view is consistent with the fact that multimodal neurons receiving sensory information from more than one modality (e.g., vision and touch) are found in primates (Rizzolatti et al. 1981) and lower vertebrates (Nauta & Feirtag 1979). Furthermore, it has been argued that there are no clear-cut boundaries between the modalities (Shimojo & Shams 2001), and cells that typically belong to one modality can be recruited to function for another modality (Hyvarinen et al. 1981). These considerations lead me to suggest that flashes activate neurons for which stimulation with this time profile is common. This predicts that perception of flashes should share common features with other stimuli, such as a mechanical stimulation of the skin, that have an abrupt onset followed quickly by offset (e.g., a brief tap on the skin surface). The sensed position of a tap on the observer's hand (say) occurs in hand-centered coordinates, and shifts with the movement of the hand. This explains why the perceived position of the flash occurs in retina-centered coordinates, and appears shifted in the direction of eye-movement.

B&H are correct in raising "Berkeley's challenge," which says that perceived color is not any more subjective than the more "basic" features such as object shape. However, if something as basic as visual location of objects in space is not physically "given," how can color be? The above experiments suggest that the response of color-sensitive neurons (which perhaps exclusively serve a visual function) is modulated by the sensed spatial coordinates of objects.

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Have Byrne & Hilbert answered Hardin's challenge?

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Abstract: I argue that Byrne & Hilbert (B&H) have not answered Hardin's objection to physicalism about color concerning the unitary-binary structure of the colors for two reasons. First, their account of unitary-binary structure seems unsatisfactory. Second, *pace* B&H, there are no physicalistically acceptable candidates to be the hue-magnitudes. I conclude with a question about the justification of physicalism about color.

In their impressive target article, B&H attempt to answer Hardin's objection to physicalism about color. In my opinion, the attempt doesn't succeed. First, their account of unitary-binary structure in terms of the representation of four hue-magnitudes (call the account "MR") seems mistaken. Consider a possible world *W* where, as it happens, everything that is visually represented as circular is visually represented as (having a ratio of) **R** and **Y**. In *W*, circularity satisfies B&H's formula, but it is not binary reddish-yellowish. It would not be satisfactory for B&H to reply that the reason why circularity in *W* is not reddish-yellowish is that it is not a color, that is, on B&H's view, an SSR-property. Why should an SSR's satisfying B&H's formula suffice to make it reddish-yellowish, while a shape's doing so does not suffice? Adding the modal operator "necessarily" to the original account may solve this problem (since in *W* it only *happens* to be the case that circularity satisfies B&H's formula), but it raises another one. Since it is necessary that nothing is visually represented as prime, it is necessary that everything that is visually represented as prime is visually represented as **R** and **Y**. But primeness is not reddish-yellowish. To rule out such vacuous cases, a further proviso must be added to the effect that the property involved is possibly visually represented. Perhaps MR could be amended to avoid counterexamples, but even then I don't think that it could be right.

B&H don't say what they mean by "account," but I take it that at a minimum, for q to be an adequate account of p, q must specify the way the world must be in order for p to be true.[1] But what could make it the case that "That shade of orange is reddish-yellowish," for instance, that it has the very complicated truth-condition B&H must assign to it? When we utter such a sentence, we don't mean to attribute to the color a complicated relation to perceivers. Rather, it seems we mean to say something about its intrinsic nature. And an externalist/natural-kind account of how the sentence could have the required truth-condition seems inapplicable in this case. For this and other reasons (cf. Pautz 2002b), I think that MR does not correctly capture the unitary-binary distinction, and hence cannot be used to answer Hardin's challenge.

Even aside from these problems there is reason to think that MR cannot provide a solution to Hardin's challenge. MR appeals to four hue-magnitudes, but it is hard to see how these could be extradermal physical properties. B&H say that an object is reddish to a certain degree if it produces more L-cone activity than M-cone activity (sect. 3.2.3). However, they don't want to identify a certain degree of reddishness with a disposition involving perceivers, but rather, with a corresponding extradermal physical property not involving perceivers (B&H, personal communication). What is this physical property? They don't say. Could it be the disjunction of all the SSRs of all actual or possible objects that are (in their view) reddish to that degree? Or maybe the property of having an SSR whose S*, M*, and L* components stand in a certain complicated relationship, where S*, M*, and L* correspond to the short, medium, and long regions of the visible spectrum (Bradley & Tye 2001)? Aside from *a priori* problems to do with the explanatory gap between qualities and quantities (a problem which B&H don't address), my main worry is that none of the extradermal candidates stand in the same higher-order relations of congruence and proportion that the degrees of reddishness, and so on, stand in. It doesn't even make sense to say that the difference between the disjunctions of SSRs D1 and D2 is the same as the difference between the disjunctions of SSRs D2 and D3, or that D1 is twice as great as D2, while it certainly makes sense to say such things of degrees of reddishness. As for the second candidate, equal differences between degrees of yellowishness, for instance, do not map onto equal differences between the corresponding values of [(L* + M*) – S*], because the relationship between these variables is nonlinear (Werner & Wooten 1979). Since degrees of yellowishness and the corresponding values of [(L* + M*) – S*] stand in different congruence relations, they cannot be identical. (Compare pitch and frequency.) B&H might reply by adding co-efficients, exponents, and so on (following Bradley & Tye 2001). But these operations don't apply to properties (it makes no sense to square a property), but to the numbers by which we index them. So this maneuver doesn't yield a new set of physical properties which do correlate with degrees of yellowishness, but only a new way of assigning numbers to objects, that is, a new set of relations between objects and numbers. And degrees of yellowishness certainly aren't relations to numbers.

MR also appeals to visual representation, but there is very good reason to think that it cannot be reduced. (I understand reduction broadly here to include identification with physical properties *or* physically-realized functional properties.) Visual representation is a relation between people and extradermal properties such as colors (on B&H's view, SSRs). (Strictly speaking, it is supposed to be a relation between peoples' *experiences* or *brain states* and *propositions*, but such niceties will not matter here.) So, in B&H's view, if visual representation is identical with a physical/functional relation, it is identical with a physical/functional relation between people and (inter alia) SSR properties. Call this the "Relationality Constraint." But what physical/functional relations obtain between people and SSR properties to which visual representation might be reduced? It seems that the only candidates are *extrinsic*, causal/teleological relations (Dretske 1995; Tye 2000). But there are good reasons to think that visual representation cannot be such a relation.

First, there are serious problems of detail (Loewer 1997). Concerning causal theories, B&H themselves say "we do not actually find any of these theories convincing" (sect. 2.6). Second, there appears to be a very simple argument, from the opponent process theory of color vision (OPT) and representationism, to the failure of all such externalist accounts. (B&H appear to accept both premises. See Byrne & Hilbert [1997c] and sect. 3.5 of the target article.) Let w be the closest possible world where, owing to differences in our postreceptoral processing, our opponent channel states are regularly different, but where our receptor systems are the same, so that the states of our visual systems, though different, are optimally causally corrected with, and designed by evolution to indicate, the very same extradermal properties. By OPT, we have different color experiences in w, and so, given standard representationism, represent different color properties (in B&H's view, different hue-magnitudes or different ratios of the same hue-magnitudes), under the same circumstances. But the states of our visual systems are *optimally causally correlated with* and *designed to indicate* the very same properties (e.g., the very same SSR properties). So, our representing different color properties in w cannot be accounted for in causal/teleological terms (for full details, see Pautz 2002a). Could visually representing a certain color then be reduced to a neurobiological (e.g., opponent channel) property, or to a forward-looking narrow functional property, concerning which other inner states and behaviors a given inner state is apt cause for? No, because (artificial tricks aside) these "internal" properties don't satisfy the Relationality Constraint: none is a relation to a color. At most, visually representing a certain color (and hence, given standard representationism, color phenomenology) *supervenes upon* or is *constituted by* such an internal physical/functional property, without being reducible to it. (On supervenience/constitution without sameness of logical form, see Horwich 1998 and McGinn 1996.) For these reasons it appears that something like Primitivism is the right view of visual representation. Many would argue that this is not an isolated case, and that reduction (as opposed to the weaker relation of supervenience/constitution) is in general an unattainable aim.

This raises a question for B&H. Either they must convince us, as against these arguments, that there is a physical/functional relation between people and SSRs to which visual representation might be reduced,[2] and more generally that reduction is the rule; or else they must explain why, if the "plausibility" arguments for reduction (avoiding brute emergence, causal considerations) don't work in general, we should think that they work in the case of colors, notwithstanding the considerable *a priori* and empirical obstacles standing in the way.

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NOTES

1. B&H say that their account explains why "a binary hue like orange *appears to be* a 'mixture' of red and yellow" and why "green (and yellow, red, and blue) are *said to be* 'unique' hues" (sect. 3.2.3, para. 3; my emphasis). Do B&H then deny that orange *is* reddish-yellowish, and that red *is* a unique color? B&H's circumspection here suggests that, despite what they say (sect. 3.2, final para.), they are *error theorists* about the unitary-binary distinction, and that their goal is to explain the error. So it is not entirely clear to me what B&H are up to.

2. Hilbert and Kalderon (2000) give a kind of mixed theory of color representation, but I find it hard to make out. I cannot determine what physical/functional property a person must have, on this view, in order to *visually represent* a certain color (e.g., a certain determinate shade of unitary red).