Special issue on colour for the journal *Minds and Machines*, eds. Mazviita Chirimuuta & Greg Wheeler.

The Self-Locating Property Theory of Color

Berit Brogaard
April 22, 2014

Abstract
The paper reviews the empirical evidence for highly significant variation across perceivers in hue perception and argues that color physicalism cannot accommodate this variability. Two views that can accommodate the individual differences in hue perception are considered: the self-locating property theory, according to which colors are self-locating properties, and color relationalism, according to which colors are relations to perceivers and viewing conditions. It is subsequently argued that on a plausible rendition of the two views, the self-locating theory has a slight advantage over color relationalism in being truer to the phenomenology of our color experiences

Keywords: color physicalism, color relationalism, color relativism, self-locating properties, self-locating property theory of color, synesthesia, variation in color perception

1. Introduction

In this paper I defend the self-locating property theory of color.[1] This is one of two theories that Alex Byrne and David Hilbert call 'color relativism'.[2] The other is Jonathan Cohen's relational theory of color. I do not intend this paper to provide an ultimate defense of the self-locating property theory. Rather, I consider this an opportunity to explain why I think the theory is more promising than color physicalism and color relationalism.

The self-locating property theory of color borrows its name from David Lewis' self-locating property theory of belief. John Perry's well-known example of the messy shopper illustrates how de se belief differs from de re and de dicto belief:

> I once followed a trail of sugar on a supermarket floor, pushing my cart down the aisle on one side of a tall counter and back the aisle on the other, seeking the

[1] I have defended this theory under different labels in, among other places, Brogaard (2009, 2010, 2012a: chap 8, 2012b).

[2] In their talk at the Color and Philosophy conference at Auburn University, March 2-3, 2012, Byrne and Hilbert used 'color relativism' as a label for my self-locating property theory and Jonathan Cohen's relational theory. Elsewhere I have used the label 'color relativism' more narrowly for the self-locating property theory. See Brogaard (2012b). There are, of course, numerous other defenders of these or similar views of color. One that immediately comes to mind is Mazviita Chirimuuta (In Press). David Chalmers (2006) defends a kind of color physicalism but takes the content of color perception to include self-locating properties.

> shopper with a torn sack to tell him he was making a mess. With each trip around the counter, the trail became thicker. But I seemed unable to catch up. Finally it dawned on me. I was the shopper I was trying to catch. (Perry 1979)

The passage makes it clear that Perry's belief changed when 'it dawned on him' that he was the messy shopper. He then acquired a *de se* belief. All *de se* cases involve believing or asserting in a special first-person or immediate present tensed way, whereas *de re* and *de dicto* cases involve believing or asserting in a neutral way. To deal with cases like these, Lewis proposes to treat belief as a self-ascription of a property, for example, the property of being the one who is making a mess as opposed to the property of being such that someone is making a mess. All beliefs, on Lewis' theory, are what he calls 'self-locating'. As he puts it:

> I say that all belief is 'self-locating belief'. Belief de dicto is self-locating belief with respect to logical space; belief irreducibly de se is self-locating belief at least partly with respect to ordinary time and space, or with respect to the population. I propose that any kind of self- locating belief should be understood as self-ascription of properties (1979, p. 522)

The properties that are self-ascribed in irreducibly *de se* belief differ from the properties that are ascribed in other cases. They are not instantiated by entities with respect to the world as a whole. For example, in the Perry case, Perry first self-ascribes the property of being such that someone is making a mess and then the property of being such that I am making a mess. The first property is one that can be correctly attributed to a person with respect to the world as a whole (if only one person is making a mess). The latter property is one that can only be correctly attributed to a person relative to a centered world, a world in which an individual (and a time and perhaps a perceptual circumstance) is marked. For the property to correctly apply to you, you must be the individual at the center of the world. Such properties are sometimes called 'centered properties' or 'self-locating properties'. Other examples of self-locating properties include *being to the right*, *being such that the tree is further away than the house*, *being the phenomenal look this rose would cause in me in bright daylight*, *being tasty* and *being self-identical*.

On the property self-locating theory of color, colors are self-locating properties of the form *being qualitative red/green/blue*, etc. These properties can be instantiated by an object only relative to a centered world. So, the same object may be red relative to a centered world in which you occupy the center but orange relative to a centered world in which I occupy the center. There are as many centered worlds as there are <individual-time, perceptual circumstance, world> triples.[3] There could in principle be just as many correct attributions of colors to one and the same object as there are actual centered worlds, i.e., a centered world in which the world and individual-time parameters are actual.

[3] Individuals and times cannot be chosen at random. For example, there is no centered world containing the time 2000 BC and me at the center, as I didn't exist then.

It is unclear that any errors can occur on the this view, as the correctness conditions for perceptual states simply require that, say, a red object is qualitatively red relative to the centered world of which the perceiver is currently at the center (see Cohen 2010: 128ff for relevant discussion). Error, however, can enter when people attribute color properties in ordinary language and thought. When color properties are attributed in ordinary language and thought, speakers and thinkers do not always attribute colors relative to their own centered world. That is, they do not always use them in a first-person sense. Sometimes color terms are used deferentially. For example, if Jim tells you that he bought a red car, then you might report that using the sentence ‘Jim’s car is red’. If you are using the term ‘red’ deferentially deferring to Jim, then what you said is correct only if Jim’s car is red relative to the centered world he occupies.

We can also use color terms generically. Suppose you say ‘Australian mailboxes are red’, using the term ‘red’ generically. Then you mean something like this: Australian mailboxes are red relative to a centered world occupied by a normal perceiver in normal viewing conditions. Here it is easy to see why the time parameter of the centered world plays a crucial role, as the same individual can be in normal viewing conditions at one time but not at another. It is notoriously difficult to say what “normal” means in these contexts, and it may well be that the vagueness built into ordinary language and thought prevents a precise characterization of these expressions.

In ordinary language and thought we very often use color terms generically, and we often assume that *we* are normal perceivers in normal viewing conditions. So, we think that our own perception of an object is a good guide to the object’s generic color and hence we only attribute a particular subset of all the self-locating color properties. As we will see below, we are often mistaken about that. Objects may very often fail to have generic colors in any meaningful sense either because there is too much variation in color perception across individuals to meaningfully say that there is such a thing as a normal perceiver, or because it is unclear what a normal viewing condition is. A good example of the latter pertains to coral reef.[4] A coral in the white light we are exposed to at the seashore is brown and colorless, whereas a coral in full-spectrum light with a shift towards the blue part of the spectrum looks astonishingly bright pink and green. This is because a coral’s pigment doesn’t reflect light the way most materialsl do. When we see an Australian mailbox as red, this is because the mailbox absorbs most blues and green but doesn’t absorb reds and hence reflects them. Molecules and proteins, on the other hand, make the wavelength longer and hence shift the color towards the red part of the color spectrum, which can create a color in full-spectrum light that is lacking in normal white light. On the one hand, then it may seem that the true, or generic, color of a coral should be determined in full-spectrum light under water. On the other hand, it may seem that the generic color of a coral should be determined on white light normally present at the seashore, as that is where human perceivers are naturally located. It is not clear that the question of what the correct viewing conditions are can be settled, except by convention.

[4] See e.g. discussion here.
http://notes-from-dreamworlds.blogspot.com/2013/06/fluorescent-colors-of-reef-coral.html

This concludes my brief overview of the self-locating property theory of color. In what follows I will defend the theory against two popular competitors, color physicalism and color relationalism. First, I will argue that the self-locating property theory of color has fewer problems than color physicalism. I will then compare and contrast the self-locating property theory and color relationalism.

2. Color Physicalism

A popular theory of color, often assumed but only rarely defended in the philosophical literature, is color physicalism. The view has been defended at length by David Hilbert (1987) and by Alex Byrne and Hilbert (2003) several years later in an influential target article in *Behavioural and Brain Sciences*. David Armstrong and Michael Tye have also been avid advocates of color physicalism (see e.g., Armstrong 1961, Armstrong 1968 and Tye 2000).

Most color physicalists take color tokens to be surface spectral reflectance properties. A surface spectral reflectance property is the percentage of the light at each wavelength across the visible spectrum that is reflected by a surface.

One of the obvious problems for this variant of color physicalism is the problem of metameric matches. Metamers are objects with different surface spectral reflectance properties that appear to have the same color under certain sorts of illumination. For example, a surface that has a peak in reflectance at 500 nm and a second peak at 650 nm gives rise to the same green color appearance in daylight as a surface with a peak in reflectance around 550 nm. Metameric matches are due to the fact that each object triggers very similar neurophysiological processes in the brain. The reason that metamers trigger similar neurophysiological conditions is that the brain processes wavelengths as ratios of excitation of cones in the retina. Any two surfaces that stimulate the three cone types in the same ratios will give rise to experiences of the same hue (Hardin 1985: 44). For example, monochromatic light of 580 nm and a mixture of light of 540 nm and 670 nm can both trigger an experience of unique yellow, a yellow that is neither reddish nor greenish, as long as the ratio of excitation of the cones is the same.

A version of physicalism that takes the colors to be surface spectral reflectance properties cannot explain this, as it would predict that metamers should have different colors despite being indistinguishable by us. Hilbert (1987) bites the bullet. He proposes that each surface spectral reflectance is a different color, and accepts an error theory regarding the perception of metamers. Hilbert and Byrne (2003), on the other hand, avoid the problem of metamers by denying that color types (e.g., red, yellow, green and blue) are surface spectral reflectance properties. The color types, they say, are sets of these surface spectral reflectances. So, metamers whose spectral reflectances correspond to those to monochromatic light of 580 nm and a mixture of light of 540 nm and 670 nm have the same color, viz. unique yellow, because their spectral reflectances belong to the same reflectance type, viz. that for unique yellow.

This reply to the problem of metameric matches, however, runs into additional problems. One is that it fails to explain why there is a unique yellow but not a unique orange, that is, one that is neither reddish nor yellowish. The latter problem does not go away simply by assuming that the reflectance types red and yellow are sets with members in common, viz. the orange members. If physicalism is true, physical description alone must imply that it is possible for there to be a unique yellow but impossible for there to be a unique orange. As Larry Hardin puts it:

> If yellow is identical with G, and orange is identical with H, it must be possible for there to be a unique G but impossible for there to be a unique H. If hues are physical complexes, those physical complexes must admit of a division into unique and binary complexes. No matter how gerrymandered the physical complex that is to be identical with the hues, it must have this fourfold structure, and, if objectivism is to be sustained, once the complex is identified, it must be possible to characterize that structure on the basis of physical predicates alone (Hardin 1985: 66).

Edward Averill (1992) lays out two further problems for what he calls the ‘property view’. The property view is an umbrella term encompassing views that, like color physicalism, claim that colors are objective properties of objects. First, he envisages a scenario in which the human perceptual system drastically changes. In particular, he suggests that the liquid in the eyeball between the lens and the retina is replaced by a fluid that absorbs all and only the lower part of the yellow frequencies of the color spectrum. This narrow band of the color spectrum, then, does not reach the retina, which will introduce a change in how things look. For example, objects that only reflect light from this range would seem to be black to normal observers after the change, and an object that reflects light in this range and in the red range would seem to be red to normal observers. Golden objects are a case in point. So, the envisaged change in the human perceptual system would have the consequence that while gold still has the property of being yellow, no normal observer can see its color in optimal viewing conditions. A similarly bizarre consequence would occur if the environment were to change. Here Averill envisages a gas being released into the atmosphere that absorbs all and only the light in the lower part of the yellow frequencies of the color spectrum, thus resulting in gold looking red to normal observers in optimal viewing conditions, despite being yellow. Both of these problems appear to be unacceptable consequences for color physicalism.

A further challenge for color physicalism is that of accounting for the colors of light, air and water. When the sky is blue, it is because only the shorter wavelengths of light are absorbed by the gas molecules and scattered in all directions. This is also known as the ‘Rayleigh scattering’. Given that surface spectral reflectance properties are properties of surfaces, it would seem that the reflectance physicalist is bound to say that light, air and water do not have colors. But if they do not, then obviously true color attributions, such as ‘the sky is blue’, said on a bright summer day, turn out to be false. This consequence deprives physicalism of one of its advantages compared to color theories like eliminativism which take most color talk to be false, viz. its ability to grant that color talk has meaningful truth-conditions.

Averill (1992) and Mohan Matthen (1988) argue that the latter sort of move is consistent with biological adaptation. The biological function of human vision, they say, is to recover the surface spectral reflectance properties of objects. However, this claim is rather questionable. It is important for us to be able to recover spectral properties of light, air and water. This sort of detection ability likely has played a crucial role in our evolutionary progress. The human eye, in fact, has the highest degree of sensitivity to the average wavelength of light at a forest floor, suggesting that the ability to detect the spectral properties of light has had a greater evolutionary advantage than the ability to detect the spectral properties of surfaces (Hardin 1985, xxv).

The most natural way to avoid this problem is to expand physicalism to include ‘productances’. Byrne and Hilbert (2003) propose to characterize productances in terms of the light that would *leave* the object or volume, rather than the light that a surface would reflect.

However, sets of surface spectral reflectance properties and colors appear to come apart in a number of other ways. First, there are spectral reflectance properties that do not correspond to any regularly instantiated human colors; for instance, the reflectance properties of ultraviolet light. This observation by itself does not necessarily present a problem for physicalism, as the claim that the colors are identical to sets of surface spectral reflectance properties does not entail that *every* set of surface spectral reflectance properties is a human color.

There is, however, a problem for the physicalist in the vicinity. As the human lens absorbs ultraviolet light, most individuals cannot see light in this range of the color spectrum. There is, however, evidence to suggest that individuals who have had cataract surgery, which consists in the removal of the lens, can interpret light in the near ultraviolet range of the color spectrum (Stark 1987 and Stark, et al. 1994). The condition is also known as ‘aphakia’. Light in this range gives rise to a desaturated (or white) blue experience because, while all three cones in the human eye are sensitive to ultraviolet light, the blue cone is more sensitive to light in this range than the other two.

How would the color physicalist account for the blueness of ultraviolet experiences? One possibility would be to deny that blue is presented in ultraviolet experiences. However, this seems plainly ad hoc. Another possibility would be to say that ‘ultraviolet blue’ is a reflectance property that is a member of the color blue and hence that blue is presented in ultraviolet experiences. But this possibility, too, is unsatisfactory. The only thing that would make this particular set of reflectances identical to blue would be that it happens to bear some causal relation to human color experience that is subjectively describable as ‘blue’. This seems to make the colors nomologically dependent on human subjects, which does not seem true to the basic tenets of color physicalism.

Second, there are colors that are not relevantly causally connected to any set of surface spectral reflectance properties. An example of this is the so-called Martian colors perceived by some synesthetes, particularly color blind and blind synesthetes (Ramachandran and Hubbard, 2003; see also Bor 2007; Brogaard, et al. 2013; Dixon, et al. 2003). As these kinds of synesthetic colors are never instantiated by objects, there is no set of surface spectral reflectance properties that regularly triggers them. But if the colors are sets of surface spectral reflectance properties, then presumably color experiences represent a color only if, in normal conditions, the sets of surface spectral reflectance properties are relevantly causally related to the color experience (Chalmers, 2006). In the case of alien colors this relevant causal connection is lacking. So, the color physicalist must deny that these synesthetic experiences represent colors, hardly a satisfactory result.

The physicalist may attempt to avoid this objection by insisting that these color experiences are illusory. This, however, is not an option. The color experiences in question evidently are not veridical. But that is not the problem. The problem is that even illusory color experiences ought to (mis)represent objects as having particular colors. If I misperceive a white table as being red, my color experience is illusory but it nonetheless represents the table as being red. The physicalist normally accounts for how an experience comes to represent an object as having a particular color by saying that the color the object is represented as having is the reflectance property that would give rise to an experience of an object having that color in veridical circumstances (Chalmers, 2006). But there is no reflectance property that would give rise to an experience of an object having an alien color in veridical circumstances.

A further example of colors not relevantly causally connected to any set of surface spectral reflectance properties is that of reddish-green and bluish-yellow. That reddish-green and bluish-yellow can be experienced was first demonstrated by Hewitt D. Crane and Thomas P. Piantanida (1983). The stimulus was adjacent red and green stripes (or blue and yellow stripes); when the stimulus was held in the same position relative to the participants' eyes, some of the subjects experienced reddish-green or bluish-yellow. The study was successfully repeated by Vincent Billock, et al. (2001), who also adjusted for variation in luminance. Despite the fact that some subjects can experience reddish-green and bluish-yellow, these shades of color have no instantiated physical color correlates. So, color physicalists must deny that these unusual experiences represent colors.

Physicalists might, of course, insist that reddish-green and bluish-yellow are just illusions due to weird viewing conditions. But that doesn't solve the problem. Even when an experience is illusory, we need to account for how it comes to represent the color properties in question. As noted above, the standard way to do that is to say that an experience represents a color C just in case C regularly gives rise to experiences with that color phenomenology in veridical cases. But reddish-green and bluish-yellow do not regularly give rise to experiences with the phenomenology in question in veridical circumstances, as there are no objects instantiating corresponding reflectance properties. A further problem with this kind of reply is that there is great variation in color perception among individuals who pass tests of normal color vision, making it difficult to characterize unusual color experiences as 'just illusory'. I cover some of the evidence for variation in color perception across individuals in the next section (see also

Brogaard, 2009).

3. Variation in Color Perception

It has been shown on several occasions that there is considerable variation in color perception across individuals who pass tests for normal color vision. Webster, et al. and other groups (e.g., Webster, et al. 2000, 2002, 2010; Kuehni 2001; Malkoc, et al. 2005) have conducted several studies of variation in individual color perception. In one study, Indian and American participants were first asked to select the one chip from an array of 320 Munsell chips that best represented a particular color. For example, the chip that was the best example of the color 'blue'. They were then asked to identify the stimuli that seemed like the example of a unique hue (red, green, blue or yellow) by choosing a point on a grading series of hues at high saturation. They found significant within-group and across-group variation. For example, in the first study they found variations across the groups that corresponded to a full Munsell chip (2.5 hue steps) for yellow and within-group standard deviations ranging from 1.5 to 2.1 hue steps (see **Fig. 1**).

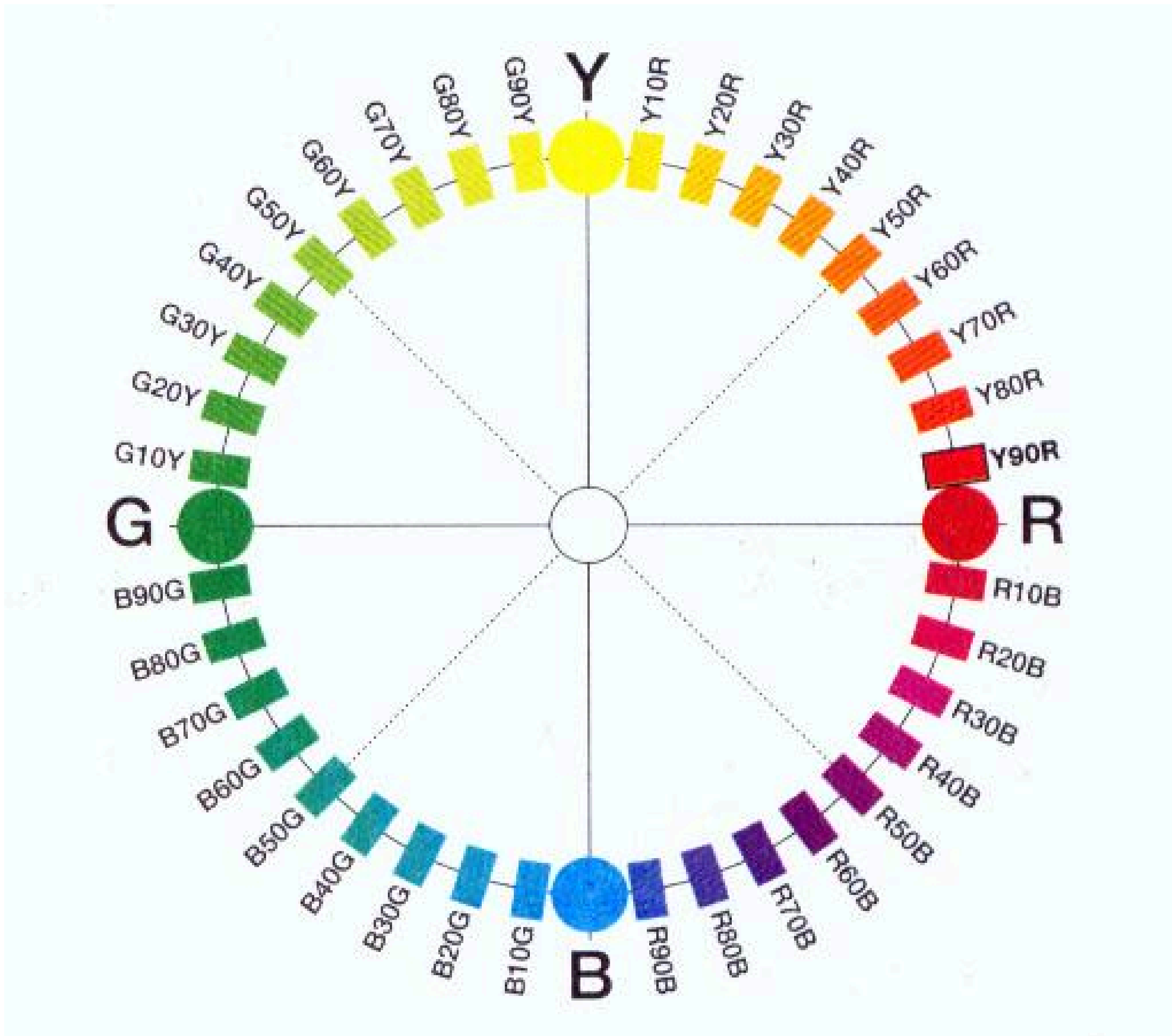

Figure 1. Munsell Color Wheel. Variation among individuals in determining the best example of a hue varied with as much as one munsell chip (for example R40B to R30B). Webster, et al., 2002.

Another example of variability is that among normal Caucasian males, who fall into two types of perceivers that differ in terms of their average peak responses to red light. In one study, the difference in average peak response to red light between the two participant groups was found to be 5 nm (Winderickx, et al. 1992).

There are also data that suggest that some individuals, for instance the mothers and daughters of dichromats, or colorblind individuals, experience colors that no normal perceivers can experience (Jameson 2007). Dichromats are almost always men. In most cases the color disturbances are due to an abnormality in a red or green photoreceptor gene on the X chromosome. If the dichromat inherited the atypical gene from his mother or passes it onto his daughter, then it is possible for mother and daughter to express normal red or green photoreceptors as well as a red or green photoreceptors that are not as 'well spaced' in their absorption peaks as occurs in the typical trichromat retina. As cone types are defined by photopigments, some of these women have four cone types, and may potentially be tetrachromats. Just as trichromats can make more color discriminations than dichromats, functional tetrachromats would be able perceive a greater number of color discriminations than trichromats. Studies have indeed shown that people with four cone types sometimes do see colors that neurotypical people do not see, and hence that some women are tetrachromats (Jameson, et al. 2001; Jameson et al. 2006).

One thing that is interesting here is that variation in color appearance across individuals and groups is not directly correlated with variation in color sensitivity (Webster, 2010). Individuals vary widely in their sensitivity to wavelength. This variation is much more extreme than the variations found in color appearance, which suggests that color appearance is compensated for by the spectral sensitivity limits of the perceiver (Webster, et al. 2010). For example, as we age the pigment in the lens becomes more dense, resulting in a yellowing of the lens. This means that the lens absorbs more of the short wavelengths of light, so less light in the range of the color spectrum reaches the photoreceptors in the eye. Although this change in sensitivity in some cases can make it difficult to see differences in shades of blue, green, and violet, it more often has little to no effect on color appearances. Apparently visual adaptation corrects for variations in the stimulus.

Adjustment for differences in light sensitivity is believed to be the same kind of adjustment as that involved in color constancy. Although the Adelson checker illusion is not due to differences in light sensitivity, it serves as a good example of the kinds of adjustments involved in cases of color constancy as well as light sensitivity (see **Fig. 2**). If we were to see the object pictured in the checker illusion out in the real world, we would accurately perceive A and B as having different gray colors (Chirimuuta, manuscript).

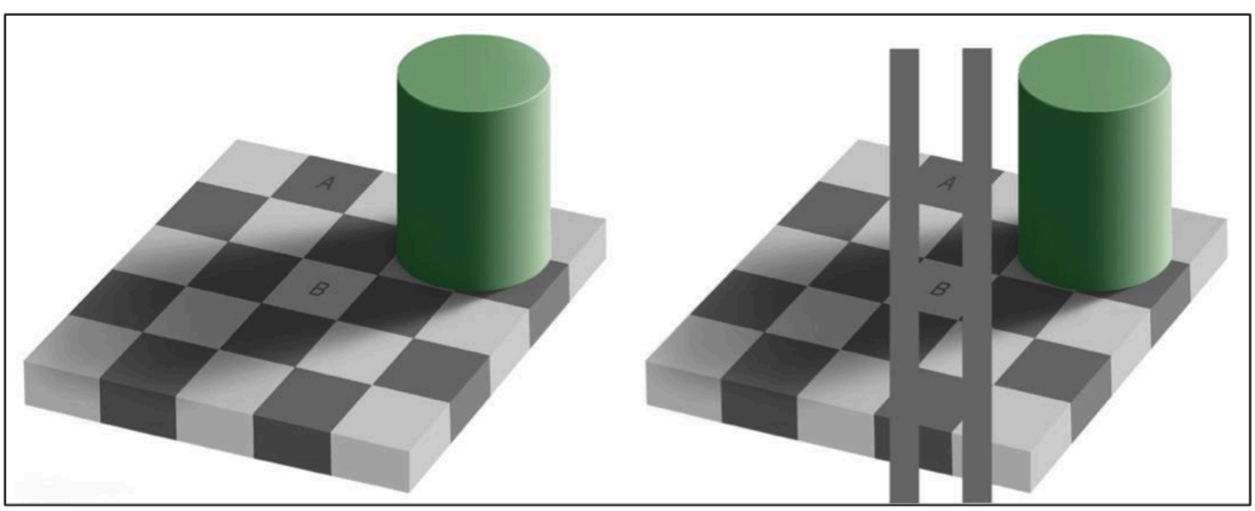

Figure 2. Edward Adelson's Checkerboard Illusion. The visual system adjusts for the apparent differences in the spectral power distribution of the illuminant, which leads us to perceive A and B as differently colored. Image adapted from Wikimedia commons.

The reason we wouldn't be fooled in the real world owes to our evolutionary adaptation to variances in the level of energy of the light at each wavelength in the visible spectrum, also known as 'the spectral power distribution' (SPD). In our environment the SPD varies greatly across different light sources (illuminants) and different times of the day. Cool white fluorescent light and sunlight have radically different SPDs. Sunlight has vastly greater amounts of energy in the blue and green portions of the spectrum, which explains why an item of clothing may look very different in the store and when worn outside on a sunny day. The SPD of sunlight also varies throughout the day. Sunlight at midday contains a greater proportion of blue light than sunlight in the morning or afternoon, which contains higher quantities of light in the yellow and red regions of the color spectrum. Sunlight in the shade, when it is not overcast, contains even greater amounts of blue light. Our perceptual system adjusts for many of these changes in the SPD of natural illuminants, but the adjustment is less likely to occur when the illuminant is artificial. For example, when you look at a dandelion facing away from the sunlight, your visual system adjusts for the change in the SPD (Akins, 2001). As a result, the dandelion doesn't look bluish-green but continues to look yellow. The principles governing these changes are intra-perceptual principles similar to those that govern other visual adjustments in that they do not conform to any standard tenets of rationality but conform to their own principles. The reason the checker illusion occurs is that our perceptual system adjusts for changes in the SPD of the illuminant, thus treating an image the same way it would treat an object in natural illumination conditions. But in the case of the checker illusion, the environment does not cooperate. So, we mistakenly perceive A and B as having different colors when they in fact have the same color. Intra-perceptual principles thus play a crucial role in how things perceptually seem to us (Pylyshyn, 1999).

In spite of this kind of visual adjustment there is significant variation in color perception across individuals and groups. The kind of variation that exists independently of perceptual adjustments made by the visual system is particularly hard for color physicalists to account for. Alex Byrne and David Hilbert claim that it is very simple to accommodate the variability data: Whenever two individuals disagree about the color of an object, at least one of them is wrong (Byrne, 2006). There is thus no inconsistency between physicalism and the evidence for perceptual variation.

There are multiple problems with this sort of reply to the problem of variability in color perception. As there are no independent physical criteria for the identity of hues, Byrne and Hilbert's view entails that there are unknowable color facts. So, this sort of response entails a kind of epistemicism about color (Brogaard, 2009). In numerous cases it is impossible to discover who (if any) is right about the color of an object. If a trichromat and a tetrachromat disagree about the color of an object, who is right? Is it the trichromat because she is a member of the majority. Or is it the tetrachromat because she can discern more differences in the colors of objects compared to her neurotypical counterpart? If Byrne and Hilbert are right, we will never know. For any object, there presumably are two individuals who disagree about its color on the basis of normal perception. So the color of every object is unknown. I find this view extremely puzzling, especially because we could not detect in any empirical paradigm what the color of the object is. Hypotheses that are empirically untestable are typically regarded as meaningless. A further problem for color epistemicism is that it is hard to see what could possibly ground the fact that an object has one color rather than another? Saying that we can simply measure the surface spectral reflectance of the object is not a feasible response, if colors are *sets* of surface spectral reflectances. It furthermore leads to an eliminationist approach to color discourse. When we attribute colors to objects, the attribution is incorrect in the majority of cases.

4. The Relational Theory vs. the Self-Locating Theory

Unlike physicalism and other forms of objectivism, the self-locating theory has no trouble explaining the individual differences in color perception. Individual differences are due to differences in the neurophysiological events triggered by the incoming stimuli. The differences in the neurophysiological events, in turn, are due to genetic differences in cone photopigments. The ascription of colors to objects by individuals is best understood as relativized to these individual differences in neurophysiological events and genetic differences. As mentioned above, we often use color concepts as denoting generic colors. However, which color is presented to the perceiver itself must be understood as relativized to individual differences.

There is, however, a different view of color that can also accommodate variations in color perception, viz. Jonathan Cohen's relational view of color. On this view, the colors are best understood in terms of relations between subjects plus perceptual circumstances and objects. According to the specific version of relationism endorsed by Cohen, "colours are identical to the functional roles of disposing their bearers to look colored to subjects in particular circumstances" (Cohen, 2009). For example, red for *S* in *c* is the functional role of disposing its bearer to look red to *S* in *c*.

The difference between the self-locating property theory and the relational theory comes down to this. The relational view takes colors to be the functional roles of disposing their bearers to look colored to subjects in particular circumstances, whereas the self-locating view takes them to be the self-locating properties of the form *being red/green/blue, etc.* Both views provide identical metalinguistic truth-conditions for color claims, for example, '*o* is red to you in circumstance *c*' is true just in case *o* would present itself as being qualitative red in you, were you to be in circumstance *c*. On the self-locating property theory, however, '*o* is red to *S* in *c*' does not have the semantic content '*o* would present itself as being qualitative red in *S* in *c*, were you to be in *c*', whereas it does have this content (or something like it) on the relational view.

At this point the reader may wonder whether the self-locating property theory merely is a technical variation on the relational view. It's not. Any virtues one of these theories might have compared to the other will be somewhat limited, but there are important differences between the two views. If an American girl is 6’4’’, she is tall. So, she instantiates the property of being tall, and she does so in virtue of being 6’4’’. When you perceive the girl, it is unlikely that you perceive her as being 6’4’. You may simply perceive her as *tall*. Likewise, when we look at an object, we don’t perceive it as being disposed to cause this or that phenomenal look, we perceive it as being, say, red or green or blue. On the basis of experiences of this kind, we can then attribute colors to the bearer in thought or language.

Cohen considers the potential worry that it may not perceptually seem to us that colors are relational entities. He responds: ‘To see the force of the question we are pondering, notice that corresponding claims about the phenomenology of non-color properties can seem somewhat bizarre. For some non-color properties (e.g., *being water*, *being square*, or *being a table*) it just seems implausible that phenomenology represents their constitution (a fortiori, their relationality or non-relationality) at all’ (Cohen, 2010, pp. 3-4, in the online version). Although not all thinkers would maintain that it is bizarre to hold that the phenomenology of experience represents constitution in all of these cases,[5] I agree with Cohen that it doesn’t. But those who agree with Cohen (like myself) do not tend to think that, say, H_2O is presented in perceptual experience at all (Brogaard, 2013). Colors, on the other hand, are presented in perceptual experience. Being H_2O is a high-level property, whereas being red is a low-level property. It is widely debated whether high-level properties are presented in perception, whereas it’s relatively innocuous to claim that low-level properties, such as colors, are so presented (Siegel 2005; Brogaard, 2013).

But if the phenomenology of experience represents colors, and the relational view is correct, then it ought to represent perceivers, perceptual circumstances, the property of being disposed to do something, and so on. Yet it is plainly obvious (to me anyway) that the phenomenology of experience represents no such things. In this regard the self-locating property view of color has an advantage over the relational view, because it does not claim that the colors are identical to functional role properties and hence it does not have the implication that color experience represents perceivers, perceptual circumstances, the property of being disposed to do something, and so on.

Cohen responds to this kind of worry that there is no inference from a) S's perceptual experience represents the constituting conditions C of X, to b) S is reflectively or introspectively aware, by virtue of the phenomenology of her experience, that X is constituted by C. And the reason why the inference from a) to b) fails, according to Cohen, is that 'color experiences (like water experiences) present the properties that are constituents of their contents under modes of presentation', and hence phenomenal 'looks' contexts are 'highly intensional' (Cohen is at 2010: 165-166, including footnote 16).

Adapting this point to the present case, our objector may submit that it is unclear that the phenomenological objection should trouble Cohen too much. Cohen accepts that color

[5] Here I have in mind people who think that the phenomenology of perception is externalist and who think that high-level properties, like that of being water, is presented in perception.

experiences represent color properties, and moreover holds that color experience represents the relationalist constitution conditions for colors. The reason why this is not evident from the phenomenology is simply that the modes of presentation for these contents do not put the subject in an epistemic position to acquire the knowledge that the color that one is experiencing is constituted in this way.

The main problem with this response is that it treats color properties similarly to high-level (or natural kind) properties, such as H_2O and tiger-DNA, properties that we may not be in a position to consciously perceive, as phenomenology puts constraints on which properties are presented in perception (the argument can be found in Brogaard, 2013).

If color experience is thought to *represent* color properties, then the relational view runs into further trouble (Brogaard, 2012a: chap 8). It is fairly plausible to think that you and I could have indistinguishable color experiences in the same viewing conditions. Yet if phenomenology determines the representational content of perception, which is also plausible, then it follows that you and I cannot be constituents of the representational content. Yet on Cohen's view, if color properties are constituents of the representational content of perception, then perceivers are also constituents of the representational content of perception. But now we are have a contradiction. So, one of the premises must go. If you already hold a representational view of perceptual experience, which it seems that Cohen does (Cohen, 2010), then it would be highly controversial to deny that content supervenes on phenomenology. The two most common forms of the representational view, viz. representationalism and the mental paint view, which rejects that phenomenology supervenes on content, both maintain that content supervenes on phenomenology (see e.g. Tye, 1995, Block, 1990, 1996, 2010). So, it seems that Cohen must ultimately hold that while color experiences represent shape and texture, they do not *represent* color properties. But that, too, seems rather implausible. What else could they possibly be taken to represent?

The self-locating property view is not subject to this problem, as it does not hold that perceivers are constituents of colors. So, it can maintained that you and I could have the same color phenomenology when looking at the same objects in the same circumstances without having to reject the plausible view that the phenomenology of perceptual experience determines the representational content of the experience.

A final worry about the relational view concerns its ability to explain the case of alien colors in synesthesia. If colors are the functional roles of disposing bearers to look colored to subjects in particular circumstances, we might rightly ask which bearers are disposed to cause the alien color properties in synesthetes? If the colors are self-locating properties, then the alien colors that synesthetes experience can simply be taken to be uninstantiated self-locating colors. As they are not instantiated by any external object, there is no need to answer the question of which bearers dispose perceivers to experience them.[6]

5. Conclusion

Color physicalism has difficulties explaining a wide range of phenomena, including unusual colors like ultraviolet, alien colors, the colors of the ocean and sky and the variability of color perception. Neither color relationalism nor the self-locating property view faces these difficulties. The two views are fairly similar in treating colors as intimately tied to perceivers and perceptual circumstances. I have argued here, however, that the self-locating property view is truer to the phenomenology of perception than the relational view.

References

Akins, K. (2001). "More Than Mere Coloring: A Dialog Between Philosophy and Neuroscience on the Nature of Spectral Vision", in *Carving our Destiny,* S. Fitzpatrick and J. T. Breur, editors. Joseph Henry Press: Washington, D.C. 2001.

Armstrong, D. (1961). *Perception and the Physical World*, London: Routledge and Kegan Paul.

Armstrong, D. (1968). *A Materialist Theory of Mind*, London: Routledge and Kegan Paul.

Averill, E.W. (1992). “The Relational Nature of Color”, *The Philosophical Review* 101: 551-588.

Billock, V.A., Gleason, G.A, Tsou B.H. (2001). “Perception of forbidden colours in retinally stabilized equiluminant images: an indication of softwired cortical colour opponency?”, *Journal of the Optical Society of America A (Optical Society of America)* 18: 2398–2403

Bor D, Billington J, Baron-Cohen S. (2007). “Savant memory for digits in a case of synaesthesia and Asperger syndrome is related to hyperactivity in the lateral prefrontal cortex”, *Neurocase* 13:311-319.

Block, N. (1990). “Inverted Earth”, In J. Tomberlin (Ed.), *Philosophical Perspectives* 4. Atascadero, CA: Ridgeview.

Block, N. (1996). “Mental Paint and Mental Latex”, *Philosophical Issues*, 7, 19–49.

Block, N. (2010). “Attention and mental paint”, *Philosophical Issues*, 20 (1), 23-63.

Brogaard, B. (2009). “Color in the Theory of Colors? Or: Are Philosophers' Colors All White?”, *The Center Must Not Hold: White Women on The Whiteness of Philosophy*, George Yancy, ed.

[6] Thanks to Mazviita Chirimuuta, and an anonymous reviewer for very helpful comments on an earlier version of this paper.

New York: Lexington Books, 131-152.

Brogaard, B. (2010). “Perspectival Truth and Color Primitivism”, C. Wright and N. Pedersen, eds. *New Waves in Truth*, New York: Palgrave Macmillan, 249-266.

Brogaard, B. (2012a). *Transient Truths*, New York: Oxford University Press.

Brogaard, B. (2012b): “Colour Eliminativism or Colour Relativism?”, *Philosophical Papers*, 41:2, 305-321.

Brogaard, B. (2013). “Do we Perceive Natural Kind Properties?“, *Philosophical Studies* 162, 1 (2013): 35-42.

Brogaard, B. Manuscript, *Seeing and Saying*.

Brogaard, B. Vanni, S, Silvanto, J. (2013). Seeing mathematics: perceptual experience and brain activity in acquired synesthesia, *Neurocase* 19(6):566-75.

Byrne, A. (2006). “Comments on Cohen, Mizrahi, Maund, and Levine”, *Dialectica* 60: 337-40.

Byrne, A and Hilbert D. R. (2003). “Colour Realism and colour Science”, *Behavioural and Brain Sciences*, 26: 3-21.

Chalmers, D. J. (2006). “Perception and the Fall from Eden”, in T. Gendler and J. Hawthorne (eds.) *Perceptual Experience* (49-125), Oxford: Clarendon Press.

Chirimuuta, M. (In Press). “Perceptual Pragmatism and the Secondary Qualities”, in *Outside Colour*, chapter 5. Cambridge, MA: MIT Press.

Cohen, J. (2009). *The Red and the Real*, Oxford: Oxford University Press.

Cohen, J. (2010). "Color Relationalism and Color Phenomenology", in *Perceiving the World*, ed., Bence Nanay, 13-32. New York: Oxford University Press.

Dixon MJ, Smilek D, Merikle PM. (2004). Not all synaesthetes are created equal: projector versus associator synaesthetes, *Cognitive, Affective, & Behavioral Neuroscience* 4:335–343.

Crane H.D. and Piantanida T.P. (1983). “On Seeing Reddish Green and Yellowish Blue”, *Science* 221: 1078–80.

Hardin, C. L. (1985). *Color for Philosophers: Unweaving the Rainbow*, expanded edition, Indianapolis: Hackett Publishing Company.

Hilbert, D. (1987). “Colour and Colour Perception: A Study in Anthropocentric Realism”, Stanford: CSLI.

Kuehni R. G. (2001). “Determination of unique hues using Munsell colour chips”, *Colour Research & Applications* 26: 61–66.

Jameson, K.A. (2007). “Tetrachromatic colour Vision”, in P. Wilken, T. Bayne, and A. Cleeremans, (eds.) *The Oxford Companion to Consciousness*, Oxford University Press: Oxford.

Jameson, K.A., Highnote, S.M., & Wasserman, L.M. (2001). “Richer Colour Experience in Observers with Multiple Photopigment Opsin Genes”, *Psychonomic Bulletin & Review* 8: 244-261

Jameson, K.A., Bimler, D., and Wasserman, L.M. (2006). “Re-assessing Perceptual Diagnostics for Observers with Diverse Retinal Photopigment Genotypes”, in *Progress in Colour Studies 2: Cognition*, N. J. Pitchford, and C. P. Biggam, (eds.), Amsterdam: John Benjamins Publishing Co., 13-33.

Lewis, D (1979). “Attitudes De Dicto and De Se”, *The Philosophical Review*, 88, 513 - 543.

Malkoc, G., Kay, P., and Webster, M.A. (2005). “Variations in Normal colour Vision. IV. Binary Hues and Hue Scaling”, *Journal of the Optical Society of America*, A 22, 2154-2168.

Matthen, M. (1988). “Biological Function and Perceptual Content”, *Journal of Philosophy* 85: 5-27.

Murray I.J, Parry, NRA, McKeefry, DJ, Panorgias, A. (2012). “Sex-related differences in peripheral human colour vision: A colour matching study”, *Journal of Vision* 12 no. 1.

Perry, J. (1979). “The Problem of the Essential Indexical”, *Noûs* 13, 1: 3-21.

Pylyshyn, Z. W. (1999) “Is Vision Continuous with Cognition? The Case for Cognitive Impenetrability of Visual Perception”, *Behavioral and Brain Sciences*, 22, 341–423.

Ramachandran, VS and Hubbard, EM. (2003). “The Phenomenology of Synaesthesia”, *Journal of Consciousness Studies* 10: 49-57.

Siegel, S. (2005). “Which properties are represented in perception?” In T. Szabo Gendler & J. Hawthorne, (eds.), *Perceptual experience*, Oxford: Oxford University Press, 481-503.

Tye, M. (2000). *Consciousness, Colour, and Content*, Cambridge, MA: MIT Press.

Webster MA, Miyahara E, Malkoc G, Raker VE. (2000). “Variations in normal color vision. II.

Unique hues”, *J Opt Soc Am A*. 17:1545–1555.

Webster MA, Webster SM, Bharadwaj S, Verma R, Jaikumar J, Madan G, Vaithilingham E. (2002). “Variations in normal color vision. III. Unique hues in Indian and United States observers”, *J Opt Soc Am A Opt Image Sci Vis.* 19(10):1951-62.

Webster MA, Juricevic I, and McDermott, KC (2010). “Simulations of adaptation and color appearance in observers with varying spectral sensitivity”, *Ophthalmic Physiol Opt.* 30(5): 602–610.

Winderickx J, Lindsey D.T., Sanocki E, Teller D.Y., Motulsky A.G., Deeb S.S. (1992) “Polymorphism in Red Photopigment Underlies Variation in Colour Matching”, *Nature* 356: 431-3.