This is a draft of an article whose final and definitive form will be published in Dialectica

Color Constancy Illuminated[1]

Vivian Mizrahi

Les soleils couchants
Revêtent les champs,
Les canaux, la ville entière,
D'hyacinthe et d'or;
Le monde s'endort
Dans une chaude lumière.

—Baudelaire, "L'invitation au voyage"

Abstract

The phenomenon of color constancy has often been appealed to in philosophical discussions of the nature and perception of colors. In these discussions, two ways of interpreting the role of illumination and illuminants in color vision are prominent. Color realists and objectivists argue that colors are illumination-independent properties because they are perceived and recognized despite changes in illumination. Color relationalists and subjectivists, on the other hand, deny that colors remain constant across changes in illumination and conclude that colors are relative and illumination-dependent properties.

I offer an alternative to these opposing views and argue that colors are illumination-dependent but also objective and intrinsic properties of surfaces. The result is an entirely original approach to the role of illumination and illuminants in color perception.

[1] Many thanks to Kevin Mulligan and to two anonymous referees of this journal for their comments and suggestions.

1 Color Constancy and Color Ontology

Although the light which is reflected by any particular object and reaches the observer constantly changes throughout the day, most of our surrounding objects seem to retain their color appearances[2] despite these variations. Grass is green, lemons are yellow, and tomatoes are red whether it is morning, noon, or sunset.

Color constancy, which is the phenomenon of unchanging color appearance across changes in illumination, plays a central role in discussions of the nature of colors. Roughly, it is argued that if perceived colors remain unchanged across changes in illumination, colors must be identified with stable properties of objects that are illumination-independent and can be perceived and identified across different circumstances. If this were not the case, that is, if colors varied according to circumstances and especially the nature of the illumination, perceived colors would be better identified with transient properties whose identification would be tied to the way they are experienced in particular situations.

According to Allen, for example, color constancy supports the claim that colors are mind-independent properties:

> The view that colours are mind-independent properties of things in our environment best explains a number of aspects of the phenomenology of colour experience related to the phenomenon of colour constancy: roughly speaking, the phenomenon whereby the colours of objects are typically perceived to remain constant throughout variations in the

[2] As it will become clear later, I do not understand "appearances" or "color appearances" as referring to subjective or mental features of our experiential states, but rather as objective properties accessible through perceptual experiences. The way an object appear can vary according to our perceptual experiences, but its appearances are neither subjective nor mental. They are mind-independent features of the object that are singled out in our perceptual experiences.

> conditions under which they are perceived. This suggests that in the order of philosophical explanation, colours enjoy a distinctive priority over colour experiences: our colour experiences are experiences of independent properties of things in our environment. (Allen 2016, 1)

And it is for similar reasons that reflectance physicalism, a major trend in color physicalism, claims that colors are illumination-independent properties of surfaces. Byrne and Hilbert write:

> Although the causal chain extends from the illuminant to the stimulus via the object, it is of course the object that looks colored (more strictly, its surface), and so the relevant physical property must be a property of objects (more strictly, surfaces). We can narrow the field further by noting that the color vision of human beings and many other organisms exhibits approximate color constancy (Jameson & Hurvich 1989; Werner et al. 1988); for instance, tomatoes do not seem to change color when they are taken from a sunny vegetable patch into a kitchen illuminated with incandescent light. Assuming that our perceptions of color are often veridical, we therefore need a physical property of objects that is largely illumination-independent—a physical property that an object can retain through changes in illumination. (Byrne & Hilbert 2003, 9)

Whereas color objectivists and physicalists often maintain that color constancy supports a subject- and illumination-independent view of colors, their opponents adduce the fact that in most of the cases in which color constancy is supposed to occur, variations in illumination are accompanied by changes in perceived colors. Color constancy therefore appears as a dual phenomenon involving the simultaneous experience of a constant color and of some chromatic variations. As superbly illustrated by Claude Monet's *Haystacks* series, colors change according to weather conditions and the time of day. And it is only through changes in the colors of objects that these atmospheric and illumination changes are noticed. Seasonal differences and differences in the time of day are manifested, for example, through the continuous and gradual changes in the colors of Monet's haystacks, which vary from shades of yellow in the morning to oranges and reds at sunset.

Cohen summarizes this complex situation as follows:

> On the one hand, normally sighted subjects find that the two (successively presented) regions of interest are, in some sense to be explained, alike in apparent colour. And on the other hand, normally sighted subjects find that the two (successively presented) regions of interest are, in some sense to be explained, easily, obviously, and quickly visually discriminable in apparent colour. (Cohen 2008, 63)

In other words, if one grants that the same color is perceived across shifts in illumination, one must admit that perceiving shifts in illumination involves the perception of some change in colors.

The phenomenon of color constancy has had some influence on the philosophical discussion of the nature of colors by contrasting two ways of interpreting the role of illumination and illuminants in color vision. Whereas color realists and objectivists argue that colors are illumination-independent properties because they are perceived and recognized *despite* changes in illumination, color relationalists and subjectivists conclude that this cannot be the case, because variations in illumination are accompanied by chromatic variations.

I offer an alternative to these opposing views by defending one claim made by relationalists and subjectivists and one claim made by objectivists and physicalists. Like relationalists and subjectivists, I deny that color constancy demonstrates that perceived colors are constant across changes in illumination. But I also defend an illumination-dependent and intrinsic view of colors which is compatible with an objectivist and physicalist approach.

After presenting the philosophical challenge that color constancy poses for different color theories in §2, I offer a defense of reflectance physicalism in §3. I then argue, in §4, against the most influential theory of reflectance physicalism and show that its account of color constancy is unsatisfactory. In §5, I propose a new approach to reflectance physicalism according to which *colors are both illumination-dependent and intrinsic properties of surfaces.* This approach provides a new explanation of color constancy. In §6, I further develop this view, distinguishing two kinds of color variations and explaining the role of illuminants as color selectors. In §7, I discuss the possibility of perceiving illumination without perceiving light itself and propose an original account of the special epistemic role of natural daylight in color perception.

2 The Color Constancy Challenge

I believe color constancy is a challenge for color theories because it reveals two fundamental and yet apparently incompatible facts about colors:

(1) Colors are intrinsic properties of surfaces.

(2) Color appearances are essentially determined by the properties of the illuminant.

(1) expresses the commonsense idea, endorsed by color realism and color objectivism, according to which bananas are yellow by virtue of the color of their skin, and not in virtue of properties of the eye of the observer or of the composition of light. (2) is motivated by the fact that changes in the nature of the illuminant affect our chromatic experiences through changes in color appearances. Yet, the nature of the illuminant can cause our color experiences to change because either

(2.1) the nature of the illuminant affects the colors we perceive

or

(2.2) the nature of the illuminant affects our perception of colors.

Now, both suggestions (2.1) and (2.2) seem to conflict with the objectivist proposal contained in (1). (2.1) implies, it seems, that colors can't be intrinsic properties of surfaces, because contrary to the objectivist's claim, color variations can occur without any variation in the surface's intrinsic properties. (2.2) seems to show that color variations are subjective, because illuminant changes affect the way we perceive colors without affecting the objective properties of objects. Apparently, there is then no way to reconcile (1) the fact that colors are intrinsic properties of surfaces as required by the objectivist view with (2) the fact that colors are essentially determined by the properties of the illuminant. Yet, I believe (1) and (2) capture some fundamental characteristics of color experiences, namely the fact that color experiences give us access to properties that are mostly stable and unchanging and that this stability is given through chromatic experiences that vary and change constantly according to the nature of the illuminant and the lighting conditions. Given this difficulty, should we renounce the idea that the manifold of color appearances revealed by variations in the illuminant is constitutive of the nature of colors and endorse a view that this manifold is mostly illusory or only apparent (E.g. Allen 2010)? Or should we rather renounce the idea that color experiences give us access to objective and intrinsic features of surfaces and embrace a subjectivist or relationalist view of the nature of colors (E.g. Cohen 2008)?

I argue that we should not renounce either of these ideas, because contrary to what (2.2) seems to suggest, the fact that illuminant variations change our perception of colors doesn't force us to abandon color objectivism and the idea that colors are intrinsic properties of surfaces. To understand how color experiences vary with lighting conditions while presenting stable and intrinsic physical properties of surfaces, we must start by understanding the nature of the relation between light and colors and its consequences for color vision. As I will show in the next section, reflectance physicalism provides the best approach to this question.

3 Reflectance Physicalism

Reflectance physicalism offers a compelling account of the relations between colors, surfaces, and light. This account identifies colors with reflectance properties or sets of reflectance properties (Hilbert 1987; Byrne and Hilbert 1997; Tye 2000). Reflectances are metaphysically interesting entities, because they are dispositional properties of surfaces to reflect a determinate amount of the incident light.

Such properties precisely explain

(1) why colors are perceived at the surface of the objects,

(2) how colors are related to light, and

(3) why colors are the proper objects of sight.

(1) Unlike other sensible qualities, such as odors, sounds, tastes, density, elasticity, …, colors are perceived at the surface of objects. [3] They are superficial or surface qualities. Surfaces are depthless spatial regions that structure the visual space into different units and ultimately into objects.[4] By identifying colors with physical properties of surfaces that change the properties of the incident light, reflectance physicalism explains the central role played by colored surfaces in visual perception. In particular, it explains why the visual field is segmented into surfaces (Stoner & Albright 1995, Nakayama, Shimojo, & Silverman, 1989, Gibson 1986) and also why vision cannot penetrate colored surfaces which are "solid to vision as well as to touch" (Gibson, 368).

(2) Most other ontological theories of color seem unable to explain the simple fact that colors cannot be perceived without light. For such approaches, it is as if light were only accidentally responsible for perceiving colors or merely one among the many circumstantial variables — like distance, angle, and simultaneously seen objects…— that explain chromatic perceptual variations. Reflectance physicalism, by contrast, offers a very different picture of the relation between light and colors, because it explicitly states that colors and light are united by an essential relation. According to reflectance physicalism, colors depend ontologically upon light, because colors are reducible to just the disposition of a surface to interact with light in a

[3] Following Katz (1911), philosophers often distinguish between different "modes of appearance of colors". They argue that "colors come in several flavors: *surface* colors, *volume* colors, and *illuminant* colors" (Byrne and Hilbert 2003: 11). The approach proposed in this paper is restricted to surface and illuminant colors, but I have argued in Mizrahi (2010) that transparent objects are not colored and that there are no volume colors.

[4] It doesn't mean that surface perception is the only mechanism, or even the primordial one, that underlies object detection.

particular way. Unlike transparent media, like glass or water, which transmit light from the perceived object to the perceiver without obstruction, colored surfaces interfere with light by scattering and partially absorbing the incoming light rays. What distinguishes colored surfaces from colorless surfaces is therefore the former's capacity to change the properties of the incident light in a specific way. Objects and materials that lack this property, like transparent materials and mirrors, are in effect colorless (Mizrahi 2010, 2018).

(3) Reflectances are objective (i.e. mind-independent) properties because the proportion of the incident light a given surface is disposed to reflect is not dependent on the existence of an observer. But being an objective property is not enough to capture our intuitive conception of colors. Colors are indeed sensible properties anchored in our perceptual experiences. Accessed only through vision, they are distinct from what is perceived in other sensory modalities. Any ontological theory of color must therefore account for the sensible nature of colors along with their objectivity.

One of the numerous merits of the reflectance theory of colors is that it provides a very straightforward way of explaining why colors are the proper objects of sight and why they are therefore essentially distinct from entities accessible by other sense modalities, such as smells, tastes, sounds, … If colors are identified with the dispositional property of surfaces to interact with light in a determinate way, detecting this property indeed requires a perceptual system sensitive to light variations. Identifying colors with reflectance thus explains not only why colors are attributed to external objects, but also why there are, in Aristotle's terms, the proper objects of sight. Unlike subjectivist and primitivist theories, which claim that truths about colors are phenomenological in essence, reflectance physicalism can explain without circularity what all colors have in common and why they are essentially different from the sensible qualities perceived in other sensory modalities. Therefore, reflectance physicalism identifies not only the best physical candidates for explaining color experiences, but also candidates that can explain how aspects of the external world can be directly accessed by the sense of sight, that is, the sensory modality responsive to optical phenomena.

Although identifying colors with reflectance properties deepens our understanding of colors by providing a compelling picture of the physical and objective nature of colors as the proper objects of the sense of sight, I believe that most philosophical accounts of this identification have been misleading and wrongheaded. Rather than stressing the intimate ties between colors, light, and the sense of sight, most reflectance physicalists have, in one way or another, separated them in order to guarantee to colors an immutable and objective status. Thus consider the view expressed by Byrne and Hilbert (2003, 7):

> Assuming that our perceptions of color are often veridical, we therefore need a physical property of objects that is largely illumination-independent—a physical property that an object can retain through changes in illumination. This last constraint rules out properties an object has only if it is actually reflecting light of a specific character—for instance, light with a certain wavelength-energy distribution (spectral power distribution), or wavelength composition.

Byrne and Hilbert's assumption seems to be that if colors are identified with physical properties related to the nature of the illuminant, those properties will vary with changes in illumination and therefore fail to exhibit the intrinsic and mind-independent features compatible with color physicalism. In other words, they assume that colors can be perceived as stable and intrinsic properties of objects only because they are illumination-independent.

The central goal of this paper is to show that reflectance physicalism does not require colors to be illumination-independent properties and that the versions of reflectance physicalism that neglect the intimate relation between color and illumination fail to properly account for color constancy and other phenomena related to variations in illumination. In the next section, I focus my attention on Byrne and Hilbert's version of reflectance physicalism and I consider in more detail how color constancy is characterized in this important framework.

4 Byrne and Hilbert's Approach to Reflectance Physicalism

As stressed above, reflectance properties are consistent with our conception of colors. It is therefore unsurprising that colors have been identified with reflectances and that reflectance realism, developed first by Hilbert (1987), has become a major philosophical approach to the nature of colors. Although Hilbert's view has been deeply influential, it has encountered some important challenges. My aim in this section is to show that most difficulties faced by reflectance realism originate from a misconception of the theoretical commitments of reflectance realism from its inception and that a fresh approach is needed.

Since its first formulation, reflectance realism has been presented in terms of spectral surface reflectances (SSR). Yet SSRs are only one kind of many different surface-reflectance properties. They correspond to the way a surface reflects each wavelength of visible light. But as recognized by Hilbert himself, this property is inaccessible to humans, because the human visual system cannot discriminate between the wavelengths constituting full-spectrum light:

> Human color vision involves three types of receptors, each of which has its own characteristic sensitivity. The sensors responsible for human color vision are all sensitive to a broad range of wavelengths and their ranges of sensitivity overlap considerably. These receptors are sensitive only to the total amount of light they receive in the range of wavelengths to which they are sensitive. They do not give any information about the distribution of energy within their range of sensitivity. As a consequence any pair of objects that reflect the same amount of light within each of the three wavebands will produce the same response from the sensors. (Hilbert 1987, 131)

The solution to this problem proposed by Byrne and Hilbert is that the colors perceived by humans are not specific SSRs, but rather types or sets of reflectances. They maintain that although human color vision cannot differentiate between specific SSRs, there is a disjunction or a set of SSRs that can be identified with each perceived color. But as I will show, this approach is unpersuasive for many reasons.

First, on the metaphysical level, what does it mean to say that we perceive sets or types of reflectances? Identifying colors with reflectances seems to capture the fact that perception of a colored object is a relation between particulars—a perceiving subject and a colored object. Identifying colors with *types* or *sets* of reflectances seems to move away from this plausible view and introduce many difficulties. What does it mean to perceive types? Surely perception is of particulars.[5] And in what sense can a subject be in a relation to a type or set without being in a relation with the elements of this set?

[5] For the defense that perception is of particulars only, see Mulligan 1999.

It is unclear how our perceptual relation to colored objects can be mediated by some perception of types if the chromatic features of our visual experiences are explained by the colors in the environment. One plausible view of color is indeed that colors are individual properties the surfaces on which they are perceived. In particular, this view explains how we distinguish and individualize surfaces according to their colors. It also accounts for the fact that colors allow us to recognize and classify objects according to their appearance. By introducing types or sets into their ontology of colors, Byrne and Hilbert seem to reject the validity of these intuitions and to deprive perception of its most basic characteristic, that is, to be in direct contact with the objects and their particular qualities.[6]

Identifying colors with types of SSRs encounters many difficulties in addition to the general ontological problems discussed so far. Consider first the problem of metamers, which is Byrne and Hilbert's primary motivation for identifying colors with types of SSRs. Surfaces with different SSRs can match visually under a given illuminant and for a given observer. Such surfaces are said to be metamers for that illuminant and that observer. But because metamers demonstrate that there is no one-to-one correspondence between SSRs and perceived colors, it has been argued that metamerism undermines the identification of colors with SSRs. Byrne and Hilbert reply to this objection (1997, 2003) by identifying colors perceived by humans with reflectance types rather than with particular SSRs. Although they acknowledge that the set of reflectances selected in this way is "quite uninteresting from the point of view of physics or any other branch of science unconcerned with the reactions of human perceivers," they stress that it

[6] For a similar view, see Armstrong (1987, 42): "When we perceive the sensible qualities of physical things the quality must presumably play a causal role in bringing the perception to be. But now consider a disjunctive property. It cannot be thought that the disjunctive property itself plays any causal role. Only the disjuncts do that. So if sensible qualities are disjunctive, how can they be perceived?"

nonetheless captures only objective and physical properties of surfaces and therefore avoids identifying colors with “unreal or somehow subjective” (2003,11) categories.

But perceived colors cannot be identified with sets of SSRs unless one specifies the illuminant. In effect, given their different spectral reflectances, metamers under a given illuminant will not appear to match under some other illuminant. Consider the particular shade of yellow exhibited by a ripe banana perceived in daylight. In this condition, the yellowness of the banana will match in color with surfaces with identical SSRs (SSR_1) but also with surfaces with very different SSRs. Yet, according to Byrne and Hilbert, it is possible to identify the perceived color of the banana in daylight with a set S1={ SSR_1, SSR_2, …} of reflectances including SSR_1, SSR_2, and reflectances of other metameric surfaces. But metamerism is relative to the illuminant, and perceiving a banana under a different illuminant would therefore result in the identification of the banana’s colors with a different set S2={ SSR_1, SSR_3, …} of reflectances including SSR_1 and SSR_3 but not SSR_2, for example. The problem is that by definition, metameric surfaces differ according to the illuminant and that reflectance types cannot therefore satisfy Byrne and Hilbert’s own view of the nature of color, which is that a color is “largely illumination-independent—a physical property of objects that an object can retain through changes in illumination” (2003, 9).

Another problem for physicalists who identify colors with SSRs, or with types of SSRs, is that they must assume that only an entire-spectrum illuminant can be used to perceive an object’s color. Because SSR is the proportion of incident light a surface is disposed to reflect *at each wavelength in the visible spectrum*, they sensibly argue that entire-spectrum illuminants are required to discriminate between SSRs and therefore to perceive colors. However, this approach is misleading. If reflectance physicalists are unwilling to arbitrarily restrict the capacity to perceive colors to humans, and because many species can see frequencies of light that cannot be detected by human color receptors, reflectance physicalists have to extend the visible spectrum to wavelengths invisible to the human eye. Yet extending the notion of “visible light” to frequencies that cannot be perceived by humans has several important consequences. First, if SSR is defined as the proportion of light that a surface reflects at each wavelength in the visible spectrum of any species, and because colors are in this case identified with physical properties that cannot be detected by the human visual system, human observers can strictly speaking *never* perceive colors. Moreover, it would not help to identify colors with reflectance types instead of SSRs, as proposed by Byrne and Hilbert (2003). We do in fact know that many nonhuman animals, unlike humans, have color receptors sensitive to UV light (Knut 1981). The capacity to perceive reflectance relative to UV light can make a huge difference in terms of the colors perceived. In fact, what the UV color vision reveals is that there is no nonarbitrary way to choose between illuminants.

For most observers and activities, color comparisons are done in some form of “white” light (daylight or artificial light). However, for certain laboratory or industrial purposes, the relevant illuminant may be composed of different bands of wavelengths or even a unique wavelength. For example, metameric inks, which match in “normal” light conditions, can be used in security applications. Using this technique, a printer can conceal a word, message, or image, which is invisible to the human eye until the lighting conditions change. The same technique is used in banknote printing to prevent counterfeiting. Reflectance physicalists, who single out entire-spectrum illuminants as revealing the real colors of things, have to deny that chromatic discontinuities perceived under narrow-band light sources are real. They must therefore conclude, against common sense, that visual experiences in which pieces of evidence or hidden messages are detected by using particular light sources are illusory, because the colors perceived under such illuminants are only apparent. But this odd conclusion has no obvious justification, except perhaps a practical preference for entire-spectrum illuminants. The use of narrow-band light sources does in fact reduce our discriminatory capacities in everyday life, because differences in reflectance relative to a few wavelengths are much less numerous than differences in reflectance relative to many wavelengths. This simple fact is sufficient to explain why forms of white light are usually preferred for color perception and object recognition. But from an ontological point of view, there is no reason to favor white light over narrow-band or single-wavelength illuminants.[7]

But why should one assume that systematic chromatic changes due to illuminant variations are only apparent? Are reflectance physicalists really willing to set aside all color variations due to illuminant variations as illusory because they do not involve SSR variations? Is the greenness of a banana under a "blue" light not as fundamental for understanding colors as its yellow appearance in daylight? Is the pink shade of snow at dusk not a real chromatic phenomenon worth explaining? More generally, would our knowledge of colors be the same if all these variations were absent from our experience? I doubt it. Color variations are diverse. We can assess the maturity of a piece of fruit by noticing a change in the color of its skin, but we can also observe changes in atmospheric properties by noticing a transient change in a meadow's color. Those color variations are different in nature, but why should we not consider them equally real? In the next section, I propose a new approach to reflectance physicalism which takes all color variations seriously and considers that the nature of the illuminants is at the core of a proper account of colors.

---

[7] The preference for natural daylight and its epistemic role is discussed in §7.

5 Reflectance Physicalism Revisited

Reflectance physicalism supports the view that colors exist independently of our perception of them and that they are identical to reflectances—the physical dispositions of surfaces to reflect a certain proportion of the incident light. Because reflectances are specific ways of interacting with light, reflectance physicalism seems to involve the claim that colors are dependent on light. Colors depend on light in the same way weight depends on gravity or solubility depends on a solvent. Yet, most reflectance physicalists insist that this is not the case. For example, Byrne and Hilbert write:

> Assuming that our perceptions of color are often veridical, we therefore need a physical property of objects that is largely illumination-independent—a physical property that an object can retain through changes in illumination. This last constraint rules out properties an object has only if it is actually reflecting light of a specific character—for instance, light with a certain wavelength-energy distribution (spectral power distribution), or wavelength composition. (2003, 9)

It seems that Byrne and Hilbert conflate distinct and crucial notions. First, reflectances, as dispositional properties, are intrinsic properties of their bearers. Their manifestation is possible but not necessarily actual. The fact that color must be "a physical property that an object can retain through changes in illumination" therefore has nothing to do with the fact that reflectances are *illumination-independent*; rather, it is related to the fact that reflectances are *dispositional* and *intrinsic* rather than *categorical* and *relational* properties of surfaces.[8] Colors do not change with

[8] For a good defense that dispositions are actual and non-relational properties, see Mumford 2003: §4.5.

changes in illumination, because they remain “in” their bearers whether or not they are manifested. As with any other dispositional properties, changes in the conditions—here, changes in illumination—can bring about or fail to bring about the manifestation of a dispositional property. Similarly, weight is not gravity-independent, because an object retains its weight across changes in gravity. Weight is a gravity-dependent property that is both dispositional and intrinsic to an object with a mass. For example, an object is six times lighter on the moon than it is on earth. And the fact that an object is located on earth doesn’t change its lunar weight; it just prevents its lunar weight from being manifested.

The idea that reflectances are illumination-independent is very misleading and has fueled many misconceptions. The main unfortunate consequence of this mistake is the unsatisfying account of the phenomenon of color constancy given by most philosophers who endorse an objectivist view of colors. As Cohen correctly points out, color objectivists have described color constancy as a kind of invariance by neglecting the color variation caused by illumination:

> And this has led to a more or less standard understanding of colour constancy as a kind of invariance. In particular, on this view (henceforth, invariantism), colour constancy is an invariance of apparent colour across changes in illumination. Invariantism has become the de facto standard understanding of colour constancy in both philosophical and scientific work on colour. (Cohen 2008, 64)

As Cohen and many other authors have stressed, the readiness of subjects to acknowledge that some surfaces look chromatically the same despite differences in illumination does not exclude their awareness of the chromatic changes caused by variations in illumination. For example, it is through the changes in the colors of Monet’s haystacks themselves that we become aware of the season and the time of day represented by Monet’s paintings. Although illumination doesn’t appear to change the physical properties of the haystacks, there is a clear sense in which the sunset light can actually turn our perceptual experiences of haystacks from yellow to vivid red.

Cohen’s own response to color variations caused by changes in illumination is to defend a relationist view of colors according to which colors are relations not only between objects and subjects but also between objects and circumstances. The fact that the same surface can appear to have different colors across changes in illumination is what a relationalist would expect, because colors are, in this approach, constituted by their relations to viewing conditions: changing the illumination changes the viewing condition and therefore changes the color. For a relationalist, the difficulty is rather to account for color constancy, that is, the fact that a surface seems in a certain sense to retain its color despite variations in illumination. To accommodate his relationalism to color constancy, Cohen proposes a counterfactualist account of the apparent unity presented by a surface across differences in illumination. Unlike invariantism, the counterfactualist account does not explain the apparent chromatic unity exhibited by a surface across differences in illumination by appealing to the fact that a surface exhibits the same occurrent color across such differences, but rather by appealing to the fact that a surface would exhibit the same color properties in the same counterfactual situations. As Cohen explains, “[Counterfactualism] does not say that such regions are alike in that they share an apparent colour. Rather, it says that the two regions are alike in that they would share an apparent colour if, contrary to fact, both regions were presented under the same illumination.”

Cohen's view provides two important insights: illumination cannot be excluded from an account of the nature of color, and color variations across changes in illumination are at the heart of the phenomenon of color constancy itself. In the remainder of this section, I will show that objectivism regarding colors and reflectance physicalism, contrary to what is usually assumed, can endorse Cohen's insights into color constancy. In particular, they can both acknowledge the simple phenomenological observation that the colors we experience vary as lighting changes and reject the invariantist conception of color constancy used to support ontological theories of color and especially color objectivism. However, the view I will defend differs from Cohen's in many ways. For example, rather than arguing for a relational and subjectivist view of colors, I maintain that colors are objective and intrinsic properties of surfaces. And in contrast to Cohen's counterfactualist approach to color constancy, my view explains the unity put forward in the phenomenon of color constancy by appealing to the phenomenological stability provided by a selectionist view of color experiences.

To understand how reflectance physicalism can explain the phenomenological observation that color experiences vary with changes in illumination, it suffices to notice that reflectance is both a disposition to interact with light and a disposition that varies according to the nature of the light. The approach taken by most reflectance physicalists centers on the notion of SSRs, that is, the dispositional properties of surfaces to reflect a determinate amount of the incident light at each wavelength in the visible spectrum. Yet, as §4 shows, SSRs cannot be the physical properties detected by the human visual system, because it cannot discriminate between all the wavelengths constituting full-spectrum light. Moreover, if colors were SSRs, color vision would be restricted to perception in full-spectrum light, which could be the case only if we arbitrarily restricted the notions of visible light and veridical perception.[9] But SSRs are not the only reflectance properties of surfaces. A surface's reflectance property corresponds to the way a surface reflects the incident light, but its reaction to the light depends on the wavelengths entering into the composition of the incident light. This is why a blue surface on a white background that reflects a large proportion of short wavelengths included in white light (i.e. light source that approximates a uniform spectral power distribution) will reflect almost no light and appear almost black when illuminated with filtered light composed exclusively of long wavelengths. There is not a unique way for a surface to interact with light, because light is not a simple and unique phenomenon. By decomposing light into rays of different wavelengths, Newton demonstrated that white light, though apparently simple, is in fact complex. Although light is not visible,[10] the complexity of light is directly related to the variety of the colors we perceive. To grasp the importance of this relation, consider what our perception of colors would be like if light were simple and could vary only in intensity. If light were uniform, each point of a surface would reflect a determined proportion of the illuminant, but there would be no differences related to wavelengths. Provided that they reflect the same proportion of light, red, green, blue, and yellow surfaces would therefore be indiscriminable. Without the complexity of light, all phenomenological properties associated with color perception would vanish, because it is only through the interaction of surfaces with various wavelengths that the diversity of the intrinsic properties of surfaces can be accessed.

Unlike most objectivist and physicalist accounts of colors, my proposal does not favor one illuminant, or one type of illuminant, over others. In particular, it does not assume that

---

[9] In § 7, I discuss the ontological and epistemic reasons to favor a particular illuminant.

[10] This claim will be explained and argued in detail in §7.

natural daylight or any other entire-spectrum light source is preferable for determining an object's real color.[11] It can certainly be argued that entire-spectrum light is superior for some tasks[12], but it cannot be concluded from this fact alone that illuminants that do not emit light continuously across the entire visible spectrum cannot give us access to an object's real color. According to this account, numerous colors can then be perceived in the absence of most wavelengths constituting the visible spectrum. In fact, as it appears, light composed of any combination of wavelengths projected onto a white surface will give rise to characteristic color experiences.[13] None of those colors can be identified with SSR, because a surface's disposition to reflect a characteristic proportion of light at each wavelength cannot be accessed in the absence of those wavelengths. Although SSR cannot be perceived in the absence of entire-spectrum light, all colored surfaces have stable dispositions to reflect different lights. In fact, for any illuminant and any particular surface, there is a characteristic proportion of the incident light that a surface is disposed to reflect.

Traditional reflectance physicalism rightly identifies colors with dispositional properties of surfaces to interact with light, but it neglects two basic facts: light is not a single and uniform phenomenon, and each surface has as many reflectance properties as there are illuminants of different natures. Although all reflectance properties are intrinsic and mostly stable properties of surfaces, they are accessible only under particular illuminants.

---

[11] For a defense of natural daylight as determining the real colors of objects, see Allen 2010.

[12] The epistemic advantage of daylight is discussed in §7.

[13] Notice that the colors perceived in the absence of most wavelengths are typically the colors used in colorimetry to quantify and physically describe human color perception. Cf. CIE (1932). *Commission internationale de l'Eclairage proceedings, 1931*. (Cambridge: Cambridge University Press).

Perceived colors vary across illuminants not because colors are relational or transient properties, but rather because the nature of the illuminant selects which reflectance properties are visually accessible to an observer. This is also why invariantism, according to which “colour constancy is an invariance of apparent colour across changes in illumination,” (Cohen2008, 64) is wrong.

There is no invariance of perceived color across changes in illumination, because each different illuminant gives access to different reflectance properties. However, the kind of color changes caused by variations of illuminants is very different in nature from the kind of color changes that can be traced to changes in the properties of the colored surfaces. The color changes involved in perceiving a surface across different illuminations are different from color transformations involving a chemical or physical change to the surface of a material object, because color changes due to illumination result not from changes on the surface of colored objects but rather from the way lighting selects which color is perceived. Unlike chromatic discontinuities due to physical discontinuities of a surface—like the different colors of a multicolored beach ball, which correspond to differences in the physical properties of its surface—the differences in color resulting from the projection of light of different wavelengths on a wall are not due to any physical discontinuities of the wall's surface. Those color differences correspond to colors made visible by using light of different wavelengths. The surface of a wall can then appear to be of different colors without any discontinuities in the surface’s physical properties.

6 Counterfactualism Revisited

The account of colors proposed here distinguishes between two kinds of *experiences* of color variations. When we experience the color of a surface as changing under fixed illumination, we witness a change in the dispositions of the surfaces to interact with light. We therefore witness a change *in the intrinsic properties of the surface*. In contrast, when we perceive a change in color caused by a change in lighting, the color of the surface is replaced by another color of the same surface *in the subject's experience*. Although a new color appears in the subject's experience after a change in lighting has occurred, this color was present in the surface all along. In the latter case, none of the colors of the surface has changed, but our awareness of them has changed according to the circumstances. I believe this approach captures the contrast between transient and stable colors used by some philosophers to describe color constancy. Armstrong offers the following argument:

> When considering the phenomenology of colours in particular, it is useful to draw a distinction between *standing* and *transient* colours. This is intended as a distinction in the coloured object, and is not perceiver-relative […]
>
> Now consider a coloured surface such as a piece of cloth with fast dye which is subjected to different sorts of illumination. We often say that it presents a different *appearance* under the different illuminations. This seems misleading. In a standing sense the colour does not change. But in a transient sense it really does change colour. The mix of light-waves that leaves the surface is different. A standing colour is thus a disposition to have that transient colour in normal lighting conditions. (Armstrong 1987, 45, n.6)

As this quote exemplifies, the constancy phenomenon is often viewed as implying a dichotomy between different kinds of colors or color appearances. In my view, this dichotomy is empty, because all colors perceived are of the same nature; what is transient or stable is our access to them. If colors are dispositions of surfaces to reflect any illuminant or any combination of illuminants, this disposition doesn't change unless there is a change in the physical properties of the surface. But changes can occur in the perception we have of those colors. According to the view of colors defended here, color perception is always partial, because our color experiences give us access to only a fraction of the plurality of the colors there is. This form of color pluralism[14] indeed involves color selectionism,[15] that is, the idea that interpersonal and intrapersonal color variations can be explained by the selective role of the visual system and the environmental conditions. In short, the spectral sensitivities of a given observer's color receptors determine which colors this observer can perceive. According to this view, most intersubjective color variations can be explained as differences arising from which set of colors is accessible to individual perceivers given their particular visual systems. Although colors are mind-independent and color experiences are veridical, the selectionist approach to color perception explains how different subjects endowed with different visual systems experience different colors. A similar explanation is available for variations in lighting. Which colors a particular observer can perceive in a particular situation depends on both the spectral sensitivity of the observer's color receptors and the spectral properties of the illuminant.

---

[14] Color pluralism is the view that objects have simultaneously different colors. It has been defended in Matthen (1999), Mizrahi (2006), Kalderon (2007), and Allen (2009).

[15] For the relation between color pluralism and selectionism, see Kalderon (2007)

Consider a ripe banana perceived in daylight. It appears yellow to a normal trichromat, because a trichromat's visual system has the capacity to detect colors that correspond to color variations along three wavebands S, M, and L. But the same banana also reflects a determinate ratio of each wavelength or each arbitrary waveband included in the visible spectrum. It reflects, for instance, a determinate ratio of light at 650 nm. Yet, when a banana is seen under a red monochromatic light at 650 nm, the visible light is limited to the spectral range of the L receptor, causing the banana to appear red.

Visual systems and illuminants are causal intermediaries in the perceptual process that transmit information about a surface's dispositions to interact with light in a particular way. But like all perceptual media, they also select the kind of information that is available to the perceiver.[16] Perceiving different colors in different lighting conditions must therefore be distinguished from perceiving intrinsic color variations. When perceived across varying illuminants, the colors of surfaces remain unchanged and stable; what changes is the subject's perspective. When changes in illumination occur, it is therefore not colors that are transient, but rather the subject's access to them. Changes in illumination, or wearing "colored" glasses, modify color experiences in a way similar to the use of optical instruments. Periscopes, telescopes, and microscopes give rise to visual experiences very different from those delivered by the naked eye. All these experiences are, however, veridical and enrich our knowledge by expanding our visual capacities to spatial and even temporal regions inaccessible to our visual system. Perceiving through optical instruments changes the subject's visual experiences by changing what is accessible to the perceiver. Moreover, it would be misleading to say that what is perceived through a microscope or a telescope appears different. For example, perceiving

[16] See Mizrahi (2018)

through a microscope doesn't make objects appear larger, because the kind of information delivered in this case is different and in a certain sense incommensurate with what is perceived by the naked eye. Similarly, perceiving colors under different illuminants or through color filters changes our chromatic perception by changing the chromatic portions of the world we can access. By traveling across different chromatic portions of the world, we come into contact with different "families of colors." Each family of colors is united by relations of similarity, difference, and exclusion, but such relations do not hold between members of different families.[17] The use of telescopes has been fundamental for scientific progress because they make possible the observation of distant objects and allow unexpected realities to be discovered. This is what happens with chromatic realities as well. This is the case, for example, when one discovers that two garments that match perfectly under artificial light in the store appear different when one emerges into daylight, or when a forensic officer discovers a stain after projecting a black light onto a uniform and apparently immaculate carpet.

Although phenomenological differences arise from perceiving the same object through different optical instruments, we would not describe these differences as arising from the perceived object itself. Rather, the object appears to remain unchanged, whereas our perception of it changes. Similarly, some phenomenological differences emerge when we perceive a given surface across different lighting conditions, but we don't conclude that these differences correspond to differences in the intrinsic colors of the perceived surface. If the present account of color variation across differences in illumination is correct, we don't really perceive the same

[17] For the idea that visual systems and viewing circumstances determine unique colors families, see Kalderon (2007).

color across different illuminants, but we can nonetheless conclude that no intrinsic chromatic property changes while we look at a surface.

To account for the constancy of colors under different illuminants without subscribing to the invariantist approach, Cohen suggests that colors are visually represented by counterfactuals. According to this view, two surfaces under different illuminations are perceived to be alike if, contrary to fact, they would share the same color under the same illuminant. Therefore, Cohen's counterfactualism regarding the constancy of colors under different illuminants neither denies, like color invariantism, that color perception varies with illumination nor affirms that veridical color appearances should be restricted to perception occurring under certain forms of illumination only (E.g., daylight); rather, it explains "the capacity of the visual system to discern similarity in counterfactual apparent colour across differences in occurrent apparent colour" (Cohen 2008, 22).

Cohen's counterfactualism is problematic for several reasons, but it shares some important ideas with the account proposed in this paper. First, according to counterfactualism, the fact that an object retains the same color across illuminants is determined by its different color appearances under different illuminants and not by an invariable appearance. Counterfactualism, therefore, does not support the claim that color constancy motivates a light-independent view of colors. Second, counterfactualism explains color constancy by a constancy or an invariance about some phenomenological variability. We perceive stability in chromatic appearances across illuminants because they manifest some invariance that can be expressed by counterfactuals like "two regions are alike in that they would share an apparent colour if, contrary to fact, both regions were presented under the same illumination (namely, under I_1 or under I_2)" (Cohen 2008, 22).

However, one concern about a counterfactual analysis of color constancy is that it is difficult to understand what it means to perceive or experience colors that are not present but are only counterfactual. A plausible view of color perception is indeed that the phenomenology of our color experiences is explained by our direct acquaintance with colors. Yet, it is difficult to understand what a direct acquaintance would be in the case of colors that are potentially but not actually present. A similar reservation about Cohen's view on color constancy is expressed by Tye:

> [. . .] if [. . .] the perceptually distinguishable regions [. . .] manifest different colors, then, on Cohen's account of color, they actually look different colors. According to Cohen, then, there isn't color constancy (in the relevant sense). This seems wrong to me and to miss the point. I take color constancy for the purposes of this objection to be constancy in how things look color-wise through different lighting conditions. It isn't constancy, period. Cohen fixes up something that gets the latter but he doesn't get the former. (2012, 303)

Tye's objection is that color constancy is a perceptual phenomenon and that an adequate account of color constancy must refer to how surfaces appear in experience, not how they would look if they are viewed with a different illuminant. But one can doubt that color constancy is a purely perceptual phenomenon, because color constancy appears to involve a judgement about colors' stability which requires the actualization of the subject's conceptual capacities and is not limited to the subject's sensory mode of awareness. What color experiences must exhibit in order to explain color constancy is not identities of colors, but awareness of colors which justify some judgements about the surfaces in which they inhere. For example, perceiving that the color of the snow is pink at sunset justifies my belief that snow would appear white at noon. According to this view, color constancy judgements are not justified because two colors look alike in experience but because the colors perceived in experience make the perceiving subject justified in believing that snow at noon will look white if the properties of the snow remain constant.

What is problematic in Cohen’s view or any subjectivist view is not therefore that color constancy is expressed by counterfactuals, but that those counterfactuals must be somewhat accessible through perception. As Cohen puts it:

> Putting all this together, counterfactualism understands colour constancy as the capacity of the visual system to discern similarity in counterfactual apparent colour across differences in occurrent apparent colour. (Cohen 2008, 22)

The situation is very different for the color realist who takes colors to inhere in objects. If colors are nonrelational and mind independent, they exist without being perceived. Yet, to be perceived, different conditions must be met. Colors are indeed perceived only if the perceiver’s visual system has some definite characteristics and only if that perception takes place under particular circumstances, including a restricted set of illuminants. For the realist, the role of counterfactuals is therefore to express what the particular colors of a given object are and in what particular conditions they can be perceived. Unlike in Cohen’s approach, counterfactuals do not enter perceptual experience, but they capture which dispositional properties characterize a given surface and what the surface’s colors are, provided there is no alteration of the colored surface. According to the realist, the list of counterfactuals proposed by Cohen does not therefore provide a reductive analysis of what remains constant in color experiences under different illuminants, but it captures an important truth regarding colors. The counterfactuals proposed by Cohen do express the fact that colors, despite their dispositional nature, are actual, intrinsic, and stable properties of surfaces that ground the characteristic invariance of appearances manifested by surfaces across different illuminations. The invariance associated with color constancy is not an invariance regarding the color appearances themselves or, in other words, the phenomenal character of these experiences, but an invariance regarding the kind of variability exhibited by a colored surface under different illuminants and the systematic relationships between its color appearances and the nature of the illuminants.

As Cohen emphasizes, the experimental results regarding the extent of color constancy are very different according to whether subjects are asked to match different pieces of paper "to look as if it were 'cut from the same piece of paper'" (2008, 66) or whether they are asked to "adjust the test patch to match its hue and saturation to those of the standard patch" (2008, 66). I believe this discrepancy is what is expected if what motivates a subject to conclude that two surfaces look alike under different illuminations is not the colors the subject immediately perceives, but rather his/her expectation regarding the series of simultaneous or successive color appearances presented according to his/her beliefs regarding the dispositional properties of the perceived surface. We could say that color constancy corresponds to the experience of a constant and specific variability rather than to an experience of a constant color.

7 Invisible Light versus Visible Lighting

I have criticized the invariantist approach because it fails to take into account the chromatic variations that are experienced when illumination varies. In his 2005 paper, Hilbert acknowledges this difficulty and tries to resolve it by suggesting that the visual system tracks illumination as well as reflectances:

> All of the issues with computational theories can be resolved by supposing that in addition to delivering information about the reflecting properties of objects the visual system also delivers information about the way in which those objects are illuminated. When we look at the printed page under indoor illumination we see not only that some parts of it are white and others are black but that the whole of it is dimly lit. (2005, 150)

It seems indisputable that our chromatic experiences are not limited to the awareness of the colors of opaque surfaces and that we also perceive, in a way explained below, variations in illumination. As we have noted, Monet captured such variations through series of paintings of single subjects, such as the famous *Rouen Cathedral* and *Haystacks,* for which he studied and painted the continuous atmospheric and light changes throughout the day and the year.

What exactly did Monet capture in these series? What explains the difference between the illumination of the Rouen Cathedral at dusk and its illumination at noon? What is the relationship between perceiving the cathedral and perceiving its illumination?

A simple answer to these questions is that when perceiving the cathedral and its illumination, we perceive two distinct elements, both of which contribute to the visual experience of the scene. This is the approach articulated, for instance, by Brown (2014), who argues that a color experience involves two colored layers and that both contribute to the explanation of color constancy. On this account, the perceived object exhibits a constant color that can be supplemented by the color of the light through which perception takes place. “Standard” perception is therefore modeled after perception through transparent objects, in which the chromatic experience is supposed to be determined by the color of an object perceived through a transparent object and the color of the transparent object itself.[18]

I detect many problems in Brown's account of color constancy, but I will focus my criticism on the idea that light is colored and can contribute to chromatic perception by adding its chromatic properties to the color of the perceived objects. I will argue that characterizing light as one of the elements of what we perceive distorts the phenomenology and ontology of visual perception and that explaining color constancy therefore requires a very different strategy. Brown's proposal is phenomenologically suspicious because we never perceive light, at least not directly.[19] As Gibson notes, light "is never seen as such. It follows that seeing the environment cannot be based on seeing light as such" (1979, 55)[20]. In fact, in the absence of reflective surfaces, light is invisible. When it travels through outer space, light is invisible until it can bounce off something. And as Hilbert rightly points out, we never perceive beams of light, but only the reflectance properties of the dust particles they illuminate (Hilbert 1987, 162).

Arguing, like Brown, that chromatic experiences result from a combination of the colors of objects with the color of the light through which they are perceived gets the phenomenology wrong, but more significantly, it dissolves a distinction which is important for understanding colors and visual perception in general. Although the presence of light is a necessary condition for seeing, this is the case only because light contains information about visible things. As

---

[18] This approach is not available if transparent objects are colorless as I argued in Mizrahi (2010, 2018).

[19] For the defense that we perceive light independently on our seeing objects, see O'Shaughnessy (1985), Matthen (2018).

[20] This view is shared by many authors, see Chisholm (1957), Heider (1959), Smart (1963), Hilbert (1987).

Gibson notes, light is informative insofar as it is structured by the environment.[21] Therefore, light plays an essential role in vision not by virtue of its own phenomenological and physical characteristics but rather because it can be structured by the environment. Similarly, Heider explains why the information conveyed *by* light cannot be *about* light itself. From an ontological point of view, light does not possess the characteristics it conveys because light is composed of a manifold of independent light rays that vary independently. When a particular structure emerges from this manifold, it does not therefore characterize the manifold but rather the event or the object that imposes its structure on it. Heider explains:

> The mediator processes which meet our sense organs are spurious units; they have unitary form not because they are coordinated to objects. If one does not refer them to their unitary cause, they are unexplainable. A manifold of light rays which has been produced by a source of light cannot be compared to an event, such as the fall of a stone, which also had its causes but which it stands, so to speak, by itself. The light rays have no "reality" without their cause. They contain a strict order which cannot be attributed to the waves themselves since they are independent of each other. (Heider 1959, 7)

This understanding of the role of light in vision is in perfect accordance with reflectance physicalism which identifies colors with dispositional properties of surfaces to interact with

---

[21] Gibson writes: "In the case of unstructured ambient light, an environment is not specified and no information about an environment is available. Since the light is undifferentiated, it cannot be discriminated, and there is no information in any meaning of that term. The ambient light in this respect is no different from ambient darkness. An environment could exist behind the fog or the darkness, or nothing could exist; either alternative is possible" (1986,52).

light. According to this view, then, attributing color properties to light is incoherent, because it would involve the capacity of light to be transformed by itself.

If light is invisible, how then does simply looking out a window inform us of the time of day, the weather conditions (Jameson & Hurvich, 1989; Endler, 1993; Zaidi, 1998), and even the geographical location (Judd, MacAdam, & Wyszecki, 1964) of what we perceive?

If we take seriously the phenomenology of the perception of colors under changing illuminants but deny that the color variations due to different illuminants can be partially attributed to the color of those illuminants, we must conclude the colors we see across changes of illuminants are the colors of the surfaces themselves. Therefore, according to this approach, if we can perceive the illumination of a scene, this perception is nothing over and above perceiving the colors of the objects within a particular scene. The challenge is then to explain how perceiving colors of objects across variations in illumination gives access to the illumination itself. In other words, what does it mean to say that we perceive the illumination of a perceived scene?

To answer this complex question, I propose that we consider the special relationships between colors under a given illumination and colors under different illuminations. If colors C_i under a given illuminant *I* are identified with dispositions to reflect a certain proportion of *I*, a uniform colored surface has only one C_i at a time. A given uniform colored surface has, however, a plurality of colors, because there is at least one color for each different illuminant. Now, the colors we can perceive only under a particular illuminant *I* constitute a distinctive family of colors united by particular relations of similarity and exclusion. Unlike colors perceived across different illuminants, colors perceived under the same illuminant are indeed exclusive. This is why a green surface under *I* cannot simultaneously be yellow, blue, or magenta and, more generally, why being a particular color under *I* excludes being any other color under *I*.

Note that the exclusion relations characterizing colors perceived under a particular illuminant *I* follow from the fact that colors are a disposition to reflect a certain proportion of a particular illluminant. For any given illuminant, a surface cannot have more than one of those dispositions at the same time. As we have seen, the situation is different with colors perceived across different illuminants. Colors perceived across different illuminants belong to different families and are therefore not exclusive. A surface can be white in I_1 but blue in I_2 or red in I_3, because the surface reflects a distinct proportion of each given illuminant I_1, I_2, and I_3. Thus, the light-dependent reflectivist view defended here does not deny the possibility of perceiving different colors across different illuminations, but it does deny the possibility of perceiving different colors at the same place under the same conditions.

It seems we are now in a better position to answer our initial question: what does it mean to perceive illumination? Although we don't directly perceive the light that enables color perception, we can access illumination through the unique family of colors revealed to us by each individual illuminant. Colors perceived under the same illuminant are indeed united by similarity and exclusion relations unique to them. Thus, because similarity and exclusion relations hold only within a family, for each given subject, there is a one-to-one correspondence between color families and illuminants. Perceiving a particular illuminant is therefore perceiving colors belonging to a particular family.

Although very minimal, this approach to illumination is enlightening. Consider our preference for natural daylight. Average daylight or sunlight is often taken as standard for color vision, and we seem to assume that natural daylight gives us access to the true colors of objects. But as we have seen, if colors are illumination-dependent properties, this cannot be the case, because whatever the illuminant, for each colored surface, there is a true color corresponding to the way this surface interacts with a given illuminant. So why do we prefer daylight? Are we forced to conclude, with Michaelson and Cohen (2020), that our appeal to natural daylight is unmotivated and that our preference is ontologically or epistemologically unjustified? I don't think so. The account of illumination defended above provides a very different interpretation of differences between illuminants. Although all illuminants, as argued above, are equal with respect to the veridicality of the color experiences they select, the color families they determine are different. For instance, they can be of different sizes. Yet, the size of a family of colors is important for color perception, because the more colors we can discriminate under a given illumination, the more chromatic nuances and contrasts we can perceive. Consider Akins' contrasting example of a case of perception under monochromatic light:

> For the trichromat, under a red illuminant, everything that is visible appears in shades of red from bright red to red-black. But what is visible against a bright red wall? A magenta figure (e.g. the fox) will reflect a large percentage of red light. A red fox does not contrast with a red wall. The same holds true for all of the magenta figures. Paradoxically, under the red illuminant, figures rendered in the blue ink will be the most visible. A blue figure reflects very little red light under any lighting conditions, hence it will now reflect very little light at all. The blue alligator thus appears as a black figure against a red wall. (Akins 2014, 181–2)

Under monochromatic light, the colors perceived are restricted to a relatively small set of colors. If the light source emits only short wavelengths, all surfaces will look bluish, but if the same scene is perceived under an illuminant including only long wavelengths, everything will appear reddish. In both cases, the richness and the vividness that characterize our perception in standard daylight are lost. So the size of the color family that characterizes an illuminant matters. It matters because it corresponds to a more or less extended palette of colors. Our preference for daylight is not justified because it reveals an object's real color, as argued by Allen, nor is it merely arbitrary, as argued by Cohen. Natural daylight is generally preferred because it provides a rich palette of colors that allows us to easily discriminate between surfaces and identify objects.

Although I have argued that daylight, or any other entire-spectrum light, doesn't provide better access than other illuminants to the real colors of objects, I think it is possible to explain the epistemological advantage of certain illuminants over others by appealing to the complexity of the network of relationships they allow. The same explanation provides an answer to Michaelson and Cohen's criticism of Allen's defense of natural daylight. They indeed argue that there is no basis for choosing between different types of daylight and that, despite daylight's intuitive appeal, our preference for it is unmotivated. Although not all illuminants are equal with respect to the size of their corresponding color families, in some cases the sizes of such families are more or less equivalent. This happens in particular when sources emit light continuously across the entire visible spectrum. I agree with Michaelson and Cohen's point that, in this case, there seems to be no basis for choosing one illuminant over others from an epistemological point of view.

8 Conclusion

I have argued that conceiving colors as objective light-dependent properties explains not only why entire-spectrum illuminants are preferred, but also how it frees us from arbitrarily choosing certain color appearances over others—what Russell refers as "color favoritism" (Russell 1912).

Color constancy has been a challenge for psychologists and philosophers since Helmholtz published his work in the mid-nineteenth century, and its formulation has not changed much since that time. The Helmholtzian idea was to explain the constancy of the colors perceived across different illuminations by “discounting the illuminant” (Helmholtz 1909, 287) from the information carried by the light reaching the observer’s eyes. I have argued that this approach is fundamentally wrong, not only because invariantism favors a faulty view of the phenomenology of color vision but above all because it fails to offer a full account of the significance of the color constancy phenomenon for color vision and theories of the ontology of colors.

I have argued that the chromatic variations resulting from changes in illumination demonstrate that colors are light-dependent properties and that the constancy of the colored objects across these variations is grounded in the dispositional and intrinsic character of color properties. Rather than “discounting the illuminant,” I have shown that observers have access to the plurality of illuminants through the palettes of colors these illuminants disclose. To quote Laforgue’s nicely expressed insight into the innovations introduced by impressionism, it is not by “painting the light” that impressionists have grasped the nuances of the atmosphere and the complete range of variations in illumination, but rather by capturing the polyphony of colors these variations reveal:

> In a landscape flooded with light, in which beings are outlined as if in colored grisaille, where the academic painter sees nothing but a broad expanse of whiteness, the Impressionist sees light as bathing everything not with a dead whiteness but rather with a thousand vibrant struggling colors of rich prismatic decomposition…

> The Impressionist sees and renders nature as it is—that is, wholly in the vibration of color. No line, light, relief, perspective, or chiaroscuro, none of those childish classifications: all these are in reality converted into the vibration of color and must be obtained on canvas solely by the vibration of color. (as cited in Harrison, Wood & Gaiger 1998, 937–8)

References

Akins, Kathleen 2014. "Black and White and Colour" In R. Brown (ed.) *Consciousness Inside and Out: Phenomenology, Neuroscience and the Nature of Experience.* Springer Verlag.

Albright, Thomas D. & Gene R. Stoner 1995. “Visual motion perception”. Proceedings of the National Academy of Sciences. 92 (7): 2433–2440.

Allen, Keith.2009. "Inter-Species Variation in Colour Perception." Philosophical Studies 142 :197–220.

— 2010. “In defence of natural daylight”. Pacific Philosophical Quarterly, 91: 1–18.

— 2016. *A Naïve Realist Theory of Colour*. New York: Oxford University Press.

Armstrong, David M. 1987. “Smart and the Secondary Qualities” in P. Pettit, R. Sylvan, and J. Norman (eds), *Metaphysics and Morality: Essays in Honour of J. J. C. Smart*, Oxford : Basil Blackwell: 1–15. Reprinted in Byrne and Hilbert 1997: 33–46.

Brown, Derek 2014. “Colour layering and colour constancy”, *Philosophers' Imprint* 14(15):1–31.

Brown, Derek H., & Macpherson, Fiona (Eds.). 2020. *The Routledge handbook of philosophy of colour*. London: Routledge.

Byrne, Alex. and David R. Hilbert (eds) 1997. *Readings on Color*, Vol. 1, *The Philosophy of Color*, Cambridge, MA: The MIT Press.

— 1997. "Colors and Reflectances" in Byrne and Hilbert,1997: 263–288.

— 2003. "Color realism and color science". Behavioral and Brain Sciences 26(1):3–21.

Chisholm, R. 1957. *Perceiving: A Philosophical Study.* Cornell: Cornell University Press.

Cohen, Jonathan 2008. "Colour constancy as counterfactual". Australasian Journal of Philosophy, 86(1):61–92.

Crowther, Thomas & Mac Cumhaill, Clare (Eds.) 2018. Perceptual Ephemera. Oxford: Oxford University Press.

Endler, John 1993. "The Color of Light in Forests and Its Implications". *Ecological Monographs 63*(1): 2–27.

Gibson, Jerome J. (1950). "The perception of visual surfaces". American Journal of Psychology, 63:367–384.

—1986. *The Ecological approach to visual perception*, Hillsdale, NJ: Erlbaum.

Harrison, Charles, Paul Wood & Jason Gaiger 1998. *Art in theory 1815-1900: An Anthology of Changing Ideas*. Wiley-Blackwell.

Heider, Fritz 1959. "Thing and medium", Psychological Issues I:1–34.

von Helmholtz, Hermann 1909. *Physiological Optics*, in J.P.E. Southall (Ed.), Optical Society of America, Vol. II, 1924.

Hilbert, David R. 1987. *Color and Color Perception: A Study in Anthropocentric Realism.* Stanford: CSLI.

— 2005. “Color Constancy and the Complexity of Color”. Philosophical Topics 33(1):141–158.

Jameson, Dorothea & Hurvich, Leo M. 1989. “Essay concerning color constancy”. *Annual Review of Psychology, 40,* 1–22.

Judd, Deanne, David MacAdam & Günter Wyszecki 1964. “Spectral distribution of typical daylight as a function of correlated color temperature,” Journal of the Optical Society of America 54(8): 1031–1040.

Kalderon, Mark E. 2007. "Color Pluralism." *Philosophical Review* 116: 563–601.

—2021. “Monism and pluralism” in Brown, D.H., & Macpherson, F. (Eds.). *The Routledge handbook of philosophy of colour*. London: Routledge.

Katz, David 1911. *Die Erscheinungsweisen der Farben und ihre Beinflussung durch die individuelle Erfahrung, Zeitschrift für Psychologie*, Erg.-Bd. 7, Leipzig: Barth; second ed. 1930 Der Aufbau der Farbwelt; abridged English tr. 1935 The World of Colour. London: Kegan Paul.

Knuth, P. 1891. Die Einwirkung der Bluthenfarben auf die photographische Platte. *Botanische Central Blätter* 48:161–165.

Matthen, Mohan 1999. “The Disunity of Color,” *The Philosophical Review* 108 /1: 47–84

— 2018. “Ephemeral Vision”. In Crowther, T., & Mac Cumhaill, C. (Eds.) *Perceptual Ephemera*. Oxford : Oxford University. Chapter 15.

Mizrahi, Vivian 2006. “Colour objectivism and colour pluralism” *Dialectica*, 60(3):283–306.

— 2010. “Colour and transparency” *Rivista di Estetica* 43: 1.

— 2018. “Perceptual Media, Glass and Mirrors.” In *Perceptual Ephemera* edited by T. Crowther and C. Mac Cumhaill, 238-59. Oxford: Oxford University Press.

Mumford, Stephen 2003. *Dispositions*. Oxford: Oxford University Press.

Mulligan, Kevin 1999. “Perception, particulars and predicates”. In Denis Fisette (ed.). *Consciousness and Intentionality: Models and Modalities of Attribution*. The Western Ontario Series in Philosophy of Science, Kluwer, 163–194.

Nakayama, K., Shimojo, S., & Silverman, G. H. 1989. “Stereoscopic depth: Its relation to image segmentation, grouping, and the recognition of occluded objects”. Perception, *18*(1), 55–68.

Russell, Bertrand 1912. *The Problems of Philosophy*, Oxford: Oxford University Press.

Smart, J. J. C. 1963 *Philosophy and Scientific Realism*. New York: Humanities Press.

Tye, Michael 2000. *Consciousness, Color, and Content*. Cambridge MA: MIT Press.

— 2012. “Cohen on Color Relationalism,” *Analytic Philosophy*, 53 (3): 297–305.

Zaidi, Q. 1998. "Identification of illuminant and object colors: heuristic-based algorithms," J. Journal of the Optical Society of America 15:1767–1776.