Metameric surfaces: the ultimate case against color physicalism and representational theories of phenomenal consciousness

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Abstract.

In this paper I argue that there are problems with the foundations of the current version of physicalism about color. In some sources laying the foundations of physicalism, types of surface reflectance corresponding to (veridical) color perceptions are characterized by making reference to properties of the observer. This means that these surface attributes are not objective (i.e. observer-independent). This problem casts doubt on the possibility of identifying colors with types of surface reflectance. If this identification cannot be maintained, that in turn threatens representationalist theories of phenomenal consciousness: there remains no objective, observer-independent property that color experiences represent - hence no representational content, in terms of semantic externalism, can be attributed to color experiences. I offer an alternative account of color and conclude that further empirical study is required to do justice to the basic claims of color physicalism.

1. Introduction: two tasks in establishing physicalism about color

Physicalism about color is the thesis that colors simply are external physical properties. Though colors are not reducible to (i.e. they do not stand in one-to-one correspondence with) *microphysical* properties, they are physical properties that can be realized by more than one type of microphysical constellations (Hilbert, 1987; Matthen, 1988, p24). Physicalists identify color with surface reflectance (Hilbert, 1987; Byrne and Hilbert, 1997; see also Matthen, 1988 p24; Tye, 1995, pp144-150).

Establishing color physicalism consists of two theoretical tasks. The first of these tasks is to show that our color perceptions, under normal circumstances, are reliably correlated with types of surface reflectance. The second task is to argue that phenomenal characters of color experiences are, in some way, *determined by* the physical property these experiences stand for. As Byrne and Hilbert put the point (1997, p264), phenomenal character and representational content of colors necessarily go together. A stronger claim is made by Tye (1995): phenomenal character in general, and color phenomenology in particular, is to be *identified with* certain kind of representational content (see below). So, for example, for a perceptual state to be a *red-feeling* experience is for it to have the *perceptual* (representational) content that a surface with such-and-such a reflectance is present (note that surface reflectance can be sensed only by vision).

Corresponding to these two tasks, there are two alternatives of physicalism about color (e.g. Matthen, 1988, pp24-25). The first alternative asserts that there is no identifiable observer-independent property that corresponds to our color sensations - i.e., colors are not objective (e.g. Hardin, 1988, 1995). The second alternative says that though perhaps there is some objective property that correlates well with color sensations, the phenomenal character of color experiences is 'something more than', or not inherently determined by, their objective correlates (see Hilbert, 1987, pp18-22). Color experiences are products of the brain, even though they reliably signal external states of affairs.

In this paper I will follow the strategy of the first alternative. I will argue that it is largely unclear whether the objective property currently specified by color-physicalists (i.e. integrated triplets of reflectances; see below) is indeed such that color experiences, under normal circumstances, reliably correlate with it. If it turns out that there is no reliable correlation between objective types of reflectance and color-perceptions, then the thesis asserting a necessary covariation between color content and color phenomenology loses its ground as well (unless, of course, physicalists manage to specify another objective property that reliably correlates with color perceptions). Arguing for the first alternative is more closely related to empirical facts whereas arguments for the independence of color content and color phenomenology typically proceed by entertaining possible scenarios in which phenomenology varies independently of content, or vice versa (see Byrne and Hilbert, 1997, 267-272; for a related problem see Davies, 1997). I am not going to argue for the second alternative in this paper.

The organization of this paper is as follows. In the next section I give a very brief outline of M. Tye’s representational theory of phenomenal content that relies upon the claims of color physicalism. The third section is a summary of the most important part of David R. Hilbert’s argument for color physicalism. In the fourth section I give my reasons for doubting the correctness of the physicalist view. In section five I sketch an alternative account of color – basically a return to a version of subjectivism.

2. The theory that phenomenal character is representational content

Tye (1995) presents a comprehensive theory of phenomenal consciousness that offers an account of basically all aspects and well-known problems of conscious experience. Tye's theory accommodates a great number of empirical findings related to consciousness. He claims that phenomenal character in general is identical with *a certain sort of* representational content. To support this claim Tye first argues that, contrary to philosophical orthodoxy, *every* kind of sensory or perceptual experience has representational content (Tye, 1995, chapter four). Pains are no exception: they are sensory representations of bodily damage or disturbance (p113). In his book Tye endorses a covariation theory of representational content (pp100-101), though he includes evolutionary history as well as a possible mediator of content (e.g. p153). Hence for him, a particular kind of pain *typically (i.e. under normal circumstances) covaries with*, *therefore represents that,* there is a such-and such disturbance present at such-and-such a bodily location. Another example: the content of a particular color-experience is that *a specific type of surface-reflectance is present*. However, not every kind of content is, at the same time, some phenomenal character. Belief content, for instance, is not phenomenal.

Phenomenal character is *Poised Abstract Nonconceptual Intentional Content* (that is, PANIC). The term 'poised' means that this sort of content attaches to the maplike (spatio-temporally organized) output patterns of sensory or perceptual modules, such that these contentful output patterns in turn stand in a position to influence the belief/desire system (p138). The term 'abstract' (p138) means essentially the same as 'not object-involving' (Davies, 1997, 310; 313-314): quantitative identity does not play a role in the identity of contents, only qualitative identity does. Two objects that are exactly alike regarding their perceivable properties can be substituted for each other without altering the sensory/perceptual content (hence the phenomenal character) they give rise to. This feature is obviously not true of belief content: quantitative identity of the object of belief plays a role in determining belief content. 'Nonconceptual' (p139; see also Davies, 1997, 310-311) means that the properties that enter into these contents need not be such that the subject possesses matching concepts for them. That is, perceptual states carrying PANICs do not, all by themselves, constitute concepts.

The relation between PANIC and phenomenal character is that of metaphysical necessity. Being PANIC is not a contingent, superficial attribute of phenomenal character, but rather an essential one (Tye, 1995, sections 7.1, 7.2, 7.3). Phenomenal character is not a multiply realizable abstract kind, one of whose realizations is PANIC. If Tye's theory is right then it is metaphysically necessary that phenomenal character *is* PANIC (just like water is H_2O) (p184; pp188-191). An important difference between the water-H_2O case and the phenomenal experience-PANIC one is that in the former case it is metaphysically possible that something with the superficial appearance of water is not H_2O whereas in the latter case there is no parallel possibility. Phenomenal character is an essential property of experiences, not a superficial one. Anything that feels like a pain *is* a pain (Chalmers, 1996, pp146-147; Tye, 1995, p188). To the contrary, *being the waterish stuff in our environment* is a contingent property of H_2O. Therefore in the phenomenal character case the only relevant possibility that we can claim to *really* imagine (i.e., entertain as a possibility) is that the PANIC theory is wrong. If the PANIC theory is right, then both 'PANIC R' and 'phenomenal character red' are rigid designators that pick out the same thing in every possible world. Hence there remains no way to imagine that, even though phenomenal character is PANIC in our world, it is something else in another possible world.

Within this general framework, Tye offers solutions to all important problems of phenomenal consciousness including perspectival subjectivity, phenomenal causation, transparency, color inversion and the possibility of zombies, transparency, and so on.

3. The physicalist's strategy to account for surface metamers

According to physicalism about color, colors are surface reflectances. Light-emitting surfaces (traffic lights, color TVs) are not included in the physicalist account of color (see Hilbert, 1987; Byrne and Hilbert, 1997), though sometimes it is mentioned that the account of surface color should be extended to include light emitting surfaces as well (Hilbert, 1987, p133-134). As long as this extension is not available, the physicalist has an excuse for this apparent theoretical gap. The excuse is that, from an evolutionary perspective, color vision is principally concerned with distinguishing surfaces that are not distinguishable otherwise (e.g. by means of differences in texture). It is surface reflectance (i.e. color, in the physicalist's view) that is essentially represented by color perceptions. The proposal that surface reflectance is the main concern of color vision is supported by the phenomenon of color constancy (Hilbert, 1987, chapter four). Taking this view to the extreme, color TVs, traffic lights and other fancy artifacts create color illusions, that is, misrepresentations of true color (Hardin, 1995, p504; Matthen, 1988, p24-25; Tye, 1995, p148).[1]

The central problem for the physicalist is to give a coherent account of surface metamers – surfaces that have radically different reflectances, yet are indistinguishable to the human color vision system. It may seem that such an account is possible – at least this is claimed by Hilbert (1987, chapters five and six). If this account is indeed successful, then the first step toward identifying color with surface reflectance is accomplished (see the Introduction). In this section I give a brief outline of Hilbert's solution. In the next section I show why his solution is largely problematic.

First let us see Hilbert's account (Hilbert, 1987). As he notes (p72), the physicalist about color needs the distinction between real and apparent color. This is so because, undeniably, the same surface reflectance can give rise to different color perceptions. If we accept that one and the same surface can give rise to different *and equally veridical* color perceptions, then we cannot maintain that color just is surface reflectance, because reflectance does not determine our (veridical) color perception. So, even though one and the same surface can give rise to different perceptions of color (i.e., under different illuminations), only one of these perceptions can be regarded as veridical.

Sets of surface metamers, i.e., sets of reflectances that are indistinguishable to human color vision, are also illumination-dependent. For every pair of reflectances that are metamers under standard illumination there exists some rather special (e.g. monochromatic) illuminant under which the two reflectances are distinguishable (see e.g. Hilbert, 1987, p86-87). In this paper I will only be concerned with sets of reflectances members of which are metameric *under standard illumination*. (I will call such sets MetS sets in what follows.) Any two members of a MetS set are distinguishable under certain non-standard illuminations. It also follows from what has been said that two members of a MetS set, M1 and M2, *do not elicit veridical color perceptions* in those illumination circumstances where they are distinguishable. In other words, *they are distinguishable only* *by means of misperceiving their color*; this is a strange consequence of the physicalist theory. Given standard illumination, where they are veridically perceived, M1 and M2 are indistinguishable. So if they are, in some strange illumination, distinguishable by virtue of their hue, then it follows that at least one of them is perceived to have an apparent color, not its true one. (It is typical that in such circumstances neither M1 nor M2 are perceived veridically – by the just presented idea of veridicality.) (See Hilbert, 1987, p90, p130; at these places he argues that this problem exists only for dispositionalist accounts of color. I think it cannot be avoided in Hilbert's physicalist account either.)

Now, take a MetS set, say the one members of which are the determinate hue red_{16}. Let us call it MetS(red_{16}). MetS(red_{16}) has infinitely many members. All members of MetS(red_{16}) are reflectances that are examples of the color red_{16}, and they are only perceived veridically when they are perceived as red_{16} – that is, as indistinguishable from each other. This line of thought suggests that all members of a MetS set are one and the same color.

However, there is another line of argument in the physicalist theory. To escape from the dispositionalist's definition of color (i.e., that colors are color perceptions of some standard observer; p98), the objectivist takes every single surface reflectance to be a distinct color (p83; p98). But then, members of, say, MetS(red_{16}) are, by definition, different colors.

This apparent contradiction is solved by an ingenious move (in chapter six). Hilbert goes along with his definition maintaining that members of MetS sets are indeed different colors. Why can't they be perceived as different then? Because the resolution of the human color vision system (over the range of surface spectral reflectances – SSRs) is pretty coarse. Human color vision is a *passive reflectance-measuring device* that works under whatever illumination is available and uses receptors with various spectral sensitivities (p103-105). But it has only three kinds of such receptors (i.e. short, middle and long wave sensitive cones). Apparently, such a device cannot be very good at finely distinguishing reflectances.

Now, every measuring device has some standard error; any output of such a device corresponds to, or signals, only *a class* of determinate values that are measured. We do not perceive the length of objects with absolute precision; indeed, there presumably are many more objective, determinate lengths than different length perceptions (perceptual states representing different lengths). Every veridical perception of length informs us only that there is an object present whose length is in such-and-such a range. Many different, maximally determinate, objective lengths are capable of being represented by any particular length perception. These lengths have a common property: the difference between any two of them is smaller than a certain limit. Measurements and perceptions of quantitative properties are not absolutely precise; however, *this indeterminacy of measurement does not impair its objectivity* (p106).

The same holds for color perception. Not only is it not absolutely exact, it is actually fairly crude. It does not impose a very fine division on the range of reflectances. Any veridical color perception informs us only that a reflectance in a certain (quite broad) range is present. Though every different reflectance is a different color, many different, *maximally determinate, objective colors* are capable of being represented by any particular color sensation. The analogy with perception of length is exact; this shows that there simply is no important difference here between the perception of primary qualities and that of allegedly secondary ones. The difference that we find between color and length perception is a difference in degree, not in kind.

In addition, any MetS set has a property that is true of all and only the members of that set. This property is not disjunctive, contrary to what certain philosophers assert (p110-111). It is an objective property; however, it is a highly derivative one. Common properties corresponding to MetS sets are uninteresting ones; they are 'unnatural kinds', despite their objectivity. Still, they are out there, independently of any perceiver. This view is called *anthropocentric realism* about color (Hilbert, 1987, pp13-15; p115; pp119-120). Human color vision singles out bunches or ranges of surface reflectances (maximally determinate colors), such that every range singled out has a common objective property.

The common property that characterizes MetS sets is *integrated triplets of reflectances*, or ITRs (p111). It can be obtained in the following way. Take the ranges of sensitivity of the three kinds of retinal cones: it is approximately from 400 to 525 nm for short-wave cones, from 435 to 640 nm for middle-wave cones, and from 450 to 680 nm for long-wave cones (see e.g. DeValois and DeValois, 1997, fig. 4.1 on p99). Take a colored surface; *integrate its surface reflectance above the sensitivity range* of the short wave cones (400-525nm). (I.e., add up the reflectances obtained for every adjacent, very narrow band of wavelength within that range.) This gives the first member of the ITR of the colored surface under examination. Repeat the same procedure for the remaining two sensitivity ranges, thereby obtaining the other two members of the triplet. It is claimed that basically every member of a given MetS set has the same ITR whereas members of different MetS sets have different ITRs.[2] ITRs are perfectly objective, perceiver-independent properties, just like individual, determinate reflectances. So, due to the crudeness of our color vision, different objective colors that have the same ITR are perceived as the same color.[3] So we get the objective property of surface color. As Byrne and Hilbert put the point (1997, p266; their italics):

> The reflectance-types that the human visual system represents objects as having are considerably coarser than the maximally specific colors. Hence, although of course *objects* having maximally specific colors are visible, the maximally specific colors themselves are not, because they are not properties that one can tell an object possesses simply by looking at it.

4. What is the problem with the objectivist account of surface color?

Hilbert mentions (p111, footnote 9) that in order for ITRs to (approximately) uniquely characterize MetS sets, the calculation has to be slightly modified. We have to *weigh* the integration of reflectances above ranges of receptor sensitivity with the values characterizing receptor sensitivity at the corresponding points within the sensitivity range. That is, what we integrate is not reflectance functions, but *products of spectral sensitivity functions (of receptors) and surface reflectance functions* (see McCann et al., 1976, Part II, esp. p451). I will call this modified measure weighted integrated triples of reflectances, or WITRs. However innocent this modification might seem, it is not. Here is why.

ITRs are objective, that is, observer-independent properties of surfaces exactly because their derivation does not include, or make reference to, any parameter characterizing the observer. Surface spectral reflectances (SSRs) are mind-independent: they just are out there in external reality. ITRs are observer-independent as well: every determinate SSR uniquely determines exactly one ITR – this fact is totally unrelated to any observer. However, WITRs are *not* out there in physical reality, independently of observers. A determinate SSR has no determinate, observer-independent WITR. It has infinitely many, merely possible WITRs – depending on what sort of organism happens to perceive it. To put this another way: if an abstract SSR-property is instantiated then the corresponding abstract ITR-property is instantiated as well. However, from the instantiation of an SSR-property, the instantiation of no WITR-property will follow. So, what is the common property of MetS sets? Their ITR? Probably not: there presumably is only a crude, by-and-large correspondence between ITRs and MetS sets. Then is WITR the property that characterizes a given MetS set? This sounds more plausible, but WITRs are not at all objective, observer-independent properties. They are complex properties derived both from properties of surfaces and those of observers. Therefore they are observer-dependent.

An experimental test of the predictions of Land's Retinex Theory is done by McCann et al. (1976; see also Land, 1977). In Part II of their paper, the authors examine the hypothesis that color sensations are determined by triplets of lightnesses and that these lightnesses in turn correspond to integrated triplets of reflectances (p448). As they summarize the results: 'Our results show that the color sensations are very highly correlated with the triplets of reflectance' (p446).

In the first part of their experiment, the authors asked their subjects to choose from the Munsell Book of Color the colored chips that best matched the color of each area in the so-called Color Mondrian display used in Land's experiments on color constancy (Land, 1977, 1997; McCann et al. 1976, p446). In the second part, the reflectances of areas in the Mondrian display and the matching Munsell chips were compared. The crucial question was: are the ITRs of a Mondrian area and the Munsell chip chosen as the same in color the same or close to one another? However, the authors did not even examine the hypothesis that *pure* ITRs of Mondrian areas and the Munsell chips chosen to match them are approximately the same. They began their examination by testing WITRs (p449). It is important to note that the sensitivity of each type of cone pigment varies considerably with wavelength (McCann, 1976, fig. 4. on p449; DeValois and DeValois, 1997, p99), that is, weighting with pigment sensitivity brings in a factor that does not at all seem negligible. Even more surprisingly, the authors introduce another transformation: a psychophysical rescaling of the WITRs. This transformation is nonlinear (it is a power function: p450) and it is there to compensate for the fact that equal increments in reflectance do not represent equal increments in sensation (p449). So apparently we have a psychophysical sensitivity function here whose exponent is there to characterize the sensitivity of the perceiver to the particular kind of stimulus in question. That is, *there are two different parameters characterizing the observer included in the derivation of the property common between matching Mondrian areas and Munsell chips.* The result is the so-called *scaled (weighted) integrated (triplets of) reflectances* (see also Land, 1977, pp116-118), or SWITRs. For every Mondrian area, and its matching Munsell chip, SWITRs are very close to one another. For WITRs (unscaled) the fit is looser though still quite good (see McCann et al. 1976, figures 6 and 7 on page 450; Land, 1977, fig. on p116). No examination of unweighted ITRs is mentioned in the McCann et al. paper; the same is true of Land's own experiments (Land, 1977, pp116, 117-118). Given the concerns of color physicalists, and the theoretical considerations that I have offered in this section, an experiment is needed to establish to what extent two surfaces matching in perceivable color have the same - unscaled, unweighted - ITR (or any other observer-independent measure). Such an experiment could do justice to the physicalist claim that perceivable color is, or can possibly be, an objective property. As long as data reinforcing the physicalist are not available I assume that ITR is not a property that truly characterizes MetS sets. If this is indeed the case then the physicalist owes us a new specification of some common objective property of MetS sets. In the next section I examine what consequences would it have if we could not find such a common objective property. I will also attempt to motivate the claim that for color vision to be successful no such property is needed.

5. Rough sketch of an alternative view

As we have seen, there is no known property such that it satisfies the two conditions of (i) being objective, and (ii) being true of all and only the members of a given MetS set. The only known properties that satisfy (ii) (i.e., WITRs, or SWITRs) aren't objective. They are observer-dependent. Hence, taking only observer-independent properties into account, the division of the visible range of SSRs into MetS sets seems entirely arbitrary. If there is indeed no objective property that properly characterizes MetS sets, then we arrive at the following view. (This is the view I am inclined to defend.) Color vision creates the joints for itself when carving up the relevant aspect of nature. Mechanisms of color vision do indeed divide the visible range of surface reflectances into distinct ranges (MetS sets). The division itself (or the boundaries it outlines), separated from the properties of observers, is not marked by any objective feature of reality. This division cuts in the middle of a homogeneous continuum, not along any preexisting objective border.

To extend this view slightly, here is an evolutionary consideration. It may well be true that, evolutionarily speaking, color vision is mainly concerned with surface discrimination. However, in this particular case (introducing distinctions within the realm of SSRs), evolution need not care about singling out objective properties - either natural or unnatural, highly derivative kinds. All evolution needs to care about is that color vision assign values (perceptual states) to surfaces of different reflectance such that these assignments are stable over time. A particular surface has to be perceived *as the same in color* at different times (in normal circumstances). As long as the internal parameters guiding the dissection of the range of visible SSRs (e.g. the spectral sensitivity profiles of retinal pigments) are stable over time, this constraint is not violated (see Shepard, 1997, pp326-329 for a similar idea). For discrimination and recognition, introducing arbitrary (though stable) sets of reflectances is enough. For color vision to achieve its goal, common objective properties that characterize MetS sets are unnecessary. Arbitrary sets of reflectances that hang together only by virtue of some observer-dependent property suffice for consistent surface-discrimination.[4] In general, dividing continua of stimuli into separate bands or ranges, grouping and scaling them in some arbitrary (even disjunctive) way is already a huge help to the organism in guiding its behavior and orienting in its environment (see Shepard, 1997, pp346-347).

I hasten to note that this feature of color vision need not generalize to *all* other aspects of perception. In the case of shape or length perception it is plausible that objective properties are singled out by the visual system. But perhaps in certain cases of perception, the ranges of phenomena carved out by distinct perceptual states are not properly characterized by any common objective property.

This view of color, if correct, has nasty consequences for representationalist theories of phenomenal consciousness. According to realist and semantic externalist criteria, an inner state has representational content only if it has a proper causal connection with a non-disjunctive objective property (Tye, 1995, pp194-195 and endnote 4 on p228). My argument against color physicalism suggests that there may be no *objective and non-disjunctive* property that color experiences are reliably correlated with. This in turn entails that, according to externalist criteria of content, color-experiences simply have no representational content. They do not stand for any objective *kind* (non-disjunctive property), however derivative and uninteresting. This lack of representational content satisfies Tye's own falsification condition (endnote 4 on p228) for his representational theory of phenomenal experience, hence it knocks down his theory altogether. If there is just one case in which phenomenal character is not identical to representational content in the semantic externalist sense, then the identity of content and phenomenology cannot be metaphysically necessary. Phenomenal character just isn't representational content – it is something else.

6. Conclusion

Not jumping to grandiose conclusions before testing them properly, I end this paper by suggesting that the way color physicalism is currently argued for should be subject to further empirical scrutiny. By no means does it seem entirely clear that the 'colors are reflectances' claim – in its present form at least - can be maintained.

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[1] Hardin's considerations are interesting even from a representationalist point of view about phenomenal character. Claiming that color TVs create mere illusions (i.e. misrepresentations of color) is only plausible if one accepts a theory of representational content according to which it is only, or primarily evolutionary history that determines color content. If we accept that current tendencies of covariation, *ontogenetic* causal history, or dispositions to overt behavior too have a role in the individuation of representational content in general, and color content in particular, then we cannot so easily reject traffic lights and color TVs as cases

of mere color illusion (see Davies, 1997 and Tye, 1995, ch. 5 on possible factors determining perceptual content).

[2] Even if we take the variability of MetS sets with individual perceivers into account this generalization is claimed to be true of the MetS sets of any particular perceiver. There exists some variation across normal trichromat subjects with regard to their metameric sets (Hilbert, 1987, pp96-97). For the reconciliation of normal cross-personal variability in color phenomenology with the physicalist view see Byrne and Hilbert, 1997, p272-274.

[3] A restriction has to be added here: two reflectances that have the same ITR are perceived as the same color if they appear in the same visual context. See Hilbert, 1987, p111, footnote 8).

[4] Shepard (1997) extends this idea to include color constancy. Variations in SSRs in our 'terrestrial' environment can be described by about five or six independent parameters (pp322-323; 326-327). Maloney and Wandell's model of color constancy showed that for a color vision system to decipher unknown surface reflectances is possible only if the number of chromatically distinct photoreceptors is one greater than the number of degrees of freedom of the surface reflectances. For terrestrial surfaces the number of degrees of freedom of SSRs is somewhere between five or seven. Color vision with just three chromatically distinct photoreceptors is not capable of mapping 'natural' SSRs properly – the further compression to three dimensions of color that we experience cannot be attributed to a property of the surfaces themselves, but rather, it must be imposed by our visual system (p327). However, natural conditions of lighting can be characterized by just three degrees of freedom (or three independent basis functions: pp323-324). Furthermore, color vision systems with just three spectrally distinct photoreceptors can achieve color constancy in natural lighting whose variability is due to no more than three main independent factors. Therefore, as Shepard suggests, '…the principal criterion of success of the visual system's chromatic analysis is not that it represent the full complexity of the spectral reflectance function for each surface…' but that, despite the degenerate representation of SSRs, 'the color that we do perceive is nevertheless the same color each time we view the same surface' (p328).