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Color Constancy in Philosophy and Science

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Abstract

Color Constancy in Philosophy and Science

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Color constancy is the phenomenon in which the visual system reliably ensures that objects that are the same color continue to look the same color despite, what one might call, interference. It is frequently appealed to in philosophy to support a myriad of theories about the nature of color and the metaphysics of experience. The dissertation investigates color constancy, particularly the empirical work on it, and reconsiders how it has been employed philosophically.

The dissertation begins by analyzing a landmark empirical study of color constancy and explains the ways in which this work has figured in a number of philosophical theories. Then, it is argued that there is another, more neglected, type of color constancy, and that this second type of color constancy cannot be easily assimilated by the above philosophical theories.

This second type of color constancy is then applied to a puzzle about how things look when they are under varying illumination. This puzzle has motivated certain theories of color and color-like properties. The dissertation argues that such motivation is undercut once the puzzle is seen to dissolve in light of the second category of color constancy.

Finally, the dissertation turns from the issue of what color constancy is to the issue of how it is accomplished, i.e. the mechanisms by which the visual system produces color-constant experiences. It is argued, from an empirical basis, that an appeal to color constancy in the grounding of perceptual representations falters because of error about these mechanisms.

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CHAPTER 1: ON A PHILOSOPHICAL APPEAL TO COLOR CONSTANCY

Note: Please view the figures in this dissertation in color. The arguments turn on the colors in the figures.

1.1. Introduction

Sometimes we suffer visual illusions. For example, there are circumstances when a difference in how an object is illuminated will make the object look different in color, even thought the object is of one color. But very often when the way an object is illuminated changes, we do not suffer such illusions. In such cases of veridical experience, how do things look, what are our experiences like, and how is it that the experiences are veridical? In philosophy, various answers to the above questions have been given, and an extensive debate has arisen.

One group of answers to the questions claims that experience in such cases is veridical with respect to color because there exists color constancy which, roughly, involves objects continuing to look the same in color despite changes in how they are illuminated. Thus, the above sort of illusory color changes are avoided because the objects will continue to look as they are- the same in color. In answering the above question and developing subsequent theories of color and experience, some philosophy appeals to the area of vision science which highly investigates color constancy.

In this chapter I look at some philosophical views that appeal to empirical color constancy literature, particularly, the work of Lawrence Arend and Adam Reeves, which is probably the most cited among philosophers. After a detailed analysis of their work, I present how it fits in those philosophical theories. This sets the stage for an argument in Chapter 2 that there is another type of color constancy which should be distinguished from the color constancy of Arend and Reeves and which cannot be subsumed under the presented philosophical theories.

1.2. How Things Look in Varying Illumination Cases

Suppose there is a chair on the ground which partially blocks the illumination from some light source so that the chair casts a shadow on part of the ground, leaving another part well-lit. And suppose one were to see this scene in normal circumstances. There would be certain ways that the ground looks. The above chair case is an instance of a kind of case in which an object is, or various objects are, differently illuminated either at a time or over a period of time, and the experience of the scene is not overwhelmingly illusory[1]. So consider Figure 1.1. It is meant to be a proxy for the experience one would have if one were viewing the chair described above[2]. Call this kind of case a Varying Illumination case. A significant amount of literature in the philosophy of experience concerns Varying Illumination cases.

[1] This type of case only requires that the experiences are not overwhelmingly illusory, as opposed to perfectly veridical, for reasons that will be discussed in what follows.

[2] The relationship between the experience of a picture like Figure 1 and the scene the picture is of will be discussed more in what follows.

Figure 1.1: Chair casting shadow

When we see things, they don't just look. They look certain ways. So, the first level of disagreement about Varying Illumination cases is over two ways the parts of some surface or surfaces (in the chair case, the ground) look. Do the parts look different or alike? One possible position in the debate, the Difference Only View, claims that the parts only look different. Of course, if they look different, then they very likely look different in some way. Let's hold off on this for the moment. Another possible position in the debate would hold that the parts only look alike. Call it the Similarity Only View. A third possible position in the debate holds that, not only do the parts look different, they also look alike. Call this, for reasons to be explained below, the Dual-Dimension View.

Before we move to the second level of disagreement about Varying Illumination cases, a clarificatory point needs to be made about similarities and differences. In many cases when there is a difference, there is a similarity, and vice versa. Consider first-order similarities and differences that obtain between particulars. Suppose there is an orange tangerine. It differs in color from a red apple. However, the tangerine is still similar in color to the apple. If the tangerine were yellow, it would not be as similar to the apple as it actually is. And there is a close connection between these first-order similarity and difference relations. At least for the relations mentioned, they are necessarily inversely related: increasing the difference decreases the similarity, and vice versa. And it is not possible for an orange thing to be different from a red thing without also being similar to that red thing (or at least more similar to that red thing than a yellow thing is to the red thing). Thus, when the Difference Only Views claim two things only look different in some respect, this allows that there is the above type of inversely-related similarity in how those things look in that respect, unless the things look completely different, in which case the inversely-related similarity has diminished to nothing. But when the Dual-Dimension Views talk of a similarity and difference, they do not have in mind something like the above inversely-related similarities and differences, but instead a similarity and difference in looks which are, in some sense, distinct dimensions.

So, while the three first-level positions mentioned above disagree about whether two surfaces which are differently illuminated look alike, different, or both, there is a second level of disagreement about how objects in Varying Illumination cases look. This debate concerns another level of the modification of looks. Not only might things look some way, but that way might be modifiable to a further degree. For example, while two parties might agree that parts of a surface look different, they might disagree about the way in which they look different. So under each position at the first level of disagreement, there are internal disagreements. In particular, amongst the Dual-Dimension Views, there is disagreement about the ways or respects in which parts look different and alike. Some hold that, at least as a first pass, not only do some parts look different and similar, but they also look different and similar in the same respect. For example, Jonathan Cohen writes of a cup which has one region partially in sunlight and another region partially in shadow, "If you are like most normally sighted subjects, you will find that these two regions are, in some sense to be explained, alike in apparent colour. On the other hand…you will also find that the regions are easily, obviously, and quickly visually discriminable in apparent colour (in some sense also to be explained)" (Cohen 2008: 62). So, roughly, there is one way (at least in some sense), in which the regions of this cup look alike and different- in apparent color. Others take a similar position according to which regions in Varying Illumination cases look different and similar in, at least prima facie, the same respect- either color or something color-like. This includes Gert (2010, 2013), Noe (2004), and Kalderon (forthcoming).

On the other hand, Mohen Matthen argues that Varying Illumination cases that have been described as involving surfaces that look the same and different in color really involve the *surfaces* looking the same in surface color and the *illumination* looking different in color (Matthen 2010a: 227)[3]. While Matthen and Cohen disagree at the second level about the respects in which stuff look different and similar, they agree at the first level that the stuff look similar and different.

While parties to the Dual-Dimension View disagree about the way in which, or what, things look different in Varying Illumination cases, many of the disputants agree that things look alike in color (or something color-like). As will be explained shortly, this amounts to an agreement that Varying Illumination cases exhibit color constancy. Roughly, color constancy occurs when two objects which are the same in color, continue to look the same in color despite being illuminated differently. Part of what would allow for the largely veridical experience in a

[3] Others have argued for a similar view including Hilbert (2005), though Hilbert leans more towards how an object is illuminated, a property of the object, looking colored, opposed to the illuminant itself looking colored (150-151).

Varying Illumination case would be this manifestation of color constancy. And to support this position, many Dual-Dimension Proponents appeal to empirical research on color constancy. In particular, Cohen (2008), Gert (2010), Thompson (2006: 80), and Matthen (2010a) appeal to the experiments of Lawrence Arend and Adam Reeves as evidence for the Dual-Dimension View.

In this paper, I focus on the Dual-Dimension views of Gert, Cohen, and Matthen and take a close look at the very influential experiments of Arend and Reeves. An analysis of the experiments sheds light on where Gert, Cohen and Matthen's views are situated in the first-level debate. Specifically, it sheds light on the extent to which things look different in Varying Illumination cases. And it sheds light on the character of the difference in how things look and the character of the similarity in how things look in Varying Illumination cases. Knowing these specifics of the sameness in looks and the difference in looks is essential to evaluating the Dual-Dimension views, and the views' empirical appeal fills in this gap. The next section lays out color constancy in more detail. Then the experiments of Arend and Reeves are analyzed. With some clarity on these experiments, the philosophical positions on experience and color which appeal to these experiments are explored. In Chapter 2, I argue that there is another type of color constancy, different from that found in Arend and Reeves's experiments, which challenges the philosophical positions introduced. Part of the point of Chapters 1 and 2 is to challenge the idea that Varying Illumination cases are of one theoretically-significant kind and that either the Difference Only View, the Similarity Only View or the Dual-Dimension View covers all Varying Illumination cases. Instead, I argue that there are at least two types of color constancy and so at least two kinds of Varying Illumination cases.

1.3. Initial Sketch of Color Constancy

Many color scientists investigate color constancy in the context of Varying Illumination cases. For example, Foster introduces color constancy with "If we look at a patch of green grass under a blue sky and then later at sunset, the colour of the grass seems unchanged" (Foster 2003: 439). So here we have lighting that changes from that of a blue sky to that of sunset and, seemingly, a Similarity Only View of how the color of the illuminated grass looks.

Besides such an example of color constancy, how do color scientists tend to characterize color constancy? Let's consider a few paradigmatic glosses given by vision scientists when introducing the phenomenon:

> "Color constancy refers to invariance of perceived surface colors under changes of illuminant color." (Arend, Jr. et al. 1991: 661)

> "Color constancy refers to the constancy of perceived or apparent surface color under changes of the spectrum of the illuminant or, in an extended sense, under changes in scene composition or configuration." (Reeves et al. 2008: 1)

> "Chromatic color constancy is the perception of invariant properties of a surface's spectral reflectance despite changes in illumination and viewing conditions." (Palmer 1999: 133)

In this representative sample of vision scientists' initial characterizations of color constancy, a pattern emerges, suggesting a first approximation of the phenomenon. These descriptions of color constancy involve two halves. In the first half, there is something that remains constant, invariant or unchanging. The colors perceived are perceived as the same, seen as the same or look the same. In the second half, there is something that changes- the illumination. As initial characterizations of the phenomenon, it is plausible (and desirable) that the descriptions are pre-theoretic. Therefore, we should begin with the assumption that "perceived as," "seen as," and "looks" are used with their ordinary English meanings. This assumption will be reconsidered later.

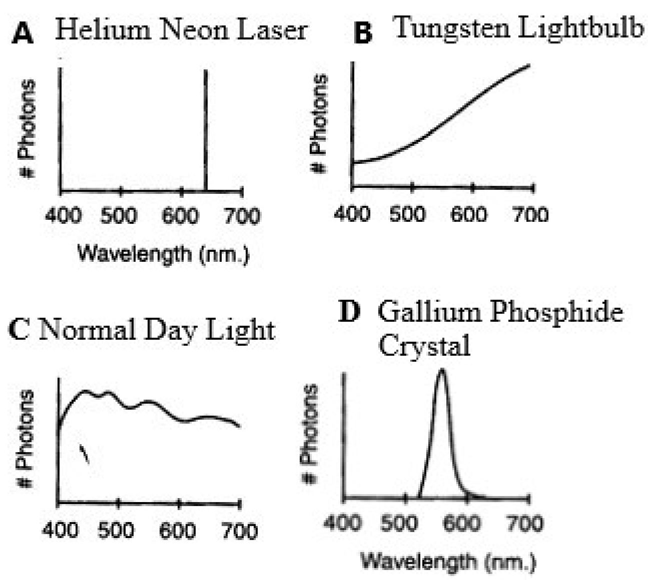
Concerning the second half of the glosses, it should be noted that they do not state that the illuminant is perceived as, seen as, or looks changing. Instead, the illuminant is different, independent of our perception of it, if we perceive the illuminant at all.

That there is color constancy is an achievement on the part of the visual system. This is because the visual system faces, what is commonly called, an inverse projection problem (See Palmer 1999: Ch.1). To provide us with the ability to see the world around us, the visual system must produce our experiences or perceptions of the world from, in large part, the energy stimulating our eyes. However, the visual system does not have direct access to external items in the world like colors, 3-D objects, and faces- the distal stuff in the environment. Roughly, all that is immediately available are the proximal stimulations of cells in the retina. This retinal stimulation is caused by light impinging on it.

For a simple model of sight and psychophysics, let's start with light. When we speak about light, sometimes we talk of a particular, like a light source. This is an *illuminant*. But sometimes we talk of a property of objects- how an object is illuminated, the *illumination* of an object, or, more technically, the *illuminance* of an object. I will use both ways of speaking. Light is a small portion of the electromagnetic spectrum, specifically, electromagnetic energy with wavelengths from about 400-700 nm to which the human visual system is sensitive. We can begin with something familiar- the *intensity* of an illuminant. Some lights produce more energy than others, and some produce less. Thus, lights vary in intensity. Likewise, some illuminances are more intense than others.

Even while two illuminances or illuminants might be the same in intensity, there are ways in which they can still differ. The photons that make up light vibrate at certain wavelengths. The *spectral power distribution* or *chromaticity* of an illuminant or illuminance captures the proportions of the total amount of the photons vibrating at each wavelength. So two illuminants might emit the same amount of photons, but they might differ in the wavelengths at which those photons vibrate. A *spectral diagram* graphs the spectral power distribution of light. The x-axis provides the wavelengths, ordered from least to greatest. For the purposes of vision only wavelengths from about 400-700 nm are relevant. The y-axis provides the intensity of the light. Figure 1.2 gives the spectral diagrams of 4 lights.

Figure 1.2: Spectral diagrams



From Palmer 1999[4]

For example, Figure 1.2 A gives the spectral diagram of a helium neon laser. All of its energy is of one wavelength, approximately 632 nm. Figure 1.2 C gives the spectral diagram of a light that has some energy at each wavelength. The above spectral diagrams are in terms of the absolute value of the intensity. In such a case, the area under the curve is the intensity. However, some spectral diagrams only tell what proportion of light is emitted by a light or

[4] Reprinted from Palmer, Stephen (1999). *Vision Science: Photons to Phenomenology*. MIT Press with permission from The MIT Press.

incident on an object at each wavelength, so two lights of different intensity which have the same spectral power distribution have the same spectral diagram.

Many objects have a *surface spectral reflectance* (SSR), a disposition to reflect, at each wavelength between ~400-700 nm, a certain proportion of the total amount of light striking it. The reflected light might then interact with some intervening medium (the *transmittance*) between the viewer and the object. If it does, then the transmittance will also have an effect on the travelling light. The portion of light that finally strikes the retina, the *spectral return* (also known as the color signal), is the product of the illuminance, the spectral reflectance and the transmittance[5]. It has an overall intensity (its *luminance*) and a measure of how much of its total energy vibrates at each wavelength (its *chromaticity*). The luminance and chromaticity of the return can be represented by a spectral diagram in the same way that the intensity and chromaticity of an illuminant can be represented. The return stimulates photoreceptors in the retina and from there the visual system processes these retinal signals to produce our perceptions.

Because of the physics of the way the illuminance, spectral reflectance, and transmittance interact to produce the return, the return confounds their effects. This creates a problem for the visual system if it aims to sort out the features of the illuminance, reflectance, and the transmittance out in the world.

Moving forward, I will make some simplifications. First, I will idealize that the retinal photoreceptors are "transparent" meaning that it is as if the visual system has direct access to the return and isn't hampered by the limitation of only 4 receptor-types. In reality, there is no such direct access and one must consider more than the information loss that occurs because of the confounding interaction between illuminances, surface spectral reflectances, transmittances, and other distal factors. Instead, the post-receptoral visual system draws on the responses of the

[5] There are further factors and complications which are being left out.

retinal mosaic of photoreceptors. However, because of the way the photoreceptors respond to light, the properties of the return are confounded such that two different returns can produce the same photoreceptor responses. So there are at least two informational collapses, one in the production of the return and another in the response of the retinal cells. The problem worsens in that "there is at most one photoreceptor at each retinal location […so] the visual system must combine information [from photoreceptors across the retina]" (Brainard & Gazzaniga 2009:2). This is a third layer of informational collapse[6]. Noise is an additional problem the visual system faces, including noise in the visual system and photon noise (Mamassian et.al 2002). To avoid these difficulties, which are not required to make my case, the idealization makes it as if there is no difference between retinal input to the visual system and the return input.

Let's look at a simple example of when the return reflected off of objects conflates the effects of the illuminance and the spectral reflectance. A white object in normal daylight will reflect a very different array of light into the eye than the light reflected by that same object in very dim lighting. Thus, two different illuminations in the distal environment yields different input to the visual system. The information available to the visual system has been confounded, and the challenge is to invert, in some sense, this confounded projection of the distal environment into experiences such that the white object looks white in both illumination-conditions.

Color constancy arises in this context of the inverse projection problem. If a subject were to see each of these white objects and the first looks white while the other looks, say, gray, then there is a failure of color constancy and an instance of an illusory experience since the objects look different in color but are the same in color. An instance of color constancy would ensure

[6] Idealizing from these two informational collapses means idealizing from two classes of metamers. In general metamers are ignored in this dissertation.

the objects look the color they are, thus avoiding illusion. Therefore, corresponding to the second half of the initial descriptions, when the illuminance of an object differs from part to part, but the colors/reflectances remain the same, the return and retinal stimulation differs. In general, the input to the visual system differs. This creates a challenge for the visual system to output the first half of the initial descriptions- sameness in how the color of the objects is perceived, seen, or looks.

So far the output involved in color constancy has consisted in an object being seen as, perceived as, or looking the same in color. One might wonder whether there are three distinctions that need to be made here between seeing, looking, and perceiving. However, for the rest of the paper, I will neglect any differences and focus on things looking the same in color. This is not an innocuous move but for the purposes of this chapter I believe that it will not matter.

Color constancy naturally divides views about Varying Illumination cases, placing the Dual-Dimension Proponents and the Similarity Only Proponents on one side and the Difference Only Proponents on the other. On the one hand, for many Dual-Dimension and Similarity Only Proponents, illusions in Varying Illumination cases are avoided because color-identical, variably-illuminated surfaces look the same in color, at least approximately. On the other hand, some Difference Only Proponents claim that the surfaces only look different in color (or something color-like). Different Only Proponents will be discussed in Chapter 3. For the purposes of Chapters 1 and 2, only Dual-Dimension and Similarity Only Proponents will be considered. In particular, the Dual-Dimension Views that appeal to empirical color constancy literature claim that not only do the relevant surfaces look alike in color, but they also look different (in something). But in addition to considering in what the surfaces look alike and different, we need to have a better first-level understanding of the views: an understanding of the sameness in looks and the difference in looks, independently of what surfaces look the same or different in. Most importantly, we need a more specific understanding of the character of the difference in looks and the extent of the difference in looks. The next section analyses the experiments of Arend and Reeves, to which the Dual-Dimension Views appeal and which provide insight into the first-level details of the Dual-Dimension Views.

1.4. Type-1 Color Constancy

1.4.1 Simultaneous Asymmetric Color Matching Experiments

In two classic papers, Lawrence Arend, Jr. and Adam Reeves developed an experimental paradigm that has come to influence much of color constancy science (Arend, Jr. and Reeves 1986; Arend Jr. et. al 1991). What has been noteworthy for philosophers like Cohen, Matthen, and Gert is that the results of the experiments seem to suggest that there are, something like, two distinct dimensions by which objects look similar and different in the constancy-involving Varying Illumination cases. These two dimensions are taken to support Dual-Dimension Views over the Difference Only View and the Similarity Only View. For example, Gert writes:

> One half of the constancy data [i.e. Arend and Reeves's data] (the relatively inconstant part) corresponds to the variable ways in which *colors appear* under changes of illuminant, while the other half of the data (the relatively constant part) corresponds to the stable color properties objects actually have, and which they also seem to have, given the patterns of change in the first sort of appearance. (Gert 2010: 672).

So, it's important that we can zero-in on the character and details of the similarity and difference involved, for merely accepting a Dual Dimension View leaves much unspecified about this similarity and difference. The experiments of Arend and Reeves are the predominant way Cohen, Gert and Matthen provide these details. In this section, I describe the experiments and draw out the account of color constancy they suggest.

These experiments investigate Varying Illumination cases. So, what are the relevant objects which are under differing illumination? The objects used in many color constancy experiments are called Mondrians, following Edwin Land's designation of similar stimuli in virtue of their similarity to the paintings of Piet Mondrian (Land 1959). The Mondrian is a flat surface composed of colored patches whose reflectances are known by the experimenter. It is under some illumination whose properties are also known by the experimenter[7]. Since the aim is to test color constancy, experiments involve subjects viewing either one Mondrian which is variably illuminated over two different times or two Mondrians which are differently illuminated at the same time. These latter, simultaneous experiments were the focus of Arend and Reeves. Arend and Reeves's experiments are instances of what are called simultaneous asymmetric color matching (SACM) experiments. In such experiments, one Mondrian, the Standard, is under one illuminant and the other Mondrian, the Test, is under another. The two Mondrians are identical in surface properties. Therefore, for example, the center patches of the Standard and Test Mondrians have the same surface spectral reflectance. We can call these center patches counterparts of each other. Given that the Standard and Test Mondrians are identical, each patch in the Standard Mondrian has a counterpart patch in the Test Mondrian. Figure 1.3 shows the uncolored versions of the Standard and Test Mondrians used in the experiment.

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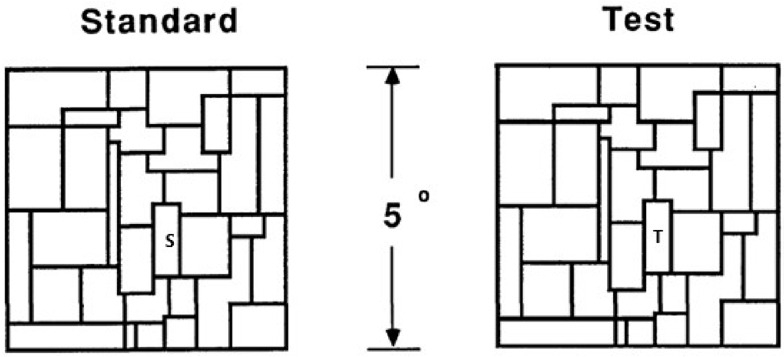
[7] Originally, the patches were Munsell papers.

Figure 1.3: Mondrian schema



From Arend Jr. et. al 1991[8]

Before we turn to the details of the experiment, a complication needs to be addressed. In the Arend and Reeves experiments "the subjects viewed simulations of colored-paper arrays [Mondrians] on a computer controlled video monitor" (Arend and Reeves 1986: 1743). Computer simulations are used, largely, for practical purposes. But as a result, the stimuli that the subject viewed were not objects of the same SSR's under different illumination. However, because of the way illuminances and reflectances interact to produce a given return as a result of light superposition, the same return can be produced from the interaction of the SSR of a Mondrian under a light source, or from the illumination of a computer screen. In experiments, color scientists often translate between computer simulations and non-simulated stimuli[9]. Following Arend and Reeves, I will not describe the experiment in terms of the simulated stimuli but instead describe the experiment in terms of reflectance-identical Mondrians under varying illumination. The relationship between the "real" stimuli and the simulations will be addressed further in Chapter 2.

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[8] Reprinted from Arend, Lawrence E., Adam Reeves, James Schirillo, and Robert Goldstein. (1991). Simultaneous color constancy: papers with diverse Munsell values. *JOSA A*, *8*(4), 661-672 with permission from The Optical Society.

[9] There can end up being considerable debate about the appropriateness of the particular simulation used in a particular experiment and whether the target phenomenon can be reproduced with a simulation. There has been increasing pressure to use real stimuli in color constancy experiments.

Now, we return to a description of the non-simulated experiment. At the start of the experiment, the Standard Mondrian is under average daylight illumination (the Standard illumination) while the Test Mondrian is under direct sunlight (the Test illumination)[10]. These two illuminations have different chromaticities, i.e. different proportions of their total energy is emitted at each wavelength. Therefore, the returns reflected from counterpart patches of the Mondrians differ. This creates an inverse projection problem and the question investigated by the experimenters is to what extent the counterpart patches (which are the same in SSR) exhibit "constancy of perceived surface color."

To test this, a matching task is utilized. At the start of the experiment, counterpart patches of the Standard and Test Mondrians have the same reflectance, except for one pair of counterpart patches. This latter pair is composed of the Standard patch in the Standard Mondrian and the Test patch in the Test Mondrian. They are marked S and T in Figure 1.3, respectively. While all other patches in the Test Mondrian match their counterpart patches in the Standard Mondrian in SSR, the Test patch is randomly set to one of a specified range of reflectances (Arend and Reeves 1986: 1744). The task of the subject is to adjust the reflectance of the Test patch until it matches, in some sense to be further explained, its counterpart, the Standard patch, hence the name "color-matching" experiment[11]. When the subject completes the task, the experimenter can measure properties of the Test patch, like its return and SSR.

Whatever the character of this match, the experimenters take it as evidence that "our observers had approximate constancy of perceived surface colors…" (Arend et al. 1991: 662), and this figures in the theory of the Dual-Dimension Proponents. But how does this relate to the Dual-Dimension Views which appeal to the experiments to support the claim that surfaces look

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[10] Correlated color temperatures of 6500K and 4000K, respectively (Arend Jr. et. al 1991: 662-665).

[11] In the actual experiments with simulated stimuli, the light-emitting properties of the computer screen, not its SSR, are adjusted.

alike and different in Varying Illumination cases? From what has been stated so far, it would seem like the SACM experiments support a Similarity Only View. The answer turns on a problem Arend and Reeves found in prior color constancy experiments and aimed to solve in their own. Discussing previous experiments like those of McCann et al. (1976), Arend and Reeves note that "the observer's task may have permitted intermixture of two types of perceptual judgment" (Arend and Reeves 1986: 1743). To remedy this, they gave two different instructions about how the Test patch should be made to match the Standard patch and found that "this distinction has a major effect on the matching data" (1743). They conclude from this that "constancy of surface color may be perceptually represented in at least two different ways" (1749)[12]. Essentially, there are two ways in which the Test Patch can be made to look or be perceived as like the Standard Patch. And it is this aspect of their experiments that proponents of the Dual-Dimension View claim supports their view of Varying Illumination cases. Let's turn to this aspect of Arend and Reeves's experiments in more detail.

While we keep in the back of our minds that the experimenters purport to investigate and draw conclusions about "constancy of perceived surface color" and while leaving the nature of perception and looking vague, it should be noted that the fundamental matching data involved in the experiments is behavioral. Subjects adjust the Test patch, via a controller, and the experimenters make subsequent measurements. The data itself might be neutral with respect to perception, lookings, visual experiences, and judgments, depending on how these and similar phenomena relate to behavior[13]. However, the conclusions drawn by Arend and Reeves, and to be discussed later, Gert, Cohen, and Matthen, go beyond the behavioral. The behavioral data is

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[12] This should not automatically be understood in terms of the visual experiential representation associated with Representationalism or Intentionalism.

[13] Thanks to David Hilbert for pressing this point.

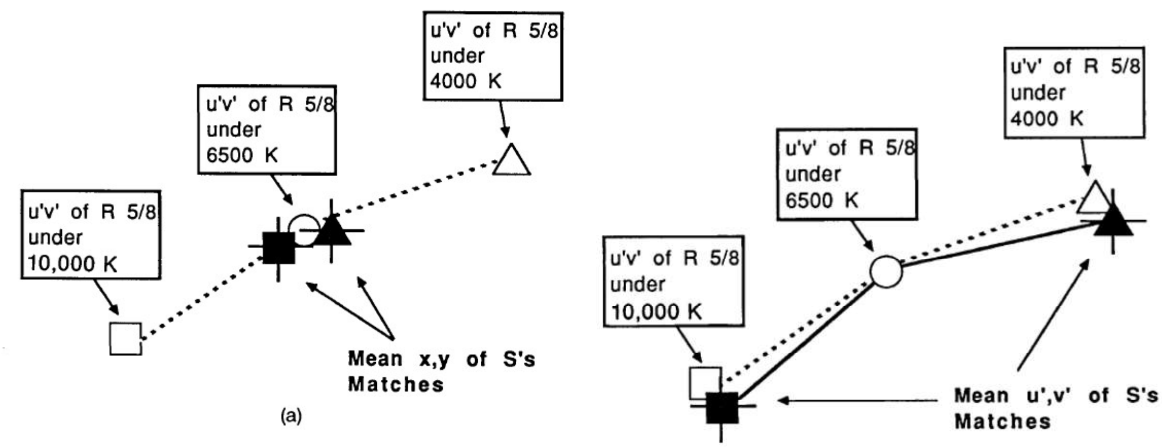
being supplemented, possibly by introspective evidence, in order to draw these ampliative conclusions.

As stated above, at least one type of match that experimenters investigated was taken to support constancy of perceived surface color for subjects. For this match, one group of subjects were "instructed to make the test patch 'look as if it were cut from the same piece of paper' as the corresponding patch in the standard array [i.e. Mondrian]" (Arend, Jr, et. al. 1991: 664). When these instructions were followed a "Paper Match" was made. So, keeping the notions of sameness in looks and perceived sameness open, let's look at the data analysis of the SSR's, returns and illuminances involved in the experiment to see why a successful Paper Match was taken to indicate that the Mondrians exhibit color constancy for the subject.

The results of the SACM task are modeled diagrammatically. Later the relationship between aspects of the data and data model will be addressed. But for now, Arend and Reeves plot the chromaticity of the return of the Standard patch as the open circle in Figure 1.4A. (Ignore the descriptions in the boxes.) The chromaticity of the return is determined by the reflectance of the Standard patch and the Standard illuminant, in this case average daylight. The open triangle represents the chromaticity of the return of the Standard patch if it were under the Test illuminant, direct sunlight. The details of the space in which these shapes are embedded can be ignored for now. The important point is that if two patches are the same in reflectance but under illuminations with different chromaticities, then the chromaticities of the returns of each patch will be different. This difference between returns is modeled by the distance between the open circle and open triangle.

Figure 1.4: Chromaticity diagrams

A **B**



From Arend et al. 1991[14]

At the start of the experiment, the Test patch has a randomly chosen reflectance, but is under the Test illuminance. Under the Paper Match instructions, when the Test patch is adjusted so that it looks like it is cut from the same piece of paper as the Standard patch, experimenters interpret the data as suggesting that subjects have adjusted the Test patch so that it approximates the reflectance of the Standard patch. How is this modeled in the diagram? The shapes represent return chromaticities, so if two returns differ in chromaticity, their representing shapes have some distance between them. So, if the post-match Test and Standard patches were to have the same reflectances but were under illuminants with different chromaticities, their returns would have different chromaticities. If the chromaticity of the return of the post-match Test patch is represented by a closed triangle, then, after a successful adjustment, the closed triangle would coincide with the open triangle (the chromaticity of the Standard patch if it were under the Test illuminant). Since a subject's making the patches look like they are cut from the same piece of

[14] Reprinted from Arend, Lawrence E., Adam Reeves, James Schirillo, and Robert Goldstein. (1991). Simultaneous color constancy: papers with diverse Munsell values. *JOSA A*, *8*(4), 661-672 with permission from The Optical Society.

paper is taken to indicate that the subject perceives that the patches are alike in surface color, and they are of the same reflectance but under different illumination, this is taken to be evidence of color constancy in the subject. As Arend and Reeves write, "perfect color constancy would occur it the subject set the test-patch chromaticity to the chromaticity that the standard patch would have under the test illuminant, i.e., if open and filled symbols coincided" (Arend and Reeves 1986: 1746). Figure 1.4B depicts these results (approximately, since the closed triangle is not exactly on the open triangle).

On the other hand, according to Arend and Reeves, a subject fails to exhibit color constancy if she adjusts the Test patch in such a way that it does not have the same reflectance as the Standard patch. Thus the chromaticity of the return of the adjusted Test patch is different from the chromaticity of the return that the Standard patch would have if it were under the Test illuminant. Diagrammatically, this is represented when the closed triangle does not coincide with the open triangle. The greater the distance between the closed triangle and the open triangle, the less constancy the subject exhibits. Thus, color constancy can come in degrees. On the one hand, there is *perfect* color constancy. On the other, there is a spectrum of *imperfect* color constancy, ranging from complete failure to near perfection.

On Arend and Reeves's understanding of the conditions of perfect color constancy, none of the subjects tested exhibited perfect color constancy. The 1986 and 1991 data give various ranges of imperfect color constancy (See the Results sections of Arend et al. 1991 and Arend and Reeves 1986 for the plotted data of the experimental subjects.). For the most part, in this chapter I will focus on the idealized, perfect color constancy, as it is implied by the data model Arend and Reeves employ. This is partly because some of the philosophical views discussed present theories that don't explicitly address imperfect color constancy and partially veridical color experiences.

So in the idealized Paper Match task, when the idealized subject attempts to make the Test patch 'look as if it were cut from the same piece of paper' as the Standard patch, and experimenters conclude the stimuli exhibit perfect color constancy, the Test and Standard patches have the same SSR and differ in illumination. Again, we are leaving open the character of the way in which things look the same or are being perceived as the same.

The most common form of imperfect color constancy occurs as the closed triangle deviates from the open triangle by approaching the open circle. The typical extreme occurs when the closed triangle coincides with the open circle. See Figure 1.4A. This represents circumstances in which the subject adjusts the Test patch in such a way that the chromaticity of its return, post adjustment, is the same as the chromaticity of the return of the Standard patch. When such an adjustment is made, reflectances of the post-adjustment Test patch and the Standard patch will differ. This is because, since the illumination between the Test and Standard Mondrians differ by the experimental set-up, the reflectances must also differ in order to produce equal return chromaticities. Thus the subject has not adjusted the Test patch to be of the same reflectance as the Standard. When the open circle and the closed triangle coincide, the patches exhibit no color constancy for the subject.

Interestingly, this latter sort of adjustment plays a significant role in SACM experiments. Recall that Arend and Reeves gave two different instructions to subjects about how they were to adjust the Test patch. First, there were the Paper Match instructions. For the second matching instruction, subjects were "instructed to match hue, saturation, and brightness of the test patch to those of the standard patch" (Arend Jr. et. al 1991: 664). When these instructions were followed a Hue-Saturation Match*,* as they called it, was made. When experimenters measure the properties of the Test patch after the Hue-Saturation Match, they find that the chromaticity of the return of the Test patch approaches the chromaticity of the return of the Standard patch. Figure 1.4A plots the results of one subject, S (Arend Jr. et. al 1991: 665). The closed triangle represents the return chromaticity of the post-adjustment Test patch. It is close to the return chromaticity of the Standard patch, represented by the open circle. What does this amount to? As Arend et al. states, "[Suppose] [T]he subject would set the test patch to approximately the chromaticity [of the return] of the standard patch…in both illuminant conditions…[Then] he would set the test patch to the reflectance that, under the test illuminant, gives the same chromaticity as R 5/8 [where R 5/8 is a specification of the reflectance of the Standard patch] under the …standard illuminant" (Arend et al. 1991: 665). That is, if the subject sets the Test patch to have approximately the same return chromaticity as the Standard patch, then the patches will differ in reflectance. This is because, by the experimental set-up, the Test patch and the Standard patch are under different illumination. The only way for them to have approximately the same returns, then, is if their reflectances differ. This is indicated by coincidence of the open circle and closed triangle, as in the above case of imperfect color constancy.

At this point we can further investigate how things look or are perceived as. First, let's get a sense of how the stimuli look to subjects of the experiment prior to Test patch adjustment. Consider Figure 1.5A. How it looks to you is, to some degree, how the non-simulated Mondrian under the Standard Illuminant looks to the experimental subject[15]. So 5A is a depiction or simulation of the Standard Mondrian under the Standard Illuminant (average daylight). Figure 1.5A, this object before you that you actually see, is closer in physical properties to the stimulus the experimental subject sees when the simulations are used than to the stimulus a subject would

[15] I am assuming that you are normally-sighted.

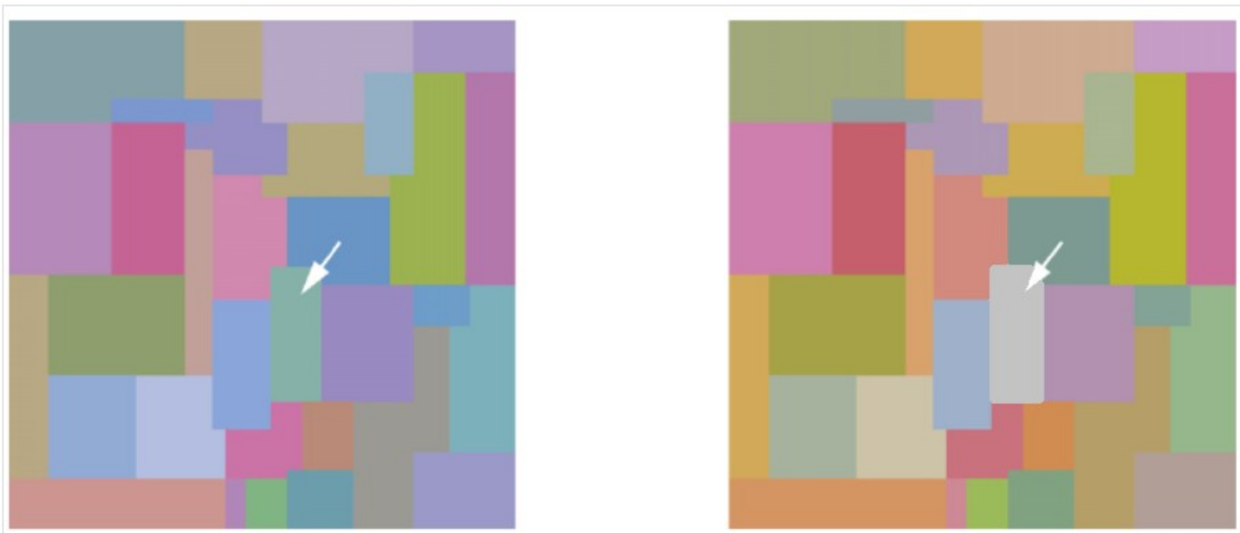
see in a non-simulated experiment. Now, consider Figure 1.5B. How it looks to you is, to some degree, how the non-simulated Mondrian under the Test Illuminant looks to the experimental subject viewing the real Mondrian.[16] So Figure 1.5B roughly depicts or is a simulation of the Test Mondrian under the Test illuminant.

Figures 1.5A and 1.5B deviate somewhat from the simulations used in the experiments. The experiments are run under precisely controlled viewing conditions, and the color gamut employed to make the stimuli are probably different than the reader's display. So, the extent of this deviation is an issue. The extent of the deviation might be significant. However, there is an aspect of the experimental displays which these Figures preserve, and it is this that is most relevant for my purposes. I will highlight it in what is to come. So, Figure 1.5 gives an idea of how things look to the experimental subject at the beginning of the experiment, that is, prior to any adjustments.

[16] And, to some degree, it looks to you how the simulated Mondrian looks to the subjects in the actual experiment.

Figure 1.5: Pre-adjustment Mondrians

A **B**



From Foster 2011[17]

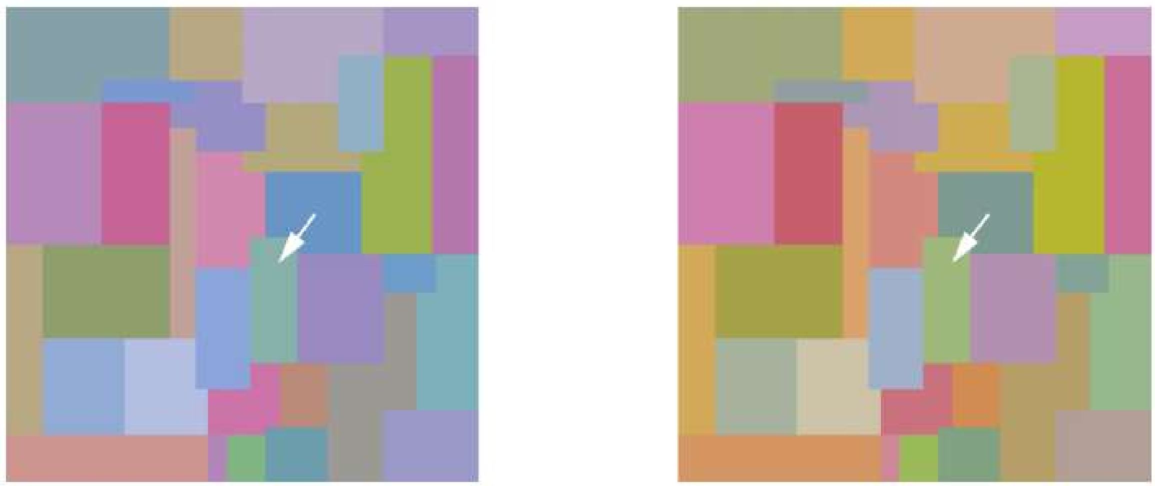
The patches marked with arrows are the Standard patch and the Test patch. Since the Test patch in the non-simulated experiment is assigned a random reflectance at the beginning of the experiment, it is depicted as gray in the figure.

Figure 1.6, A and B provides, again roughly, how things look at the point at which the Test patch is made to be a "Paper Match" to the Standard patch.

[17] Reprinted from Foster, David H. (2011). Color constancy. *Vision research*, *51*(7), 674-700.with permission from Elsevier

Figure 1.6: Post-Paper Match Mondrians

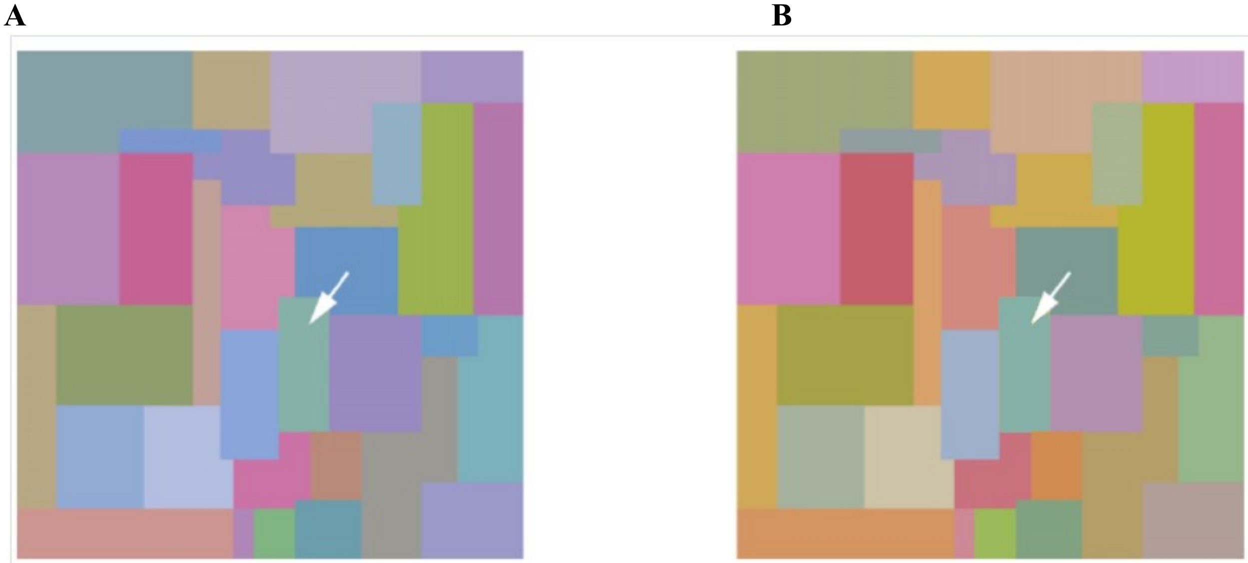
A **B**



Foster 2011[18]

Figure 1.7: Post-Hue-Saturation Match Mondrians

A **B**



Modified from Foster 2011[19]

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[18] Reprinted from Foster, David H. (2011). Color constancy. *Vision research*, *51*(7), 674-700.with permission from Elsevier

[19] Reprinted from Foster, David H. (2011). Color constancy. *Vision research*, *51*(7), 674-700.with permission from Elsevier

Figure 1.7A and 1.7B simulate the Mondrians after a Hue-Saturation Match was made. In Figure 1.7 one can see that the arrowed patches look similar. At the least, they look significantly more similar than the arrowed patches in Figure 1.6. Even though your experiences of Figure 1.6,A and B and Figure 1.7,A and B will be, to some extent, different from the experimental subject's experiences of the simulated Mondrians, your experiences of the Figures sufficiently preserves some similarities and differences between the arrowed patches. What is most important for present purposes is that, in the Paper Match and Hue-Saturation Match experiments, there is a divergence in how the Standard and Test patches come to look in the former case and convergence in how they come to look in the latter case. Given how the data is modeled, if the ideal subject is instructed to make a Paper Match, she would make an adjustment to the Test patch such that it looks different from the Standard patch in a way that is roughly like the way the arrowed patches in Figure 1.6 look to you. If this match were made, the experimenters would see that the reflectances are the same and the returns differ to a certain extent.

On the other hand if the ideal subject were instructed to make a Hue-Saturation Match, she would make an adjustment to the Test patch such that it looks the same as the Standard patch in a way that is roughly like the way the arrowed patches in Figure 1.7 look to you. When this occurs, the experimenters see that the reflectances are different and the returns are the same. This same patch-result can occur when a subject is attempting to make a Paper Match but exhibits no color constancy.

So, in the experiment, there are two circumstances in which patches look or are perceived as the same. One instance in which this occurs is in the idealized Hue-Saturation Match. This can be appreciated from the experiences of Figure 1.7 which approximates the idealized Hue-

Saturation Match. The other instance occurs in the idealized Paper Match, where the experimenters claim that surface colors would be perceived as the same. These two samenesses do not seem as if they can be of the same sort. Correlatively, depending on how much one's experience of Figure 1.6 diverges from an experimental subject's experience of the post-adjustment Mondrians in the Paper Match experiments, Figure 1.6 might not provide a similar enough experience as the experimental subject's color-constant experience of the post-adjustment Mondrians. If this is the case, then Figure 1.6 does not involve patches looking the same to the reader[20]. But if, in the idealized Paper Match, the post-adjustment patches look, even remotely, different in the way that the patches in Figure 1.6 look, there must be some distinction between the way the post-adjustment patches look the same and the way they look different to the experimental subject.

1.4.2 Phenomenal Properties

Figure 1.8: Red patch

In addressing this distinction, an initial impulse might be to appeal to some of the distinctions with respect to "look" that have been employed by many in the philosophy of perception literature, including Roderick Chisholm, Frank Jackson, and Michael Martin (Chisholm 1957; Jackson 1977; Martin 2010). However, as will be discussed more in Chapter Three there have been strong arguments against this approach. Therefore, I will draw the

[20] And note, since Figure 6 is a simulation of the experimental Mondrians, if patches do look the same to one, then this will be an illusion of color constancy.

distinction in a different way. I grant vision science's claim that counterpart patches in Mondrian A and Mondrian B look the same (are perceived as the same, are seen as the same) in color. Instead of appealing only to how things look (or are perceived as or seen as), technical terms like "phenomenal character" and "phenomenal properties" will be employed to characterize the experiences one undergoes while viewing the relevant objects. The plan is to first attempt to demonstratively point to something and then, second, put a name to it – "the phenomenal". So, consider Figure 1.8. In seeing the figure, you undergo a visual experience. As you attend to the figure, you can also attend to some aspect of the experience. Specifically, as you attend to the red of the figure, as it would naturally be described, there's an aspect of the experience you can also attend to– a certain phenomenal property. In natural language, we do not have ordinary terms for the phenomenal properties of experience.[21] So, as a first step in talking about the phenomenal, I will employ a convention introduced by David Chalmers of talking of the phenomenal in a way that is parasitic on the way we talk about the external world (Chalmers Forthcoming). For example, since the natural way to describe Figure 1.8 is as red, to refer to the phenomenal property distinctive of the experience of Figure 1.8, I will talk of the red-ish phenomenal property[22]. This appeal to red in referring to the relevant phenomenal property is not an attempt to give a definition of the phenomenal property in terms of red. It is only a means of fixing the reference of the aspect of one's experience that has been demonstrated. Besides the red-ish phenomenal property, there is a body of determinate phenomenal properties, relating to the colors the way the red-ish phenomenal property related to redness. This body of determinate

[21] Or if we do have terms in ordinary language for aspects of our experiences, they seem to be the same expression we use to describe things in the external world. See Jackson (2006) for discussion and how it motivates Representationalism.

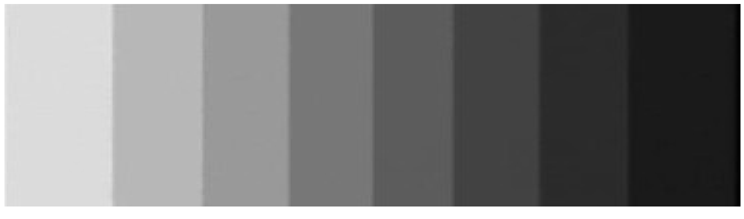
[22] Sometimes "ish" suffixes are attached to color terms for a different use, for example to characterize color mixing and combinations. See Byrne (2003), Hilbert and Byrne (2010), and Hilbert and Byrne (2008) and Bradley and Tye (2001) . Also, Chalmer's "–ish" suffix might be similar to Peacocke's primed notation in Sense and Content (1983), though I am unclear how theoretically neutral Peacocke intended to be in introducing the primed notation.

phenomenal properties is subsumed under the determinable color-ish phenomenal property.

At this stage it should not be assumed that color-ish phenomenal properties are colors, representational properties, instantiated properties of external objects, color properties of surfaces, or color properties of illuminants.

We can define a set of color-ish phenomenal properties as all and only those phenomenal properties that exist in the color-ish solid. If you were to view a color solid, you would have experiences of the object. You would need to manipulate it to see all of it. That is, at one time you would only see the colors on the surface of the solid which are facing you. So to see more of the solid, it would need to be rotated. And to see even more it would need to be cut. But if you were to see all of the colors composing it, you would have many experiences. The experiences would involve color-ish solid phenomenal properties, a, possibly proper, subset of the color-ish phenomenal properties. The color-ish solid phenomenal properties are structured and stand in similarity and difference relations which parallel our prima facie notions of the color solid. So consider Figure 1.9. Your experience of one of the middle segments has a gray-ish phenomenal property. Your experience of the region to the left of the segment you were previously attending to also has a gray-ish phenomenal property, one which is a lighter gray-ish than the first. As I am stipulating "color-ish solid phenomenal properties", the color-ish phenomenal properties of the experiences of each segment in Figure 1.9 are identical to color-ish solid phenomenal properties.

Figure 1.9: Gray gradient



I will leave it open whether the color-ish solid phenomenal properties, those phenomenal properties had by all the experiences of the colors of the color solid, are only a proper subset of all the color-ish phenomenal properties. Besides the odd-sounding name, color-ish solid phenomenal properties are very familiar and straight-forward. Color-ish phenomenal properties which are not color-ish solid phenomenal properties are trickier to get a grip on, if there are any such properties. But for the purposes of this paper, the color-ish solid phenomenal properties will be the focus.

So, we can return to Figure 1.8. With the technical notions of color-ish phenomenal properties in hand, I introduce the technical claim that experiences of the two halves of the figure each have the same red-ish phenomenal property. This red-ish is a color-ish solid phenomenal property. Likewise, there is a phenomenal sameness between one's experiences of the two halves- a sameness grounded in the experiences each having the same red-ish phenomenal property. As another example, consider Figure 1.10. There is a phenomenal difference between your experiences of the two rectangular regions. This is in virtue of each experience instantiating a different color-ish solid phenomenal property.

Figure 1.10: Two patches

Do the two halves of Figure 1.8 look the same in color? I think that is hard to deny. But since I will defer to the vision scientists in their claim that counterpart patches in Mondrians A and B look the same or are perceived as the same in color, as an instance of color constancy, there is the question of how this can be while the parts of Figure 1.8 also look the same in color. Whatever is going on in the color constancy involving the Mondrians, the way or dimension in which counterpart patches look different cannot be the same as the way or dimension in which counterpart patches look alike. But I will grant the vision scientist's, and as we will see, philosopher's, description of the situation and not venture a resolution.

1.4.3 Two Dimensions in Color Constancy

So we can return to the experiments. According to Arend and Reeves, after an ideal Paper Match adjustment, the Test and Standard patches are perceived as the same in color[23]. Even if this is so, there is a visual difference between them. And when an ideal Hue-Saturation Match is made, there is some visual sameness. It is very plausible that the visual sameness in the Hue-Saturation Match consists in a sameness between the color-ish solid phenomenal property of the experience of the Standard patch and the color-ish solid phenomenal property of the experience of the Test patch, post-Hue-Saturation Match. Two pieces of evidence support this. First, by describing the task of the Hue-Saturation Match in terms of making adjustments to the "hue, saturation, and brightness of the test patch" Arend and Reeves invoke the color solid (Arend Jr. et. al 1991: 664)[24]. Color-ish solid phenomenal properties were defined to fix our attention to those aspects of the experiences of the colors that compose the color solid. Second, in considering one's experience of Figure 1.7, which approximately preserves the similarity that the subjects experience in the Hue-Saturation Match, the experiences of the arrowed patches are similar in color-ish solid phenomenal properties. So it is very plausible that the experiences in

[23] Again, there are a number of steps from the behavioral data to this claim.

[24] To understand the Hue-Saturation task as a match in how the patches look in hue, saturation and brightness while the Paper Match is understood as a match in how the patches look in color presents some difficulties. Hue, saturation and brightness tend be treated just as the composing dimensions of color. (And Arend and Reeves do not, in these experiments, seem to countenance further dimensions of color). So it is unclear how Paper Matches are not matches in hue, saturation, and brightness. This is partly why I employ color-ish phenomenal properties instead of their distinction.

the ideal Hue-Saturation Match involve a color-ish solid phenomenal sameness. And when this sameness occurs in the idealized case, the returns of the patches are measured to be the same.

On the other hand, as the returns come to differ, and the reflectance comes to be the same, as a Paper Match is made, there is a visual difference between the patches. For parallel reasons, it is very plausible that this visual difference consists in the color-ish solid phenomenal property of the experience of the Standard patch being different from the color-ish solid phenomenal property of the experience of the Test patch. The phenomenal difference between your experiences of the Standard and Test patches in Figure 1.6 is similar to the phenomenal difference the experimental subject would have. And it's plausible that the phenomenal difference of your experience is a color-ish solid phenomenal difference. Compare that phenomenal difference with the phenomenal difference between your experiences of the rectangles in Figure 1.10. The phenomenal differences aren't exactly the same, but they are each constituted by color-ish solid phenomenal properties. So this clarifies one visual dimension involved in the SACM experiments: experiences with color-ish solid phenomenal properties.

So what is the relationship between the color-ish solid phenomenal dimension of the experience involved in a Paper Match and the features of the patches? As indicated by the data model, for the Test and Standard patches after the Paper Match, the extent of the color-ish solid phenomenal difference is the same as the extent of the difference between the chromaticities of the returns, if the subject makes a perfect match. As noted earlier, in the Paper Match, subjects don't adjust the reflectance Test patch to be exactly the same as the reflectance of the Standard patch, and they do not thereby adjust the return to be the same as the return of the Standard patch if it were under the Test illuminant. Thus, for tested subjects, the extent of the phenomenal difference is not to the same degree as the extent of the return difference. However, according to how the data is modeled, in the ideal of perfect color constancy, the phenomenal difference is to the same extent as the return difference. What we see is that the color-ish solid phenomenal properties of the experiences of the Standard and Test Patches corresponded to the patch-returns.

As this result is a product of the model of the data, it is subject to the accuracy of the model. In part, this will turn on the mapping from color-ish phenomenal properties to features like returns and illuminances. The space in which the open and closed shapes are embedded is a chromaticity diagram. It aims to capture relationships between lights and the color solid. Arend and Reeves use one chromaticity diagram but there are many others, and the differences between them can be quite complex[25]. The experimental data of Arend and Reeves does not dictate a unique model. So if their chosen model is not correct, their results in the above paragraph are at risk. For example, some doubt whether a perfect match can be made (e.g. Brainard et al. 1997); if this is correct, a model of constancy of perceived surface color should explain this, and Arend and Reeves's model does not. So in general there are questions about the accuracy of this model. However, what is relevant for purposes of this paper is laying out the model and appreciating the way Gert, Cohen and Matthen build their theories on it[26].

Returning to the relationship between the color-ish solid phenomenal difference and the return difference in Paper Matches, if this were all there were to color vision in Paper Matches, then we would lack color constancy. Recall that, because of the inverse projection problem, when two reflectance-identical surfaces are under different illumination, the returns they reflect into an observer's eyes differ. Without a color constancy mechanism, and operating solely off of the input to the retina, the visual system would output, roughly, experiences as of different

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[25] Over the decades, various CIE chromaticity diagrams have been proposed and used, including the CIE (x,y), the CIELUV, the CIEL*U*V*, the CIELAB, and more. Some reflect advances in color science like the recognition that we can make finer color discriminations among the blues than the yellows. Some are the result of practical purposes.

[26] Thanks to David Hilbert for helping focus what is at issue here.

colors, corresponding to the differing returns. The greater the illuminance difference of two reflectance-identical surface, the greater the return difference and the greater the experienced color difference.

So if we assume for the moment, in order to consider matters in terms of veridicality, a simple Representationalism, according to which phenomenal properties are associated with represented properties, if all there were to color vision were this color-ish solid phenomenal difference found in the experiences involved in Paper Matches, then the experience would represent different color properties even though the plausible color-candidate, surface spectral reflectance, is the same for both patches. Thus the experience would be illusory. However, the claim is that there is more to vision; after a successful Paper Match, counterpart pairs of patches also look the same in color. And this is evidence that we have color constancy.

A clarification is in order. Seeing as the experiments chiefly involve the Standard and Test patches in the Mondrians, one might think that color constancy is only exhibited at those patches and not at the other patches composing the Mondrians. However, the idea is that, for a normal subject, prior to adjustment of the Test patch, all counterpart patches of the Standard and Test Mondrians, except the Standard and Test patches, look alike in color and thus exhibit color constancy. The approach of the experiment, in investigating whether a subject has a visual system that employs color constancy, is to test a subject's ability to make the Standard and Test patch also look alike in color.

A different experimental method could test color constancy in a different way. Such an experiment could use a Standard Mondrian and a Test Mondrian which are reflectance-identical in *all* their counterpart patches. The Test Mondrian could then be placed under the Test illuminant. To test whether the Mondrians are color-constant for a subject, the experimenter could prompt the subject to indicate whether a patch in the Test Mondrian looks to be the same color as its counterpart in the Standard Mondrian or whether the Test Mondrian patch looks to be of a different color. The subject could also be prompted to indicate the degree of sameness or difference in looks. Supposing the subject does not know the experimental set-up, then her response would be evidence as to whether her experience is color constant or not: for example, if, to the subject, the Test patch looks different in color than its counterpart in the Standard Mondrian, though it is not different in color and is only under a different in illumination, then the subject is undergoing an illusion and the Mondrians do not exhibit color constancy. Similar experimental methods, opposed to matching tasks, are performed by Reeves et al. (2008)[27]. The point is that for a color-constant subject, the Standard and Test Mondrians in these latter experiments would look like and cause experiences with the same phenomenology as the Standard and Test Mondrians in the SACM experiments, after a successful Paper Match. All pairs of counterpart patches in the Standard and Test Mondrians in the SACM experiments, after a successful Paper Match, differ in color-ish solid phenomenal properties but look alike in color and so exhibit color constancy.

Finally, let's return to the idea that counterpart patches look the same in color. Depending on the extent to which one's experiences of the figures I provided diverge from the experiences one would have if one were in the SACM experiment, the figures might not provide a sense of the relevant color constancy. Even if they do and the arrowed patches look the same

[27] In one of the experiments, two reflectance- identical Mondrians were under different illumination. The subject's task was to rate to what degree the "center square of the second pattern 'looks as if it is made from exactly the same piece of paper (or material) as in the first pattern'" (Reeves et al. 2008:4). And whether it looked as if there were a change in material or not was understood as it looking as if there were "changes in the reflecting properties of the scene" (Reeves et al.: 2). Thus if a subject's experience involved color constancy, the Test square would not look as if it is made of a different material, with a different SSR, than the Standard square.

in color, this would be an illusion, merely providing the relevant experience[28]. However, getting clear on the sense in which counterpart patches in the SACM experiment look the same, after a Paper Match, is not necessary for the arguments to come. However it is useful to consider some possibilities. On the one hand, assuming something more is involved than the behavioral implications of the data, this sameness in looks might involve some phenomenal sameness. If this is so, it is clear that this phenomenal sameness is not of the same sort as the phenomenal sameness which involves color-ish solid phenomenal properties. It would be impossible to have experiences of counterpart Mondrian patches, after a Paper Match, which differ in color-ish solid phenomenal properties, and are the same in color-ish solid phenomenal properties. The phenomenal sameness would have to involve phenomenal properties or color-ish phenomenal properties of a different sort. On the other hand, if this sameness in looks does not involve phenomenal sameness, then we are left with the question whether it and this color constancy are genuinely visual. Maybe they are just a matter of judgment, in which case it is hard to see how it is genuinely visual[29]. I do not intend to answer these questions.

There are three important take-aways from this analysis of the Arend and Reeves SACM experiments:

1) The Phenomenal Difference -Return Correspondence. According to the model of color constancy, where the Mondrians exhibit perfect color constancy, and have pairs of

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[28] Again, it would be an illusion because the patches actually differ in color/reflectance. They are not reflectance identical patches under differing illumination.

[29] The work of Arend and Reeves does not answer this. They describe Paper Matches as involving "invariance of perceived surface color" and as a "judgment of surface color," so how they conceive of it is unclear. Also Hue-Saturation matches were sometimes described as "judgments." So, whether color constancy involves judgment without phenomenology and/or anything genuinely visual is still unclear. For some purposes of vision science, this may not matter. If the purpose it to understand how a confounding return-input is transformed into environmentally-useful behavior, it might be irrelevant whether phenomenological experience and judgment or judgment alone proceeds the behavior. But for the purposes of the relevant areas of philosophy, the distinction is important. However, Arend and Reeves do recognize a distinction in the matches in these earlier papers, which is explored later in Reeves et al. 2008. But besides reiterating the distinction, additional clarity is not provided.

counterpart patches which look or are perceived as the same in color, the extent of color-ish solid phenomenal difference is the same as the extent of the difference between the chromaticicities of the returns.

2) The Similarity-Difference Distinction. There are two color-related dimensions to the perception of the color-constant Mondrians- one which I have associated with color-ish solid phenomenal properties and the other which, at the least, involves color-looks. If both dimensions are phenomenal, they are of different phenomenal types.

3) The "Looks Similar" Uncertainty. It is, at least, not obvious how to understand the fact, if it is a fact, that pairs of counterpart patches look the same in color.

The next section looks at how these points figure in some of the philosophical theories on Varying Illumination cases and color constancy.

1.5. Mondrian Cases in Dual-Dimension Views

The Dual-Dimension Views engage in second-level disagreement with respect to Varying Illumination cases, disagreeing about *the way* things look different and *the way* things look alike. In this paper, the focus is on those Dual-Dimension disputants who appeal to the Arend and Reeves experiments- Cohen, Gert and Matthen. As noted before, my aim is not to resolve this sibling rivalry. My points will engage more with the first-level disagreements. However, having investigated the Mondrian cases, we have a clearer picture of where the views of Cohen, Gert and Matthen are situated in the first-level disagreement. That is, prior to sorting out in what way things look different (whether in surface color, illumination, or something else) and in what way things look alike (whether in surface color or reflectance or something else), the three take-aways from the analysis of the experiments shed light on the difference in looks (and phenomenology) and, very minimally, on the similarity in looks (and possible phenomenology).

These features of the difference and similarity involved in the Mondrian case are important because it is an open question as to whether and to what degree instances of color constancy and Varying Illumination cases are of a single, theoretically-significant kind. The looks and phenomenology involved in such cases might not be uniform. That is, some Varying Illumination cases might be of the Similarity Only kind while others might be of the Dual-Dimension kind. And this latter kind might divide into sub-kinds depending on, for example, the extent of the difference and the relationship between the similarity and the difference. For example, consider a uniformly-colored object in your vicinity which is partly in cast shadow and partly unshadowed. (Or consider the ground in the scene depicted in Figure 1.1). Does the object exhibit color constancy in the same way that the Mondrian cases do? The answer is not obvious. And even if it does, this could not be known just in virtue of undergoing the experience because non-visual measurements are required to know the features of the return and whether the extent of the phenomenal difference between the experiences of the parts of the surface is the same as the extent of the difference in their returns. So, one scene might verify Dual-Dimension Views in the way that the Mondrian cases seem to. Another scene might verify Dual-Dimension Views but in a different way than the Mondrian cases, for example where the extent of the phenomenal difference is not the same as the extent of the difference in the returns. And another case of color constancy might verify Similarity Only Views. This cannot be ruled out from the outset and would probably bear on the second-level positions about, for example, in what the objects look similar and different. So, it's important that we can zero-in on these details, for merely accepting a Dual Dimension View leaves much unspecified about the similarity and difference and the extent to which Varying Illumination cases are of the Dual-Dimension sort. The Mondrian cases are the predominant way Cohen, Gert and Matthen provide these details.

Before we look at how some in the Dual-Dimension Position have utilized the Arend and Reeves case of color constancy in developing their theories of experience or color, a preliminary move needs to be made by reframing this internal debate amongst Dual-Dimension Views in terms of representation instead of how things look. This is because Cohen, Gert and Matthen are Representationalists, of some sort at least, and end up framing their views representationally[30]. Let's introduce two property-names: "color-like property_1" and "color-like property_2". Maybe it turns out that they co-refer, maybe not. The represented properties "associated" with color-ish solid phenomenal properties are color-like properties_1. Because Gert, Cohen and Matthen do not specify what Representationalism consists in, the metaphysical association-relation between phenomenal properties and representational properties is left vague, that is, whether it is an identity relation, supervenience relation or something else. As will be seen, Gert, Cohen and Matthen take the experiments as evidence that the counterpart patches in the Mondrians, post successful Paper match, are represented as being the same in color-like properties_2. Essentially, Matthen claims that in Varying Illumination cases, homogenously colored surfaces are represented as being alike in color-like properties_2. And experience represents the *illumination* of the scene, not the surface, as different in color-like properties_1. On the other hand, Cohen and Gert claim that homogenously colored surfaces are represented as being alike in color-like properties_2 and are represented as different in color-like properties_1.

[30] Though Matthen doesn't always frame matters representationally in this paper, I assume Matthen is a representationalist here because he writes about experience syntactically, having subjects, predicates and predicative structure, and affirms Representationalism in Matthen 2010b. Cohen and Gert more thoroughly claim that experiences represent, however, neither is explicit about their view on Representationalism. That is, they do not explicitly endorse one of the mainstream forms of Representationalism/Intentionalism. Nor do they explicitly present their own version of Representationalism. In *The Red and the Real* Cohen states, in the context of considering what follows from a "variation in the way that the stimulus looks," that "[o]n a more or less standard view of the visual system as visually representing the world, this entails that… there is a set of variant representations … of the stimulus" (Cohen 2009: 22). However, side-stepping the framing of Representationalism in terms of looks, this is not a clear acceptance of something like Weak Representationalism, nor is it clear that this is all he commits himself to. And, for his purposes in Cohen 2008, it would be best if this is not the extent of his Representational commitments, otherwise providing a sameness in content for a sameness in looks would be unmotivated.

Mohan Matthen appeals to Arend et al. (1991) to come to his conclusion about Varying Illumination cases. He centers his paper on one Varying Illumination case involving the look of a white wall in "the pinkish light of the late afternoon" (Matthen 2010a: 226). Accepting the Dual-Dimension View, Matthen thinks that, in his paradigm case, there is some difference involved in how things look even though things, in some way, look the same. Towards arguing against parts of the *wall* looking pink, Matthen asks "What is the subject of this predicate, *pink*?" (Matthen 245). That is, is pink predicated of the wall or is it predicated of the illumination? To address these "details of visual phenomenology," Matthen turns to Arend et al. (1991) to "[anchor] this issue in empirical bedrock" (Matthen: 245).

Matthen rehearses the distinction between Hue-Saturation versus Paper Matches and argues that the work of Arend et al. supports the view that "the pinkness cast by the afternoon sun… is not attributed to the wall" (Matthen 249). To briefly review his argument, he begins with the premise that the visual system has data in stores or files. Some of the data is color data. Matthen hypothesizes that "there is a certain separation between one's records concerning different things" (Matthen 247). As a result of this separation, one file of data, which includes color data, might be indexed to a material object like a wall. Another file of data, which also includes color data, might be indexed to illumination. Matthen claims that "the work of Arend and his co-workers suggests that colour data coming from the same location is separated into separate stores or *files"* and so supports his idea that color data can be separately indexed to different things, specifically material objects, illumination and spectral returns (Matthen 247). Claiming that "data concerning something is just information predicated of that thing" and "this relationship between data and index corresponds to predication," Matthen concludes that the pinkness in his case is not predicated of the wall but of either the illumination or the light coming off of the object (Matthen 247).

The assimilation of the pinkness in his paradigm case to a color-like $property_1$ is central to Matthen's argument. That is, Matthen is intending to give a general account of a large body, if not all Varying Illumination cases. And he employs the case of a wall in pinkish light as a paradigm from which general conclusions about Varying Illumination cases can be drawn. To understand his paradigmatic case, he turns to the Mondrian case. We noted the three key features of the Mondrian case. Thus, given his appeal to it, we should expect that Matthen thinks his paradigmatic case, and the cases he wishes to generalize to, share these features. So to assimilate the pinkness in his paradigm case to color-like $properties_1$ gives us a clear idea of the pinkness. Color-like $properties_1$ are associated with color-ish solid phenomenal properties that ground the phenomenal difference between counterpart patches of the Standard and Test Mondrians after a successful Paper Match is made, and the extent of this difference is to the same extent as the difference between the returns and illuminances of the counterpart patches[31].

Matthen makes this assimilation when he describes the pinkness as "the pinkness that accounts for matches of 'unasserted' colour" (Matthen 247). "Unasserted colors" are what are involved in Hue-Saturation matches (Arend et al. 1991: 661). Therefore, if Section 1.4 is correct, the relevant phenomenal properties of experiences of unasserted colors are color-ish solid phenomenal properties. And, since Matthen needs to connect the work of Arend and Reeves with a representationalist framework, unasserted colors are color-like $properties_1$. On the other hand, color-like $properties_2$ are surface colors of objects. Thus, for Matthen, when two reflectance/surface color-identical surfaces are variably illuminated, experience represents the

[31] Since the cases of concern involve objects with regions of the same reflectances but differing illuminance, the illuminance fully determines the return difference so the extent of each is the same.

surfaces as being alike in color-like properties$_2$ and represents the illumination of the scene as differing in color-like properties$_1$.

Interestingly, Cohen uses the Arend and Reeves experiments to argue against the position that, in Varying Illumination cases, the "visual system is here discriminating a difference in the illumination falling on the surface regions…rather than a difference in apparent colour" (Cohen 2008: 67). Instead, concerning a homogenously colored surface which is variably illuminated, Cohen writes:

> First, we want to say that colour constancy involves some sense in which the apparent colours of these regions are relevantly alike to subjects…Second, we need a way of articulating this last idea while…avoiding the straight-out insistence that the regions are identical in apparent colour, since, as shown by the variance reaction/appearance match data [i.e. Arend and Reeves's data], there is a good sense in which they are not. (Cohen 2008: 79-80)

Similarly, Gert writes:

> One half of the constancy data [i.e. Arend and Reeves's data] (the relatively inconstant part) corresponds to the variable ways in which *colors appear* under changes of illuminant, while the other half of the data (the relatively constant part) corresponds to the stable color properties objects actually have, and which they also seem to have, given the patterns of change in the first sort of appearance. (Gert 2010: 672).

And for Gert, the stable color properties that objects "seem" to have is a genuinely visual matter, for he later writes, "we really do seem to *see* that the two regions share a common color property. Call this 'the phenomenal nature of color constancy'" (Gert 2010: 673). However, it is important to note that Gert and Cohen divide with respect to there being a represented difference in illumination across variably illuminated surfaces. Gert thinks difference in illumination is represented in such cases, though he does not indicate its presence in the relevant experiences.

To accommodate their Dual-Dimension Views, Gert and Cohen appeal to two types of properties, what I have called "color-like property$_1$" and "color-like property$_2$". For Cohen the color-like properties$_1$ are occurrent apparent colours (Cohen 2008:80). For Gert the color-like properties$_1$ are apparent colors (Gert 2013: 187).

On the other hand, the way pairs of counterpart patches look alike is in color-like properties$_2$ and experience represents members of each pair as sharing a color-like property$_2$. For Cohen and Gert, pairs share a color-like property$_2$ in virtue of, roughly, being disposed to have the same color-like properties$_1$ in the same viewing-conditions. That is, if they were in the same viewing conditions, then they would have the same color-like property$_1$. In Cohen's terms, the Standard and Test Patches in the post-adjusted Mondrians, for example, "are alike in that they *would* share an apparent colour if, contrary to fact, both regions were presented under the same illumination" (Cohen 2008: 81). That is, they are alike because each is such that 1) if it were under the Standard Illumination, then it would have the color-like property$_1$/ occurrent apparent colour that the Standard Patch actually has, and 2) if it were under the Test Illumination, then it would have the color-like property$_1$/ occurrent apparent colour that the Test Patch actually has, and so on for other pairs of viewing conditions and color-like properties$_1$. For Cohen, color-like properties$_2$ are counterfactual apparent colours[32].

For Gert, color-like properties$_2$ are something very similar: dispositional properties "associated with functions from viewing contexts to apparent colors" (Gert 2013: 187). That is, the function from viewing conditions to color-like properties$_1$ partially specified by 1) and 2) underscores the disposition that is shared by the post-adjustment Standard and Test patches.

From their accounts of color-like properties$_2$, we can see that those properties are, in some sense, in terms of color-like properties$_1$. There is a priority to the latter. Like with

[32] In Cohen (2008), Cohen argues that when surfaces look alike in color constancy cases, the experiences of the surfaces have these counterfactual apparent colors as common representational content. It is not clear that he carries this view over to *The Red and the Real.* In the book he only claims that "the subject…will ordinarily judge that the two adjacent regions have one color rather than two" (Cohen 2009: 53) and does not claim there is a common represented property shared by the experiences of the two regions. See Chapter 3 for details.

Matthen, it is from the Mondrian cases, and the three key features, that we get a sense of how things look and the phenomenology of experiences involving color-like $properties_2$ and color-like $properties_1$[33].

Additionally, there is The Similarity-Difference Distinction. Supposing that counterpart Mondrian patches look alike, if there is a phenomenal similarity between experiences of counterpart patches, then the phenomenal properties that ground this similarity are of a different sort than the phenomenal properties (color-ish solid phenomenal properties) which ground the phenomenal difference between experiences of counterpart patches. On the other hand, maybe the patches look similar without there being any phenomenal similarity between the experience of the patches, but this similarity is still a part of the visual experience[34]. Or maybe the patches' looking similar merely involves something non-visual, and possibly cognitive, like a judgment. The judgment might be about how the patches would look, or the phenomenology the experiences of the patches would have, if the patches were under this or that illumination. I do not intend to adjudicate this issue, though. The point is that the experiments and much empirical color constancy literature seem to treat the sameness in the color constancy of these SACM experiments as genuinely visual. And the philosophical literature appealing to such experiments develops theories of visual experience in which the sameness is part of the content of the experience. If it turns out this sameness is not visual then this will pose a significant problem. Specifically, for Representationalists like Matthen, Gert and Cohen, any non-phenomenological construal of the similarity in looks creates a challenge for claiming that the Mondrian cases, and whatever Varying Illumination cases they intent to generalize the Mondrian cases to, involve the

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33 Concerning Gert and Cohen, it should be noted that, while experiences represent differing color-like $properties_1$ in the relevant color-constancy cases, they do not say what instantiated properties differ which verify this representational difference.

34 This might be Alva Noe's 2004 view.

experiential representation of color-like properties$_2$. This is because mainstream Representationalism takes the form of a thesis about the phenomenal and the representational.

For his part, Gert denies a mere judgment-based color constancy which holds that constancy involves "something like an *inferred* color appearance, and not [an] *experienced* appearance." He continues with, "But this seems to get the phenomenology wrong: we really do seem to *see* that the two regions share a common color property. Call this 'the phenomenal nature of color constancy'" (Gert 2010: 673).

Putting aside these issues with the similar-looks involved in color constancy, I will focus on the difference in the way the regions look, i.e. the color-ish solid phenomenal difference between the pairs. By presenting another case of color constancy, I will argue that theories of Varying Illumination cases that appeal to empirical work on color constancy have neglected a different type of color constancy.

In summary, in at least partial support for their particular Dual-Dimension Position, Gert, Cohen and Matthen appeal to the empirical work of Arend and Reeves. This is an appeal to color constancy. Because of their heavy appeal to Arend and Reeves's work, this paper closely analyzed the relevant experiments to get a clearer picture of the prospects of the Dual-Dimension Views. Three central points emerged: The Phenomenal Difference-Return Correspondence, The Similarity-Difference Distinction, and The "Looks Similar" Uncertainty. These features inform the specifics of these Dual-Dimension Views.

CHAPTER 2: TYPE-2 COLOR CONSTANCY AND DUAL-DIMENSION VIEWS

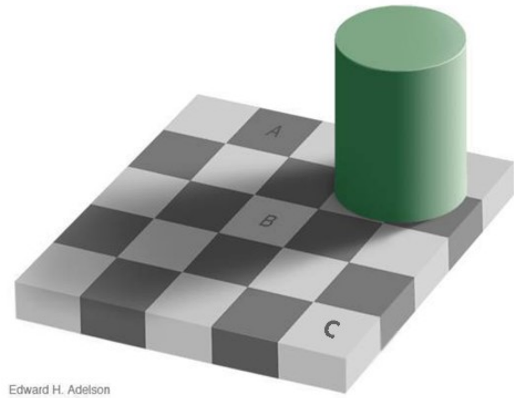
2.1. Type-2 Color-constancy

So far in the paper, one instance of color constancy has been investigated- the particular constancy involving the particular Mondrians in Arend and Reeves's SACM experiments. We must ask whether the features of that particular case are common to all cases of color constancy or, if not, to what extent other instances of color constancy differ from the above Mondrian case. The views of Matthen, Cohen, and Gert seem to take the above Mondrian case as paradigmatic of a great deal, if not all, color constancy cases, and maybe even all Varying Illumination cases. However, this chapter argues that there is a second type of color constancy.

Recall The Phenomenal Difference -Return Correspondence in the color constancy exhibited by the Mondrians in Arend and Reeves's experiments: the color-ish solid phenomenal properties of the experiences of pairs of counterpart patches differ, and the extent of this difference is the same as the extent to which the returns of the pairs of counterpart patches differ. In Section 1.2 the inverse relationship between many similarities and differences was mentioned. This is relevant here: a difference in returns is closely connected to a converse similarity in returns. As two returns become more different in their luminances (the amount of energy had by the returns), they also become less similar. Likewise, consider the color-ish solid phenomenal properties had by an experience of the gray regions in Figure 1.9, Section 1.4.2. The more different two color-ish solid phenomenal properties are from each other, the less similar they are to each other. Thus, related to The Phenomenal Difference -Return Correspondence of pairs of counterpart Mondrian patches, the color-ish solid phenomenal properties of the experiences of such pairs are similar to the same extent as the returns of the pairs are similar. Importantly, the extent to which the experiences of pairs of counterpart patches are phenomenally similar in color-ish solid phenomenal properties is not greater than the extent to which the returns of those patches are similar. This is the case even though, supposedly, in some sense, pairs of counterpart patches look the same in color. I will argue that there is another type of color constancy (Type-2 color constancy). Roughly, in Type-2 color constancy the extent to which the experiences of the patches are phenomenally similar in color-ish solid phenomenal properties is greater than the extent to which the returns of those patches are similar.

An example of Type-2 color-constancy is found in the real-world counterpart of Adelson's well-known checkershadow illusion. To argue for this conclusion, the phenomenal similarity between experiences of different regions needs to be compared to the returns reflected from those regions. But in order to get an understanding of the phenomenal similarity, I intend to give you, the reader, such experiences which have this phenomenal similarity. Unfortunately, since I cannot provide the color-constant regions which would induce the relevant experiences, I must go about things in a round-about way. Specifically, I will use pictures to induce the experiences with the relevant phenomenal similarities. From the pictures, with some empirical details about returns, illuminances, and reflectances, a real-world counterpart of the picture (essentially, what the picture is a picture of) will be "reconstructed." I will argue that the real-world counterpart exhibits color constancy. As noted in discussion of Arend and Reeves's SACM experiments which used Mondrians, simulations are often used in color constancy experiments. The present discussion will consider what is presupposed by such a method.

Figure 2.1: Adelson's checkershadow illusion



Modified from Adelson (1995)

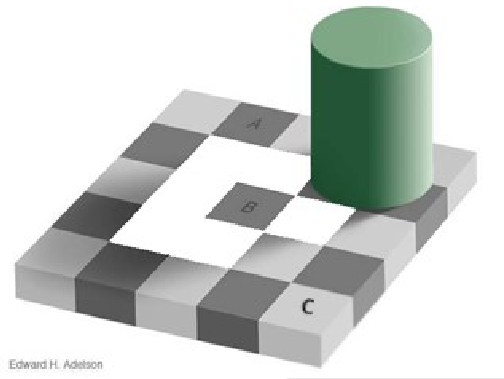
So to begin, let's consider Adelson's illusion. The flat object before you, Figure 2.1, which causes Adelson's illusion, is merely composed of colored patches on a page. The whole surface is evenly illuminated. There is no color-constancy involved. (I will write as if the Figure 2.1 that you are viewing is on paper instead of a screen to make the relationship between reflectance, returns and illuminances/illuminants more straightforward.) The experiences of parallelograms A and B are phenomenally different in a color-ish way. To recognize this leaves open many details of this phenomenal difference and any correlated representational difference. But, as Adelson describes on his website, the figure is illusory because "A and B are the same shade of gray" (Adelson 1995). That is, each is the same color and each has the same reflectance. I will assume colors and surface spectral reflectances are the same thing. A more complicated presentation could drop this assumption. As Adelson notes, we could know that A and B are the same in reflectance by, for example, measuring them with a photometer. In lieu of this, convincing evidence that B is the same color/reflectance as A is available from Figure 2.2, where, to put matters pre-theoretically, they look the same in color.

For reasons that carry over from the previous sections, color-ish solid phenomenal properties will be employed. Given how color-ish solid phenomenal properties were defined, I think it is safe to say that, at least to a very close approximation, the experiences of A and B in Figure 2.2 share a color-ish solid phenomenal property. A name can be given to that determinate phenomenal property- Dark Gray-ish. Because the issues concern illusions and veridical experiences, phenomenal properties will be associated with represented properties in some form of Representationalism[35]. So, we can give names to the determinate represented color of A and B in Figure 2.2. We can call the represented property, which is associated with the phenomenal property Dark Gray-ish, Dark Gray. A and B in Figure 2.2 are represented as Dark Gray.

One might question whether B in Figure 2.1 is the same in color and reflectance as B in Figure 2.2. One method for testing this is to print out the page and cut out B in Figure 2.1. Away from the patches that surround it in-figure, it will be represented as Dark Gray. Alternatively, one could take a piece of paper, cut it in such a way that when it is placed on top of Figure 2.1 it covers the patches touching B but does not cover B, and then place it on top of Figure 2.1. Under these conditions, B will also be represented as Dark Gray.

[35] A Representationalism committed to 2-way supervenience between the phenomenal properties and representational properties would be sufficient.

Figure 2.2: Non-illusory patches



Modified from Adelson (1995)

So, A and B in Figure 2.1 are the same in color and reflectance, though, they look different (to put it pre-theoretically), and there is a phenomenal difference between the experiences of each. Likewise, there is a phenomenal difference between the experiences of B in Figure 2.1 and B in Figure 2.2. Assuming, vaguely, Representationalism, there is a representational difference between A and B in Figure 2.1, and B is misrepresented.

While there is a phenomenal difference between the experiences of B in Figure 2.1 and B in Figure 2.2, another aspect of the illusion is important. In Figure 2.1, B is phenomenally similar to C. In fact, the experience of B in Figure 2.1 is more phenomenally similar to the experience of C in Figure 2.1 than the experience of B in Figure 2.2 is to the experience of C in Figure 2.1. What is this phenomenal similarity? Is it a phenomenal similarity grounded in color-ish solid phenomenal properties? Or is it a phenomenal similarity grounded in some other color-ish phenomenal properties? At the least, it is a phenomenal similarity that is very close to one grounded in color-ish solid phenomenal properties. That is, the color-ish phenomenal properties of the experiences of B and C in Figure 2.1 are very close to being color-ish solid phenomenal properties. For the time being, let's assume that the color-ish phenomenal properties of the experiences of B and C in Figure 2.1 are color-ish solid phenomenal properties   So, a name can be given to the color-ish solid phenomenal property of the experience of B in Figure 2.1. Call it Middle Gray-ish. And call the representational property it is associated with Middle Gray. And the color-ish solid phenomenal property of the experience of C in Figure 2.1 is Light Gray-ish. And call the representational property it is associated with Light Gray.

Since B is represented as Middle Gray, it is represented as more similar to C than it actually is. (B is Dark Gray, recall.) In that B and C in Figure 2.1 are represented as Middle Gray and Light Gray, respectively, let's say they are represented as 1 unit (of some measure) apart in represented color. This leads to the first premise of the argument for Type-2 Color Constancy.

Premise 1: In Figure 2.1, B is represented as Middle Gray and C is represented as Light Gray, and B is represented as 1 unit lower in color than C.

Additionally, it should be noted for future purposes that, while one's experience of Figure 2.1 involves an illusion, it is not entirely illusory. That is, many of the colors represented of the patches of Figure 2.1 are veridically represented. Most relevantly, A and C, being represented as Dark Gray and Light Gray, respectively, are as they are represented to be.

In that A and C in Figures 2.1 and 2.2 are represented as Dark Gray and Light Gray, respectively, let's say they are represented as 2 units (of some measure) apart in represented color. Likewise the experiences of each are 2 units apart in color-ish solid phenomenal properties. Since the experiences of A and C are veridical, the reflectances between A and C are 2 units apart. This reflectance difference tells us about another reflectance difference. Since A and B are represented as the same color in Figure 2.2 and are the same color, C is represented as being as different from A as it is from B. So:

Premise 2: In Figure 2.2, B is represented as being 2 units lower in color than C in Figure 2[36].

Premise 3: The representation of B and C in Figure 2.2 is veridical.

Premise 4: Therefore, in Figure 2.2, B is 2 units lower in color/reflectance than C.

Establishing some physical features of Figures 2.1 and 2.2, we can draw conclusions about the returns of the figures. In the simple cases employed here which lack transmittances, inter-object reflections, fluorescent objects, etc, the return is determined by the reflectance and illumination. Since the illumination of B and C in Figure 2.1 is the same, and the illumination of B and C in Figure 2.2 is the same, the return differences of the patches is determined by the reflectance difference. Therefore:

Premise 5: In Figure 2.2, B is 2 units lower in return-luminance than C.

This leads to a conclusion about the most important patches in the figures, B and C in Figure 2.1. Since the reflectance, illumination/illuminance, and returns of A, B, and C of Figures 2.1 and 2.2 are the same, we can conclude:

Premise 6: In Figure 2.1, B is 2 units lower in return-luminance than C.

With the features of Figure 2.1 and the experiences it causes in hand, we can begin to connect those experiences to the experiences of a color-constant object. To do this let's look at the presuppositions of experiments that use Figure 2.1 as a simulation for a case of color constancy. While Adelson merely presents the illusion on his website and has not published on a color constancy experiment using Figure 2.1, an experiment has been performed on a variant of Adelson's checkershadow illusion in Zeiner and Maertens 2014. Though Zeiner and Maertens use simulated stimuli, they did construct a real checkerboard.

[36] It should be understood that the units of difference is in the same respect throughout.

The first thing to note is that, in using a simulation, the experimenters go to great lengths to ensure the returns of the simulation and the real object are as similar as practically possible. Thus, they measured the return luminances of the simulated stimulus (in their case, a computer-rendering of the checkerboard presented on a computer monitor). Then the features of the real scene "were adjusted so as to produce approximately the same range of luminance values…that was measured for the rendered board on the monitor" (Zeiner and Maertens 2014: 4). They also matched the return luminances of the shadowed checkers on the real board with the return luminances of the patches of the simulation which are depicted as being in shadow.

So we have some information about the returns of Figure 2.1, its illuminances, reflectances, how it looks and the phenomenology of its experience. If we assume that there is a real checkerboard that looks the same, has an experience with the same phenomenology and content, and has the same returns, can we "reconstruct" this Real Checkerboard such that it has the illuminances and reflectances of an object that exhibits color constancy? To begin this attempt, first recall that with Figure 2.1, the whole figure is not experienced illusorily, only the patches in simulated shadow. Therefore, patches A and C, for example, are experienced veridically. To begin reverse engineering the Real Checkerboard, let's name some of the regions of this checkerboard. Corresponding to the patches A, B, and C of Figure 2.1, there are the checkers A', B', and C' of the Real Checkerboard. Again there are 2 assumptions:

Premise 7: The figure and Real Checkerboard reflect the same returns, and each patch and its counterpart checker reflect the same returns.

Premise 8: There is sameness in looks between each patch of the figures and its counterpart checker in the Real Checkerboard, and there is sameness in the phenomenal properties and content of the experiences of each patch and its counterpart checker.

Since A and C are represented veridically, A is Dark Gray and C is Light Gray. Nothing bars A' and C' from being the same colors as their Figure 2.1-counterparts, so they are Dark Gray and Light Gray, respectively. Also, in that Figure 2.1 is in normal, "white" light (roughly, light that has equal amounts of energy at all wavelengths and a relatively high overall intensity), we can stipulate that the checkerboard is in the same lighting, except for its shadow.

The place to look for color constancy in the checkerboard is at the location that is the counterpart of the location of the illusion in Figure 2.1. So, in that B is represented, with respect to color, as closer to C than it actually is (being Dark Gray but represented as Middle Gray), we should look to the relationship between B' and C'. From Premise 1 and Premise 8 it can be concluded that:

Premise 9: B' is represented as Middle Gray, and C' is represented as Light Gray, and B' is represented as 1 unit lower in color than C'.

What would color constancy be like in the real checkerboard?

Premise 10: The following would be sufficient conditions for imperfect Type-2 color constancy: 1) B' is the same in reflectance as C', but having a lower illuminance (because it's in shadow), reflects a lower return luminance than C'. 2) The degree to which B' is represented as a similar gray as C' is greater than the degree to which the return luminance of B' is similar to the return luminance of C'.

Generally, this captures the idea that color constancy occurs when the visual system overcomes the effect of differing return to produce more similar experiences. At the extreme, there would be perfect Type-2 color constancy if 1) obtained and B' is exactly the same in represented color as C'. For present purposes, there would be imperfect Type-2 color constancy if: 1) B' and C' were the same in reflectance, but because B' has an illuminance that is two units lower than the illuminance of C,' the return luminance of B' is two units lower than C'. And 2) B' were represented as only one unit darker in gray than C'. And this is what we find in a checkerboard that looks the same, has an experience of the same phenomenology and content, and has the same returns as Figure 2.1.

From Premise 6 and Premise 7, it can be concluded that:

Premise 11: B' is two units lower in return-luminance than C'.

There are a number of reflectance-illuminance pairs that can produce the type of return-luminance that is commonly reflected by B and B'. Premise 6 (In Figure 2.1, B is 2 units lower in return-luminance than C) is true since there is a reflectance difference between B and C while they have the same illuminance. But B' and C' might have any number of reflectances and illuminance and still satisfy Premise 11. The question is whether there are any combinations of reflectance-illuminance pairs for B' and C' which satisfy condition 1) of Premise 10. Suppose we assume:

Premise 12: B' has the same reflectance as C'.

If this is the case, then B' would have to have an illuminance that is 2 units lower than that of C' in order for their return-luminances to match those of B and C. So by Premise 11 and Premise 12:

Premise 13: B' has an illuminance that is two units less intense than the illuminance of C'.

Premise 13 can be true because of a cast shadow. But given the sameness in represented properties and phenomenal properties between the experience of Figure 2.1 and the Real Checkerboard, the represented colors of B' and C' are only one unit apart (Premise 9).

Therefore, the Real Checkerboard satisfies condition 1 of Premise 10, given Premises 11, 12, and 13, and satisfies condition 2, given Premises 9 and 11. Therefore:

Conclusion: The Real Checkerboard exhibits imperfect Type-2 color constancy.

The color constancy involved in the Real Checkerboard "reconstructed" above should be distinguished from the color constancy involved in the Mondrian case. In the idealized Mondrian case, there is The Phenomenal Difference -Return Correspondence.[37] If this color-ish solid phenomenal difference were all there were to the look and experiences of the patches, then at least one of the experiences would be illusory. The visual system that produced such experiences would fail to overcome the inverse projection problem, outputting experiences that differ in phenomenal properties (and represented colors) because of, and to the extent of, the difference in returns, despite the surface colors of the patches being the same. However, if the accepted view of the Mondrian cases is correct, the experiences are not illusory because the patches look the same in color and are the same in color. This was Type-1 color constancy.

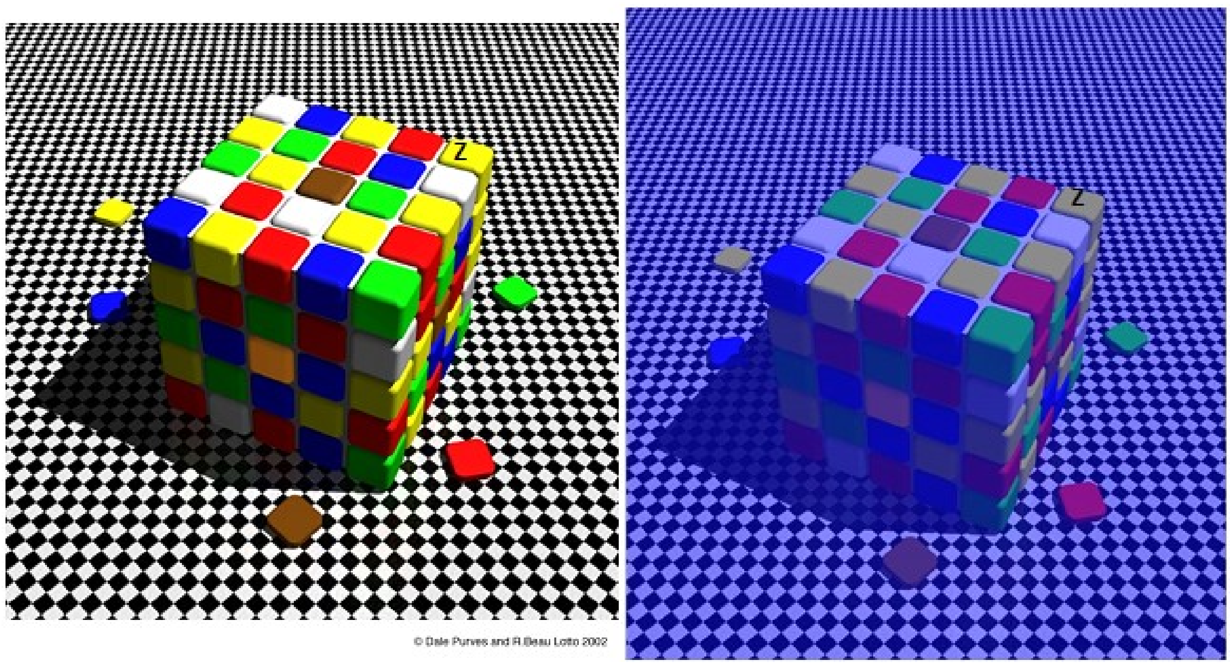
The color constancy involved in the Real Checkerboard "reconstructed" above is of a different kind because of the relationship between the color-ish solid phenomenal properties and the returns. The color-ish solid phenomenal property of the experience of B' is similar to the color-ish solid phenomenal property of the experience of C', to a certain degree. The degree of this similarity is greater than the degree to which the return luminance of B' is similar to the return luminance of C'. This contrasts with The Phenomenal Difference -Return Correspondence in Arend and Reeves's color constancy case and warrants distinguishing this as a second type of color constancy.

[37] Recall that it was not the case that, for each experimental participant, the extent of the difference between the color-ish phenomenal properties was exactly the same as the extent of the difference between the returns. This was taken to be evidence of participants exhibiting somewhat imperfect color constancy. (In light of this section, it would be imperfect Type-1 color constancy). If the extents of the differences were the same, then there would be perfect Type-1 color constancy.

Another figure and real world, color-constant counterpart might be helpful. Consider Figure 2.3:

Figure 2.3: Lotto and Purves's Rubik's Cubes

A **B**



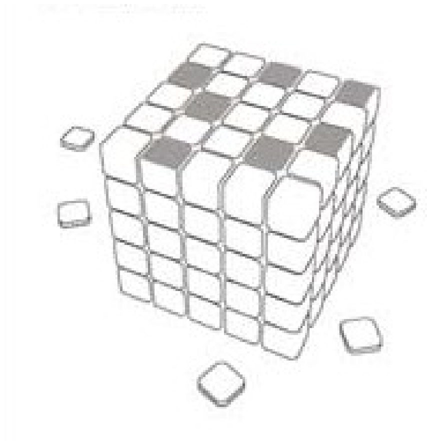
From Lotto and Purves 2002[38]

Like with Figure 2.1, I will write as if Figure 2.3 before you is on paper, instead of also describing the figure as it would be if you were viewing it on a computer or tablet screen. Figure 2.3 is a flat surface composed of colored patches. Consider the right-most yellow patch in Figure 2.3A, marked Z, and right-most yellow patch in Figure 2.3B, marked Z. Your experiences of each Z patch are not exactly phenomenologically the same. But compare Figure 2.4, and consider your experience of its Z-patch; it has a gray-ish phenomenal property. Your experience of patch Z in Figure 2.4 is veridical, whereas your experience of patch Z in Figure 2.3B is

[38] Reprinted from Lotto, Beau R & Purves, Dale (2002). The empirical basis of color perception. *Consciousness and Cognition*, *11*(4), 609-629. with permission from Elsevier.

illusory. This is analogous to the way patch B in Figure 2.2 is experienced veridically, whereas patch B in Figure 2.1 is experienced illusorily. Like with Figure 2.1, if you are unconvinced that Z in Figure 2.3B is experienced illusorily, there are ways to verify. For example, Figure 2.3B can be printed out, patch Z can be cut from the rest of the figure, and then your experience of Z will be like your experience of Z in Figure 2.4.

Figure 2.4: Non-illusory Rubik's Cube



From Lotto and Purves 2002[39]

So your experience of Z in Figure 2.3B is phenomenologically more similar, because it is more yellow-ish, to your experience of Z in Figure 2.3A than your experience of Z in Figure 2.4 is to your experience of Z in Figure 2.3A. This parallels Figures 2.1 and 2.2. One's experience of patch B in Figure 2.1 is Middle Gray-ish. One's experience of patch C in Figure 2.1 is Light Gray-ish. One's experience of patch B in Figure 2.2 is Dark Gray-ish. Therefore, one's experience of B in Figure 2.1 is more phenomenologically similar to one's experience of C in Figure 2.1 than one's experience of B in Figure 2.2 is to one's experience of C in Figure 2.1.

[39] Reprinted from Lotto, Beau R & Purves, Dale (2002). The empirical basis of color perception. *Consciousness and Cognition*, *11*(4), 609-629. with permission from Elsevier.

Now, as Figure 2.1 correlates to the Real Checkerboard which causes a very similar phenomenological-type of experience, Figures 2.3A and B correlate to real-world Rubik's Cubes, A and B, which cause very similar types of experiences. In the case of the Real Checkerboard, given the relationships between its returns, reflectances, and illuminances and those of Figure 2.1, it was argued that checkers B' and C' are alike in reflectance, B' has a lower illuminance than C', and therefore B' has a lower return-luminance than C'. However, the color-ish solid phenomenal property of the experience of B' is similar to the color-ish solid phenomenal property of the experience of C', to a certain degree. The degree of this similarity is greater than the degree to which the return luminance of B' is similar to the return luminance of C'. Therefore, B' exhibits imperfect Type-2 Color Constancy.

Similarly, the real Rubik's Cubes, A and B, exhibit imperfect Type-2 Color Constancy. Suppose, correlative to patches Z in Figures 2.3, A and B, Rubik's Cubes A and B have segments Z. Cubes A and B are SSR-identical. However Rubik's Cube A is under a light that is similar to normal daylight, radiating roughly equal energy at each wavelength in the visible spectrum, and Rubik's cube B is under a light that radiates more energy at the shorter wavelengths in the visible spectrum- call it "blue" light. The extent of the difference between the return reflected from segment Z on Cube B and the return reflected from segment Z of Cube A matches the extent of the color-ish solid phenomenal difference between segment Z of Cube A and segment Z of Cube C (where Cube C is the real counterpart of Figure 2.4). However, just as the extent of the color-ish solid phenomenal similarity between the experiences of segments Z of Cubes A and B is greater than the extent of the color-ish solid phenomenal similarity between the experiences of segments Z of Cubes A and C, the extent of the color-ish solid phenomenal similarity between experiences of segments Z of Cubes A and B is greater than the extent of the similarity between the returns of segments Z of Cubes A and B. Thus, segments Z of Cubes A and B exhibit imperfect Type-2 Color Constancy. This is a vivid example of a Type-2 Color Constancy.

Now I will address two complications. First, earlier it was assumed that the experiences of parallelograms B and C in Figure 2.1 are similar in color-ish solid phenomenal properties. (And since the phenomenology of Figure 2.1 is the same as that of the Real Checkerboard, it was assumed that the experiences of checkers B' and C' are similar in color-ish solid phenomenal properties.) That is, not only are the experiences similar in color-ish phenomenal properties, they are similar in color-ish solid phenomenal properties. So the initial assumption was that the color-ish phenomenal property of the experience of, for example B', is identical to the color-ish solid phenomenal property, which I named Middle Gray-ish. This may not be quite right. But the color-ish phenomenal property which is had by the experience of B' is very close to the color-ish solid phenomenal property Middle Gray-ish. So, at least, we can consider the assumption that the total color-ish phenomenologies of the experiences of A', B', and C' are color-ish solid phenomenologies as a close approximation. Therefore, it can still be argued that the Real Checkerboard exhibits a type of color constancy which is different than Type-1, even if this type of color constancy does not precisely involve color-ish solid phenomenal properties. For surfaces exhibiting only Type-1 color constancy, there is not a color-ish solid phenomenal similarity which is to a degree that is greater than the degree of similarity between the returns of the surfaces. Additionally, this applies to color-ish phenomenal similarities that are remotely close to the color-ish solid phenomenal similarity between experiences which are Middle Gray-ish and Light Gray-ish.

The second complication: To distinguish Type-2 from Type-1 color constancy, the focus has been on comparing the extent of the phenomenal similarity to the extent of the return-similarity. As noted earlier, many similarities are closely connected to inversely related differences, and vice versa. This would apply to color-ish solid phenomenal similarities and differences. However, if the experience of the Real Checkerboard involves a color-ish phenomenal similarity which is not a color-ish solid phenomenal similarity, I will remain noncommittal about the relationship between the color-ish phenomenal similarity and an inverse color-ish phenomenal difference. That is, I distinguish Type-2 color constancy from Type-1 in virtue of Type-2 involving a degree of color-ish phenomenal similarity which is greater than the degree of the similarity of the returns, whereas for Type-1 the degree of color-ish phenomenal similarity is not greater than the similarity of the returns. This is silent on the comparative degrees of phenomenal difference and return difference involved in Type-2. For example, this allows that, for Type-2, the degree of the color-ish phenomenal difference is the same as the degree of the difference in the returns, as long as this difference is not inversely related to the color-ish phenomenal similarity referenced two sentences back[40]. So, if one is inclined to think that the extent of the color-ish phenomenal difference between the experiences of B' and C' is to the same extent as the color-ish phenomenal difference between B in Figure 2.2 and C in Figure 2.2 (and so is also to the same extent as the difference in the return-luminances of B' and C'), there is still reason to distinguish Type-2 from Type-1.

[40] This could be the case if the color-ish phenomenal property of the experience of B' has two dimensions. The property might have two dimensions in the way that being rectangular has two dimensions of length. For the color-ish phenomenal property one dimension might make for the color-ish phenomenal similarity between the experiences of B' and C' which I claim is characteristic of imperfect Type-2 Color Constancy. The other dimension might make for a color-ish phenomenal difference between the experiences of B' and C' which is to the same extent as the color-ish phenomenal difference between B in Figure 2 and C in Figure 2.

In summary, I have argued that, as a matter of the relationship between color-ish phenomenal similarities and similarities between returns, there are at least two types of color constancy. Now, we can return to the philosophical theories of color and experience which draw support from color constancy. It will be argued that Gert, Cohen, and Matthen's theories appear unable to accommodate Type-2 color constancy.

2.2. Type-2 Color Constancy and Dual-Dimension Views

Gert, Cohen and Matthen, taking first-level positions about phenomenal and looking relationships as dictated by the Mondrian cases, provide second-level views about representational differences and similarities in at least some color constancy cases. As I will argue, the sort of phenomenal similarity present in Type-2 color constancy is not easily assimilated into their accounts.

For Gert and Cohen, the problem is that their counterfactual/dispositional accounts of color in color constancy cases competes with Type-2 color constancy in how the veridicality of experience is secured.

The problem relates to the response Gert gives to the unity problem that Kalderon poses for dispositional accounts of color. As we saw with Gert and Cohen's theories, color-like $properties_2$ are associated with functions from viewing-conditions to color-like $properties_1$. Gert explicitly states that objective colors (color-like $properties_{2)}$ are dispositions which manifest apparent colors (color-like $properties_1$). However, Cohen does not describe his view as a form of dispositionalism even though his counterfactual account is very similar to a dispositional account given the close relationship between dispositions and certain counterfactual conditionals[41]. Therefore, I will address both Cohen and Gert under the umbrella of dispositionalism, focusing

[41] This relationship can be seen in the extensive literature on dispositions and conditionals.

on Gert. So the same dispositional color-like $property_2$ is had by the Standard patch and the Test patch in the SACM experiments, post successful Paper Match. But the Standard patch, under the Standard illuminant, manifests one color-like $property_1$ while the Test patch, under the Test illuminant, manifests another color-like $property_1$. Both manifestations, in their appropriate stimulus conditions, are part of the dispositional color-like $property_2$. Kalderon's challenge to the dispositionalist is to explain why some clusters of manifestations count as colors while others do not, for certainly "not every plurality of such [manifestations] constitutes a colour" (Kalderon 2008: 950).

There is a form of this objection which is especially relevant to the present issues in color constancy. Without color constancy, when illumination, amongst other conditions, changes, our experiences would illusorily change. And we do have color illusions, sometimes because of failures in color constancy. Gert and Cohen's accounts of color constancy need to be able to allow for such color illusions. That is, the accounts need to rule out certain clusters of color-like $property_1$ manifestations as genuine colors, otherwise illusions that result from a failure of color constancy would be impossible. As Gert says, there is a burden to "explain how it is that these 'privileged' clusters [of color-like $property_1$ manifestations] can be distinguished from other 'gerrymandered' clusters that do not count as colors" (Gert 2013: 95). For an example of an instance of illusion: suppose one sees the patch in Figure 2.5 on a piece of paper. It is yellow, i.e. it has the yellow color-like $property_2$. Supposing you are in roughly "white" lighting conditions, it manifests an experience with the same color-ish solid phenomenal property your experience has as you view Figure 2.5[42]. Call the color-ish solid phenomenal property yellow-ish. And the experience represents the associated yellow color-like $property_1$. Call this scene 1.

[42] By "white" lighting I mean lighting that has roughly equal intensity at each wavelength and is of a relatively high total intensity.

Figure 2.5: Yellow patch

However, there are some conditions under which the patch could be experienced illusorily. For example, suppose the patch were moved to a different illumination, X. X interacts with the SSR of the patch in such a way that the return reflected off it has the same chromaticity as that of the return reflected off a gray object which is in the "white" lighting that the patch was originally in[43]. There are conditions under which our experience of the patch in X has a gray color-ish solid phenomenal property and represents the patch as having a gray color-like property$_1$. (Such a gray-ish color-ish solid phenomenal property would be instantiated by one's experience of a segment of Figure 1.9, Chapter 1) Call this scene 2. While the yellow color-like property$_2$ has a manifestation that involves a yellow color-like property$_1$ in the "white" lighting, amongst many other manifestations, if there is a manifestation of this disposition that involves the gray color-like property$_1$ in illumination X, then the theory would predict that scene 2 would be experienced veridically. When the patch is represented as having the two color-like properties$_1$, one in the "white" illumination and the other in illumination X, it would instantiate the yellow color-like property$_2$ in both conditions. However, scene 2 is illusory[44]. Thus, Gert and Cohen need a way to rule out, as a genuine color, a yellow color-like property$_2$ that has a

[43] The chromaticity of X would be one which, when combined by superposition with the reflectance of the patch, yields a return which has roughly equal energy at each wavelength and is of a moderate to low luminance. X could be a "blue" illumination.

[44] If one thinks that an experience of scene 2, with the gray-ish phenomenal property and representing a gray color-like property$_1$, would be veridical, then a variant case can be substituted. Certainly there is some case of the same general form that is illusory.

manifestation that involves a yellow color-like property$_1$ in the "white" lighting and a manifestation that involves the gray color-like property$_1$ in illumination X.

Gert does not explain what unifies certain clusters of manifestations as genuine colors/ color-like properties$_2$. However, he claims Kalderon's problem of unity can be solved, though it is difficult and "cannot be solved a priori. Moreover, it is unlikely that the solution can be expressed perspicuously in language" (Gert 2013: 195). He is confident it can be solved because, as he claims, within childhood we come to know, for example, when a course of experiences representing various color-like properties$_1$ under different viewing conditions involves a genuine color/ color-like property$_2$ and when a course of experiences representing various color-like properties$_1$ under different viewing conditions does not involve a genuine color/ color-like property$_2$. Gert likens this to "our ability to recognize words in our native language; an intense course of contingent experience with native speakers suffices to allow us spontaneously to pick out words-even new ones- from sounds that are not words…" (Gert 2013: 195). Some strings of sounds form a word in English. Some do not. Early on we gain the ability to distinguish the two even though it is difficult to articulate what makes a string of sounds a word in English.

Suppose Gert is right, and there is some solution to the unity problem which rules out, as a genuine color, a yellow color-like property$_2$ that has a manifestation that involves a yellow color-like property$_1$ in "white" lighting and a manifestation that involves the gray color-like property$_1$ in illumination X. One thing we see in Gert and Cohen's accounts of color constancy is that even when two surfaces exhibit color constancy, and so are both represented as having the same color-like property$_2$, the surfaces are represented as differing in color-like property$_1$ to an extent that is the same as the extent of the difference in the returns of the surfaces. We saw this in the Mondrian case. This feature of the representation of color-like $properties_1$ is shared with a subject's experience which does not involve color constancy. For a constancy-free subject, the representation of color-like $properties_1$ varies with variations in the return. For Gert and Cohen, the difference between color-constant and constancy-free subjects lies in the representation of color-like $properties_2$. It is in virtue of the representation of color-like $properties_2$ that the illusions of a constancy-free subject are avoided.

However, in Type-2 color constancy, the illusions of a constancy-free subject are avoided (or at least lessened, if the constancy is merely imperfect) in virtue of the color-like $properties_1$, that is, those represented properties associated with color-ish solid phenomenal properties[45]. In the color-constancy exhibited by the Real Checkerboard, the experience of checker B' has (at least approximately) a Middle Gray color-ish solid phenomenal property, and there is a Light Gray color-ish solid phenomenal property of the experience of checker C'. If one's experience of checker B' were constancy-free, then there would be a Dark Gray color-ish solid phenomenal property of that experience. This phenomenal property would be as different from the color-ish solid phenomenal property of the experience of checker C' as the return of B' is different from the return of C'. These features of the phenomenal properties of the experiences translate over into the color-like $properties_1$ represented by the experiences. Our imperfect Type-2 color constancy and the fact that our experience of the Real Checkerboard is less illusory than the constancy-free subject's experience are, therefore, in virtue of the color-like $properties_1$, not the color-like $properties_2$. This contrasts with the dispositional/counterfactual accounts of Type-1 color constancy.

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[45] Or at least illusions are avoided because of the representation of properties associated with some color-ish phenomenal properties that are close to color-ish solid phenomenal properties.

Type-2 color constancy also cannot be easily assimilated into Matthen's account of what is involved in color constancy cases. Recall the features of Matthen's view: Matthen assimilates color constancy cases to the Mondrian cases of Arend and Reeves's experiments. Thus, color constancy cases involve experiences with The Phenomenal Difference-Return Correspondence, The Similarity-Difference Distinction, and The "Looks Similar" Uncertainty. The color-ish solid phenomenal difference is associated with the representation of color-like $properties_1$. Experience also represents color-like $properties_2$. The later is associated with whatever is involved in pairs of counterpart patches looking alike. Color-like $properties_1$ are dimensions of the illumination. Color-like $properties_2$ are dimensions of surface color.

The problem for Matthen concerns his association, in the Mondrian cases, of represented color-like $properties_2$ with something that is not even approximately color-ish solid phenomenal properties. In the imperfect Type-2 color constancy exhibited by the Real Checkerboard, the experience of checker B' has a Middle Gray color-ish solid phenomenal property that is similar, to some less than perfect extent, to the color-ish solid phenomenal property of the experience of checker C'[46]. The extent of this similarity is greater than the extent of the color-ish solid phenomenal similarity between the experiences of counterpart patches in the Mondrians which exhibit Type-1 color constancy. This is because, in Type-1 color constancy, color-ish solid phenomenal properties differ to the extent that the returns and illuminances differ. There is not the color-ish solid phenomenal similarity that is found in Type-2 color constancy.

In Type-2 color constancy, the color-ish solid phenomenal similarity between checkers B' and C' is associated with the represented surface color of B' and C'. This explains the degree to which the experience of the Real Checkerboard is veridical. Thus, our experiences of B' and

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[46] The simple hypothesis will be employed for brevity, where the color-ish phenomenal similarity is not merely approximately, but is identical to a color-ish solid phenomenal similarity.

C' represents them as closer in surface color than a constancy-free subject's experiences would represent them. However, for the Type-1 color constancy of Mondrian cases, Matthen does not associate represented surface color (color-like $properties_2$) with color-ish solid phenomenal properties in the Mondrian cases, his pink wall case, and whatever other Varying Illumination cases he intends to assimilate to Mondrian cases. Represented surface colors (color-like $properties_2$) were associated with whatever phenomenology (if there is such) which is related to, for example, counterpart Mondrian patches looking the same.

To extend his view to Type-2 color constancy, in addition to associating the representation of surface colors with the phenomenology (or lack thereof) that he associates them with in the Mondrian cases, Matthen would need to associate the representation of surface colors with color-ish solid phenomenal properties in Type-2 color constancy. This would seem to contravene one of Matthen's tenets of his theory on experiential representation. According to his representationalism, "color experiences denote color" (Matthen 2010b: 77). However, that a type of experience denotes a type of color is contingent and a "matter of historical and genetic happenstance." But, Matthen stresses that "it is important to internal functioning that [a] type of experience consistently be used to mark [a] particular color" (Matthen 2010b: 77). This requires that, at least for an individual's perceptual system, a color should be marked by only one type of experience, not marked by one type of experience at one moment and another at the next. But to subsume Type-2 color constancy under the view he develops from the Mondrian cases, Matthen would two phenomenal-types of experiences which each mark or represent surface colors. Thus, assimilating Type-2 color constancy to Matthen's account of the Mondrian cases seems to conflict his principle of representationalism, a very plausible principle generally.

Therefore, it does not look as if Gert, Cohen and Matthen can extend the theories of color and experience which they develop from the Type-1 color constancy of the Mondrian cases to Type-2 color constancy.

2.3. Conclusion

Let's review how Type-2 color constancy is situated with respect to Varying Illumination cases. Roughly, Varying Illumination cases are situations where reflectance/color-identical surfaces are differently illuminated and our experience of the scene is, by and large, not illusory[47]. The first-level of disagreement about Varying Illumination cases concerns how things in such situations look and the phenomenology of the experiences of the things in such situations. At this level of debate, parties disagree on whether things only look different/there is only a phenomenological difference in the experiences of the things or whether things only look alike/there is only a phenomenological similarity in the experiences of the things or whether things look different and alike/there is a phenomenological difference and similarity in the experiences of the things.

Within each side of the first-level debate, there are second-level debates. Most relevant to this paper, there is the Dual-Dimension First-Level View. Proponents of such a view agree that, in Varying Illumination cases, things look different and alike/there is a phenomenological difference and (maybe) a phenomenological similarity in the experiences of the things. To take the Dual-Dimension First-Level Position leaves open sub-positions, which differ in the specifics of the dual-dimensions. However, beyond these differences, Dual-Dimension Views disagree on *the way* in which things look different and *the way* in which things look alike. And, for those

[47] Matters are restricted in various ways: the illumination varies over space at a single time; the relevant parts of the object are reflectance/color-identical; simple and direct illuminants are employed. However Varying Illumination cases can be extended to include diachronic illumination variation, illumination variation coupled with reflectance variation, inter-object reflections, non-diffuse illumination and more.

mentioned here, they disagree on the representational difference associated with the phenomenological difference and the representational similarity (possibly) associated with the phenomenological similarity.

In at least partial support for their particular Dual-Dimension Position, Gert, Cohen and Matthen appeal to the empirical work of Arend and Reeves. This is an appeal to color constancy. By appealing to the Mondrian cases of the SACM experiments, they stake out a particular first-level Dual-Dimension View, one according to which there is The Phenomenal Difference-Return Correspondence and The Similarity-Difference Distinction. Making commitments with respect to the second-level debate, Gert and Cohen, on the one hand and Matthen on the other, claim Arend and Reeves's work motivates their second-level views. Though the experiments of Arend and Reeves employ a very narrow range of stimuli (two flat, patchwork surfaces seen simultaneously under differing illumination), Gert, Cohen and Matthen do not merely mean to propose content for the experiences of these stimuli. They mean to use such scenes as paradigms of something more general, possibly Varying Illumination cases as a whole. So they might think that there is a single, theoretically-significant kind which unifies Varying Illumination cases, and of which the Mondrian case is an exemplar. And they might intend to give a theory of this kind. Or they might have more modest aims, allowing that their theories do not encompass all Varying Illumination cases.

Because of Gert, Cohen and Matthen's heavy appeal to Arend and Reeves's work, Chapter 1 closely analyzed the relevant experiments to get a clearer picture of the prospects of the Dual-Dimension Views. Three central points emerged: The Phenomenal Difference-Return Correspondence, The Similarity-Difference Distinction, and The "Looks Similar" Uncertainty.

The results of this investigation of the experiments bear on the first-level debate. My discussion proceeds without settling in what (illumination, surface color, etc.) things look similar and different and what representational similarities and differences are associated with the phenomenal similarities and differences.

With some clarity on the looks and phenomenology of the Type-1 color constancy of Mondrian cases, I argued for a second type of color constancy. In Type-1 color constancy there is no color-ish solid phenomenal similarity that is to an extent that is greater than the extent of the similarity between the returns. In Type-2 color constancy there is a color-ish solid phenomenal similarity between the experiences of the relevant regions which is of an extent that is greater than the extent of the similarity between the region's returns. Or, more cautiously, the above color-ish phenomenal similarity may not be a color-ish solid similarity, but it is close. In Type-1 color constancy however, there is not a color-ish phenomenal similarity which even remotely approximates a color-ish solid phenomenal similarity and which is of an extent that is greater than the extent of the similarity of the returns.

Therefore, again largely within the first-level debate, Type-2 color constancy is distinguished as a kind of Varying Illumination case which differs from the kind of Type-1 color constancy. Whether Type-2 color constancy falls under a Dual-Dimension View or not depends on whether the color-ish phenomenal property of the experience of, say, checker B' is a color-ish solid phenomenal property or whether it is something somewhat different. That issue must be left for subsequent work.

It was then argued that Gert, Cohen and Matthen's second-level positions within the Dual-Dimension View, which propose representational properties for the experiences involving Type-1 color constancy cases, do not seem to be able to extend to Type-2 color constancy. The role of color-like $properties_2$ in Type-1 color constancy is not the same as their role in Type-2 color constancy.

CHAPTER 3: AGAINST RELATIVISM ABOUT VARYING ILLUMINATION CASES

3.1. Introduction

Chapters 1 and 2 introduced Varying Illumination Cases, a kind of case in which an object is, or various objects are, differently illuminated either at a time or over a period of time, and the experience(s) of the scene is, presumably, not overwhelmingly illusory. In Chapters 1 and 2, we looked at various views which were united in holding that the experiences in Varying Illumination cases are not overwhelmingly illusory because of some similarity in the experiences. This similarity took different forms: a similarity in how relevant objects look, a similarity in the phenomenology of the relevant experiences, and/or a similarity in content of the relevant experiences. In this chapter, we look at another approach to Varying Illumination Cases- Relativism. Relativism does not explain the veridicality in Varying Illumination Cases in terms of some vision-related similarity. Instead, it utilizes only the differences in the experiences to recover veridicality.

The two forms of Relativism that will be discussed are that of Jonathan Cohen and Sydney Shoemaker. Roughly, the Relativist approach to Varying Illumination Cases involves observing that the differently illuminated regions of an object look different. It is then claimed that the experience is not illusory. Since the regions of the object are alike in intrinsic properties, the regions cannot look different in color and be as they look (if color is, as it seems pre-theoretically, an intrinsic property). So the Relativist proposes that the regions look different with respect to some property which is not an intrinsic property of objects. And these proposed properties are instantiated, so illusion is avoided.

I will argue that, in light of the material in Chapters 1 and 2, Cohen and Shoemaker's arguments for Relativism about Varying Illumination Cases fail. The next two sections present Cohen's argument for his version of Relativism and Shoemaker's argument for his version of Relativism. Section 3.4 challenges those arguments. First I argue that the argument for Relativism does not generally apply to Varying Illumination Cases. Then I argue against there being any Varying Illumination Cases for which Relativism is motivated.

3.2. Cohen's Argument for Relational Relativism

Cohen's argument against non-relativistic views of color and for his Relational Relativism about color takes a general form which he applies to various cases including spectrum inversion cases, Varying Illumination Cases, and more. Only the Varying Illumination Cases matter for my purposes.

Before his argument is presented, it should be noted that Cohen also had a Dual-Dimension view of Varying Illumination Cases, as discussed in Chapters 1 and 2. This view was presented in *Color Constancy as Counterfactual*. However, in *The Red and the Real*, it is not clear that Cohen still endorses this view. In the earlier paper, veridicality in Varying Illumination cases is secured in virtue of a common property represented of the surfaces under varying illumination. However, in the book discussed here, when he describes cases in which reflectance-identical surfaces are under variable illumination and so look different, he describes color constancy as a matter of judgment, claiming only that subjects judge the surfaces to be the same (Cohen 2009: 53-54). And, as we will see, veridicality is not recovered by a common represented property. Cohen's earlier and later views will be discussed more at the end of this section, where it will become clearer why I will treat them as two separate views. For now we turn to the details of his argument.

To provide the first premise of his argument, Cohen starts with an example of a Varying Illumination Case. Referring to a cup and table partly in sunlight and partly in shadow (See Figure 3.1), Cohen states, "Clearly the regions of the coffee cup (and the table) that are in direct sunlight are perceptually distinguishable for the subject from the (qualitatively identical) contiguous regions of the coffee cup (and the table) that are in shadow…" (Cohen 2009: 53). A few points of clarification: Cohen often writes of things being "perceptually distinguishable", there being "variation in perceptual effects," or there being "perceptual variation." However, Cohen uses these somewhat idiosyncratic expressions interchangeably with more ordinary expressions like "looks different" or "variation in the way that the stimulus looks." I assume Cohen means to use his idiosyncratic expressions in a way that is pre-theoretical like ordinary uses of "looks," particularly since Cohen's expressions are found early on, when the pre-theoretic groundwork is being laid out, and he does not offer any elucidation as to what he means by those expressions.

Figure 3.1: Cohen's Cup

From Cohen 2009[48]

[48] Reprinted from Cohen, Jonathan (2008). Colour constancy as counterfactual. *Australasian Journal of Philosophy* 86 (1):61 – 92. with permission from Taylor & Francis.

But is this idea that the regions of the cup are perceptually distinguishable/look different sufficient to frame the issue? Unfortunately, as noted earlier, statements of the form "X looks different than Y" or "X looks P," for some property P, are far too liberal. True instances of those sentences can have nothing to do with vision. Whatever is at issue, it must be constrained to visual matters. Fortunately, Cohen makes the traditional appeal to distinctions in "looks" that have been employed by many in the philosophy of perception literature, including Roderick Chisholm, Frank Jackson, and Michael Martin (Chisholm 1957; Jackson 1977; Martin 2010). For example, throughout his book, Cohen repeatedly highlights that he means the "phenomenal reading of 'looks' locutions" (Cohen 2009: 161, 165, 170, 178).

However, whether there is such a division in "looks" is unclear. A few philosophers have argued that, if the division is one of ambiguity, then there is good reason to think that "looks" is not ambiguous, given that it fails standard tests for ambiguity. As Michael Thau, Alex Byrne and Wylie Breckenridge have argued, "looks" fails the identity test for ambiguity (Thau 2002: 230, Byrne 2016: 7, Breckenridge 2007: 40). Additionally, as Wylie Breckenridge extensively argues, "looks" fails a number of other standard tests for ambiguity (Breckenridge 2007: 37-43). This is strong prima facie evidence that looks is not ambiguous. However, this does not rule out other divisions in "looks" that might be proposed. I will not attempt to adjudicate this issue and will not take this approach. Instead, I will continue to employ the notions of the phenomenal character and the phenomenal properties of experience. This is in part because standard accounts of Representationalism are in terms of phenomenal characters or properties, not looks, and the views discussed here are versions of Representationalism.

So, we can return to Cohen's first premise: "There are multiple, psychologically distinguishable, perceptual effects… of a single color stimulus" (Cohen 2009: 24). This can be recast in phenomenal terms. If we fix on Cohen's Cup Case, we can distinguish the left side, in shadow, from the right side, out of shadow. Suppose we have an experience of each side of the cup. Then the experience of the left side and the experience of the right side have different color-ish phenomenal properties. So we have Premise1:

Premise 1: Between experiences of different regions, the experiences have different color-ish phenomenal properties.

Cohen's second premise endorses some version of Representationalism; however, he is not clear about what he takes Representationalism to amount to. However, he does state, in the context of considering what follows from a "variation in the way that the stimulus looks[49]," that "[o]n a more or less standard view of the visual system as visually representing the world, this entails that… there is a set of variant representations … of the stimulus" (Cohen 2009: 22). Cohen does not commit to this being what it is for experience to represent; he merely states that this is a more or less standard view. However, to have something to work with, I will assume that he at least endorses Weak Representationalism, framed as a thesis about phenomenal properties.

Premise 2: Necessarily, if experiences are phenomenally different, then they differ in representational content.

In this paper, I will assume that a phenomenal difference-relation is grounded in two different representational properties. Given Premises 1 and 2, the experiences in the Cup Case have a representational difference[50]:

Premise 3: The experiences differ in representational content.

Next, Cohen argues for Premise 4:

[49] Cohen claims to utilize a phenomenal use of "looks" throughout his book.

[50] It will also be assumed that the only relevant aspects of the representational content of experience are represented properties. The subject component, if there is such, and other components of content are ignored by Cohen.

Premise 4: Whatever differing properties are represented by the experiences, they are represented veridically.

To argue for Premise 4, Cohen claims that, "There is no independent and well-motivated reason for thinking that just one of the [representational] variants catalogued at [Premise 3] is veridical (at the expense of the others)" (Cohen 2009: 24). That is, seeing as the left side of the cup is represented as having one property and the right side another, there is insufficient reason for thinking only one represented property is represented veridically. Also, Cohen denies misrepresentation of both properties, arguing that positive reasons for it are under-motivated, and it should only be accepted as a last resort (Cohen 64-74). Thus Cohen concludes that the experiences both veridically represent[51]. We will return to this premise in Section 3.4.2.

After considering what two properties could be represented such that each is instantiated by the relevant regions of the cup, Cohen will conclude that the experience represents relativized color properties. The sides of the cup have the same surface spectral reflectances and the same categorical grounds for such dispositions[52]. Generally, it is hard to see how there could be two different phenomenally-subvenient represented properties of the cup which are intrinsic or non-relational and are both instantiated.

However, one might think that there is an alternative representational difference: a difference in the represented illumination. There is actually a difference in illumination, so an experience that represented this would be veridical. But Cohen does not take this route. However, it is unclear why, exactly.

Cohen clearly thinks that the representational difference is a difference in represented color. When he describes the instances of which his general argument is meant to cover-

[51] Michael Tye (2012) and Adam Pautz (2010) deny that the conclusion follows.
[52] I by-pass the possibility that the sides of the cup have metamers.

spectrum inversion cases, interspecies variation, intrapersonal variation due to varying viewing conditions, etc.- he often states things like "there is a variation in the way that the stimulus looks (*in respect of color*) to a single subject" (Cohen 2009: 21; emphasis added*)*. And he seamlessly transitions between there being a mere perceptual variation to there being a perceptual variation in color: "Clearly the regions of the coffee cup (and the table) that are in direct sunlight are perceptually distinguishable for the subject from the (qualitatively identical) contiguous regions of the coffee cup (and the table) that are in shadow, which is just to say that there is perceptual variation in respect of color for the qualitatively identical regions of the coffee cup" (Cohen 53). For Cohen, the phenomenal difference supervenes on a representational *color* difference, and the issues turn on whether colors are relativized properties or not. Thus, for Cohen, the representational difference isn't a difference in represented illumination. However, this begs the question why it is assumed that the representational difference is a matter of color. However, I will not press this issue.

If there are not intrinsic, non-relational properties differing across the cup, and the difference in how the cup is illuminated is not represented, then Cohen's opponents seem out of options. Thus, Cohen claims he can provide a solution and abductively concludes:

Premise 5: The experiences represent different relativized properties.

At this point in the argument, nothing favors one form of Relativism over another, so I will first describe the general Relativist response[53]. The essential Relativist approach can be found in its application to traditional spectrum inversion scenarios. In such a scenario, two subjects, A and B, are spectrally inverted with respect to each other. If both are looking at a

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[53] I follow Cohen in categorizing Relationism and Selectionism as types of Relativism. In the philosophy literature, the names for these positions are not used uniformly, however. For example Byrne and Hilbert (2017) call "relationism" what Cohen calls "relativism," and so, for them, Relationism isn't a form of Relativism. Since this paper does not address any of the, in Byrne and Hilbert's terminology, Relativist views, I follow Cohen.

lime, A has an experience with a green-ish phenomenal property that we would have looking at that lime, whereas B's experience has the red-ish phenomenal property we would have when we look at a ripe tomato. Thus, like our Varying Illumination case, there is a phenomenal difference between A and B's experiences. Again like our case, there is a premise that both experiences are veridical. Additionally, if Weak Representationalism is assumed, both experiences must veridically represent a different property of the lime. The relativist proposes that A and B's experiences represent relativized properties of the lime. If the relevant properties that the lime instantiates and that experience represents are, as Cohen claims, colors, then "there are no … colors *simpliciter,* but only colors for certain kinds of perceivers in certain circumstances" (Cohen 75). In the spectrum inversion scenarios, the properties are usually relativized to either individuals or perceiver-types. So, Cohen would say that A's experience represents the lime as green *for A (*or as green-for-A). And B's experience represents the lime as red *for B*. These are two properties that the lime can simultaneously have, securing veridicality for the experiences of A and B.

As Cohen thoroughly covers in *The Red and the Real,* there are numerous types of cases where there is a phenomenal difference within an experience, or between multiple experiences, where it's argued that the experience is, or the experiences are, veridical. Therefore, a difference in representational properties that are instantiated is required. These cases include spectrum inversion scenarios, interpersonal cases involving eyes with different retinal receptors, intrapersonal cases involving variation in viewing context, amongst others. Depending on which cases the Relativist strategy is applied to, the relativized property is relativized to many different parameters, including individual perceivers, perceiver-types, viewing conditions, adaptive states of a perceptual system, and more.

For the Varying Illumination cases, the only Relativism under consideration relativizes properties to viewing conditions, in particular illumination. All the cases involve a single perceiver, so relativizing to individual perceivers or perceiver-types would not advance the Relativist. Therefore, throughout the paper, I will only refer to properties relativized to illumination conditions. This allows that the properties represented in experience are relativized to the many different parameters described above, assuming that the motivating cases are persuasive, or that the only way in which represented properties are relativized is to illumination conditions. If the former is the case, then omission of parameters other than illumination conditions should be understood as an abbreviation.

Cohen's Relational Relativism construes the relativized properties that we, supposedly, represent as relational properties. So, where a bare Relativist might respond to cases of spectrum inversion without misrepresentation by saying that subject A represents the lime as being green for A, the Relational Relativist responds to the cases by saying that A represents the lime as having some property which is constituted by a relation to A. Why Cohen opts for Relationism over other forms of Relativism does not matter for the purposes of this paper. So his argument concludes:

Conclusion: The experiences represent different relational colors.

For Cohen, who identifies these relational properties "with a particular (non-teleological) functional role," he spells out the property of being green for A as "the property of having some or other structural configuration type that realizes the functional role of disposing its bearers to look [green] to [A]" (Cohen 179). Looking green to A is spelled out in terms of appropriately causing an experience of green (182). And the notion of an experience of green is meant "to pick out a type of mental state of subjects" (184). This type of mental state is a phenomenological type, given that Cohen "intend[s] a phenomenal reading of 'looks' locutions" (178). So when all spelled out, the relevant relational properties represented in experience are of the form: the property of having some or other structural configuration type that realizes the functional role of disposing its bearers to appropriately cause a certain phenomenal type of experience to subject S in conditions C.

To abbreviate this a bit, Cohen states that the relational property is the functional role of disposing its bearers to cause a certain phenomenal type of experience to subject S in conditions C. Given my concerns, I will drop the subject parameter. And I will specify phenomenal types with the –ish suffix. So, in the Cup Case, the Relational Relativist will say that the relevant differing representational properties are 1) the functional role of disposing its bearer to cause an experience with color-ish phenomenal property X under illumination with high intensity and 2) the functional role of disposing its bearer to cause an experience with color-ish phenomenal property Y under illumination with low intensity. The right side of the cup instantiates the first property, and the left side of the cup instantiates the second. Thus, the experiences are veridical.

Briefly, let's return to what seem to be Cohen's two distinct views about Varying Illumination Cases, the one presented in *Color Constancy as Counterfactual* and the other presented in *The Red and the Real*. In *The Red and the Real*, when he describes cases in which reflectance-identical surfaces are under variable illumination and so look different, he states that "the subject will normally judge…that these perceptually distinguishable regions are of the same color", that "she will ordinarily judge that the two adjacent regions have one color rather than two", and describes experimental color constancy data as "data about subject judgments in cases of color constancy" (Cohen 2009; 53, 53, 54). Unless the omission of describing color constancy cases in terms of sameness in looks or other clearly visual notions is unintentional, it seems that in his later view, Cohen thinks the only similarity in color constancy is at the level of judgment. This is unlike *Color Constancy as Counterfactual*, where Cohen's aim was to find a common *experiential* content between experiences of regions which look the same in color but are under different illumination. But in his later theory, he does not suggest any such common experiential content. Thus, it seems that Cohen's earlier view and later view are distinct. The earlier view secures veridicality in Varying Illumination Cases via the experience of color-alike surfaces representing the surfaces as sharing a common property. The latter view secures veridicality in Varying Illumination Cases via the experience of such surfaces representing the surfaces as having different relational properties.

This is Cohen's argument for Relational Relativism about the properties represented in his Cup Case, and Varying Illumination Cases, in general. Next we turn to Shoemaker's argument for a Selectionist version of Relativism.

3.3. Shoemaker's Argument for Selectionism

Shoemaker also appeals to a Varying Illumination case to argue for a form of Relativism about the properties represented in experience. His argument is similar to Cohen's in outline but differs in details. In what follows, I present Shoemaker's argument.

The first thing to understand about his argument is phenomenal character. We get to phenomenal characters through, what Shoemaker calls, phenomenal ways of appearing. Shoemaker focuses on a particular Varying Illumination Case, call it The Table Case. Shoemaker states, "If the surface of a table is partly in shadow, one may say that the way the shadowed part of it looks is different from the way the unshadowed part of it looks, without implying that the two parts look to have different colors" (Shoemaker 2006: 461). He continues, "where looking… different ways is not a matter of looking to have…different colors…let us speak of the ways as "phenomenal" ways things look. It is the phenomenal ways things look, and more generally phenomenal ways things appear that I shall be concerned with here, and usually I shall omit the qualifier 'phenomenal'" (Shoemaker 2006: 462). So, the phenomenal way the shadowed part of a surface looks is different from the phenomenal way the unshadowed part of a surface looks. There might be other ways things look, but not all of them are phenomenal ways of looking.

Connecting phenomenal ways of looking with the phenomenal character of experience, Shoemaker states, "phenomenal characters are associated with 'ways of appearing'" (Shoemaker 2003: 276) and "the [phenomenal] way a veridically perceived color looks, and so the phenomenal character of the experience of it, depends on lighting conditions and a variety of other conditions" (Shoemaker 2006: 473). Though the connection between phenomenal ways and phenomenal characters is not clearly stated, it's plausible that phenomenal ways compose the total phenomenal character of experience. As Shoemaker uses "phenomenal character" in the customary way, the phenomenal character of an experience is complex. Two experiences may differ in their phenomenal character and at the same time be similar in their phenomenal character. A plausible way to accommodate this is to say that there are phenomenal properties and the total phenomenal properties of an experience make up the experience's phenomenal character. Thus, if two experiences differ in their phenomenal character, there is some phenomenal property one has which the other does not. And if they are similar in their phenomenal character, they share a phenomenal property. Since Shoemaker endorses a Ways=Properties Principle (Shoemaker 2006: 464), it's plausible that phenomenal ways of appearing are phenomenal properties of experience.

Are phenomenal ways the only components of phenomenal characters, or are there aspects of phenomenal characters which are not phenomenal ways? It seems that Shoemaker thinks that phenomenal ways exhaust phenomenal character. For, according to Shoemaker, there are non-phenomenal ways things look. He does not deny that things look red, green, etc. However, according to Shoemaker, looking red, for example, is not a phenomenal way of looking[54]. And he states, "our introspective access is not in the first instance to colors [things look to have] but is rather to the nameless properties [i.e. phenomenal ways things look to be] correlated in our experience with those colors" (Shoemaker 2006: 464)[55]. And, discussing the relationship between phenomenal characters and representational content, he states that "it is to this [phenomenal characters] that we have introspective access" (Shoemaker 2006: 465). So it looks as if other ways of looking, besides phenomenal ways, are excluded from the phenomenal character of experience.

With the notions of phenomenal character and phenomenal properties in hand, we can return to Shoemaker's description of The Table Case: "If the surface of a table is partly in shadow, one may say that the way the shadowed part of it looks is different from the way the unshadowed part of it looks, without implying that the two parts look to have different colors" (Shoemaker 2006: 461). Thus, the experiences of the differently illuminated region of the table differ in phenomenal properties[56]:

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[54] For Shoemaker, there are phenomenal ways objects look, and there are phenomenal ways colors look. An object may look some way, phenomenally. And an object may look some way, color-wise. But it not the case that the phenomenal way an object looks is colored.

[55] Shoemaker endorses, what he calls, the "Ways=Properties Principle" (Shoemaker 2006: 464). This principle states that "ways things look are properties they look to have" (Shoemaker 462). Since colors are ways things look, they are properties things look to have. But phenomenal ways are also properties things look to have, but these are "properties other than colors- and properties for which we have no names" (Shoemaker 462). Some including Levinson (1978), and Johnston (M.S.), have disagreed with this Ways=Properties Principle.

[56] I will assume that Shoemaker is concerned with a color-ish phenomenal difference, opposed to some other, say space-ish , phenomenal difference.

Premise 1: Between experiences of different regions, the experiences have different color-ish phenomenal properties.

As a representationalist, Shoemaker claims that "the phenomenal character of perceptual experience consists in its representational content" (Shoemaker 2006: 464). Let's call such a Representationalism Consisting Representationalism. From his discussions, it's clear that Shoemaker thinks Consisting Representationalism entails a 2-way supervenience between phenomenal properties and representational properties. For example, in considering the consequences of the content of experience being Fregean and involving modes of presentation versus being Millian and only involving properties, and assuming phenomenal ways of appearing are phenomenal properties, Shoemaker writes, "Sameness or difference of ways of appearing would amount to sameness or difference of modes of presentation, not sameness or difference of properties represented" (Shoemaker 466). Thus we have Premise 2:

Premise 2: The phenomenal character of perceptual experience consists in its representational content.

It follows that:

Premise 3: The experiences have a representational difference.

However, unlike Cohen, Shoemaker claims the representational difference is not a color difference. But Shoemaker claims that Varying Illumination cases in general, and The Table Case in a particular, do not involve illusions when he writes, "where the ways things of a certain color look are different in different circumstances…it may in some cases be right to say that in some of the circumstances an object looks to have a color it doesn't have; and this would allow the way it looks to be a color it is represented (correctly or incorrectly) as having. But this will not normally be true in the case of shadowed and unshadowed objects" (Shoemaker 2006: 462). So we have Premise 4:

Premise 4: Whatever differing properties are represented by the experiences, they are represented veridically.

So we need the phenomenal difference to consist in differing represented properties which are instantiated in the scene. Claiming the phenomenal character of experience does not consist in the representation of colors, Shoemaker thinks that the properties he will propose are the most plausible. Like Cohen, Shoemaker does not allow for the representational difference to be a difference in represented illumination, though he does not state why. He recognizes that "it is differences in illumination that account for the difference in the ways things of the same color look" (Shoemaker 2006: 462). But he presumably does not understand this "accounting" as a metaphysical relation like consisting, such that the difference in the ways the table looks consists in the difference in represented illumination. Otherwise, his theory would be finished in the first few paragraphs, without appeal to Selectionism. Instead the accounting is probably understood as causal. And Shoemaker discusses similar cases in which, "one [surface] looks to be in shadow and the other doesn't" (Shoemaker 2006: 462). But in the context its clear Shoemaker does not understand this way of looking as a phenomenal way of looking, because he contrasts it with "the 'phenomenal' ways the two surfaces look" (Shoemaker 462). Thus, a surface can look to be in shadow in a non-phenomenal way akin to the way a surface can look red. It is only the phenomenal ways of looking that relate to phenomenal character. So he does not accept the representation of illumination as what the relevant phenomenal character consists in. Again, like with Cohen, I will not press this issue about illumination representation.

Thus, without finding an alternative, Shoemaker concludes that:

Premise 5: The experiences represent different relativized properties.

To satisfy Premise 5, Shoemaker, who was once a Relationist (Shoemaker 1994), turns to the present Selectionism in Shoemaker 2003, 2006, thus concluding:

Conclusion: The experiences represent different Qualitative Characters.

According to (Shoemakerian) Selectionism, a single color has multiple qualitative characters. Qualitative characters are relativized properties. So for Varying Illumination cases, the Selectionist multiplies properties of the external world so that there can be veridical representation. For the example of The Table Case, the experience of the region of the table partly in shadow has one phenomenal property, X, while the experience of the unshadowed region of the table has another phenomenal property, Y. Each part of the table has one color. However, each token color instantiates at least two qualitative characters, call them A and B. One's experiences involving the phenomenal properties X and Y represent the color of the shadowed part of the table as having A and represent that same color, though of the unshadowed part of the table, as having B. Since the color of the table has A, B, and many more qualitative characters, one's experience is veridical. This is a form of relativism because the visual system "selects" which properties it represents relative to the viewing conditions. For the shadowed part of the table, it selects A to be represented because of the lighting conditions there. For the unshadowed part of the table, it selects B because of the lighting conditions there. There are important questions about what this selection amounts to, but for the purposes of this paper the details of selection can be left unspecified.

In conclusion, Shoemaker and Cohen argue similarly for the representation of relativized properties in Varying Illumination Cases. In the next section, I challenge their arguments, both in the particular case of Type-2 Color Constancy and more generally.

3.4. Against Relativism in Varying Illumination Cases

3.4.1. Color Constancy and Varying Illumination Cases

To argue for their forms of relativism, Cohen and Shoemaker each discuss, at most, a few instances of Varying Illumination cases. However, they clearly think that the illumination-relativized properties they propose figure in experiences which are involved in far more Varying Illumination cases than The Table Case or Cohen's Cup Case. Therefore, there's the question of to what extent experiences in Varying Illumination cases involve illumination-relativized properties. In this section, first I will argue that, if the claims in Chapter 1 and 2 are correct, then Type-2 Color Constancy cases are Varying Illumination cases for which Cohen and Shoemaker's arguments do not support the representation of illumination-relativized properties. Then I will argue that Cohen and Shoemaker's arguments generally fail to support the idea that there are Varying Illumination Cases which involve the representation of illumination-relativized properties.

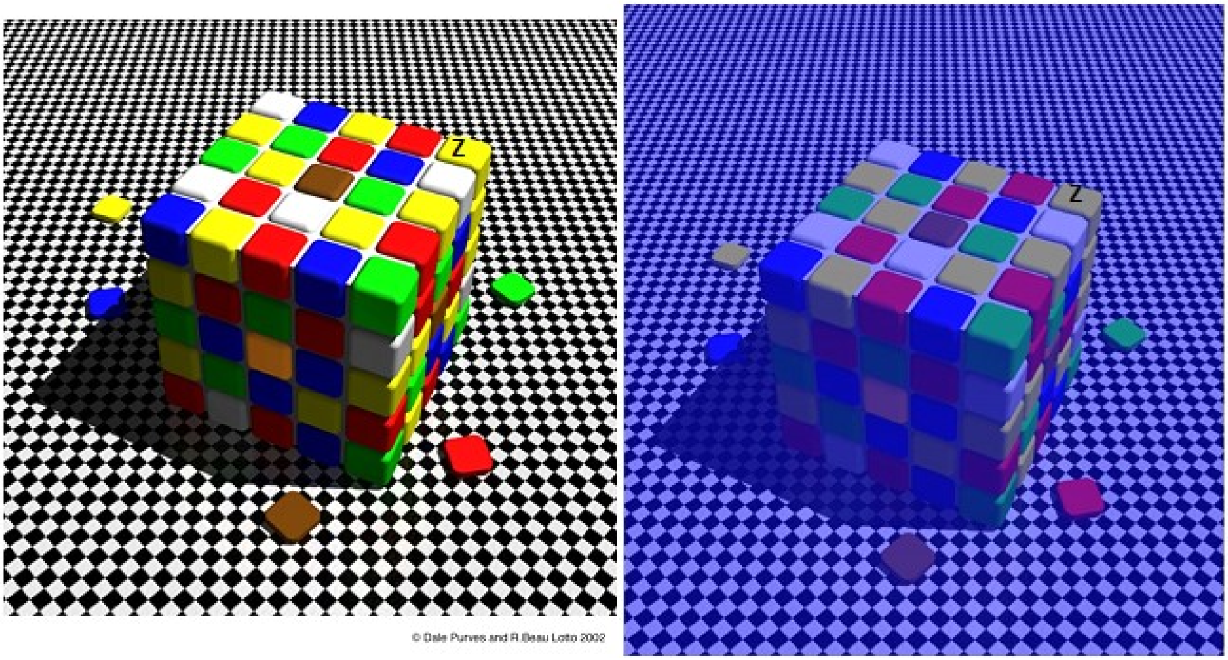
First, let's highlight the commonalities in their arguments. Both Cohen and Shoemaker begin with a P1: Phenomenal-Difference Premise. Then each's version of Representationalism entails P2: Weak Representationalism Premise. In Shoemaker's case this is entailed by his claim that the phenomenal character of experience consists in its representational content. P1:Phenomenal-Difference Premise and P2: Weak Representationalism Premise entail that the relevant experience represents different properties of the relevant surfaces- P3: Representational Difference. Next there is P4: No Illusion Premise, which claims that it is not the case that only one or neither of the represented properties are instantiated. These four premises are the most relevant for what is to come. But from there they argue that there are not differing, non-illumination-relativized representational properties which are instantiated by the relevant surfaces. Thus, Cohen and Shoemaker conclude that the experience involved in the Varying Illumination cases represent illumination-relativized properties. How Cohen argues for the representation of relational colors and how Shoemaker argues for Selectionism about Qualitative Characters is not relevant for present purposes.

In light of Chapters 1 and 2, we can consider whether all Varying Illumination cases-cases in which an object is, or various objects are, differently illuminated either at a time or over a period of time, and the experience of the object(s) is, presumably, not overwhelmingly illusory-involve experiences representing illumination-relativized properties. I will argue that many do not.

First, there are Varying Illumination cases that exhibit imperfect Type-2 Color Constancy. The Rubik's Cube Case introduced in Chapter 2 is an example. As discussed in Chapter 2, the experiences one has of Figure 3.2 are phenomenologically similar to the experiences one would have if one were looking at the real-world Rubik's cubes that the figures are of. Since what is at issue is experiences of the scenes under differing viewing conditions, and any associated Type-2 Color Constancy, the experience you are actually having will be used as a proxy for the experience you would have if you were seeing the Rubik's cubes. Therefore, I will refer to the actual phenomenology of your experience, but instead of referring to the actual object seen, a picture, I will refer to the picture's real-world counterpart. So I will refer to the parts of the pictured Rubik's cube and features of the pictured illumination instead of features of your actual environment like the picture, paper, and whatever lighting conditions you are in.

Figure 3.2: Lotto and Purves's Rubik's Cubes

A **B**



From Lotto and Purves 2002[57]

Rubik's cube A is under a light that is similar to normal daylight, radiating roughly equal energy at each wavelength in the visible spectrum, and Rubik's cube B is under a light that radiates more energy at the shorter wavelengths in the visible spectrum- call it "blue" light. Thus, there is a difference in illumination as is necessary for Varying Illumination cases. Now, consider one's experience of Segment Z of Rubik's cube A. It has a yellow-ish phenomenal property. Consider one's experience of Segment Z of Rubik's cube B. It also has a phenomenal property that is some shade of yellow-ish, though not the exact shade that is had by the experience of the counterpart segment in Rubik's cube A. Thus there is a phenomenal difference between the experiences of the segments. In fact, all experiences of pairs of counterpart

[57] Reprinted from Lotto, Beau R & Purves, Dale (2002). The empirical basis of color perception. *Consciousness and Cognition*, *11*(4), 609-629. with permission from Elsevier.

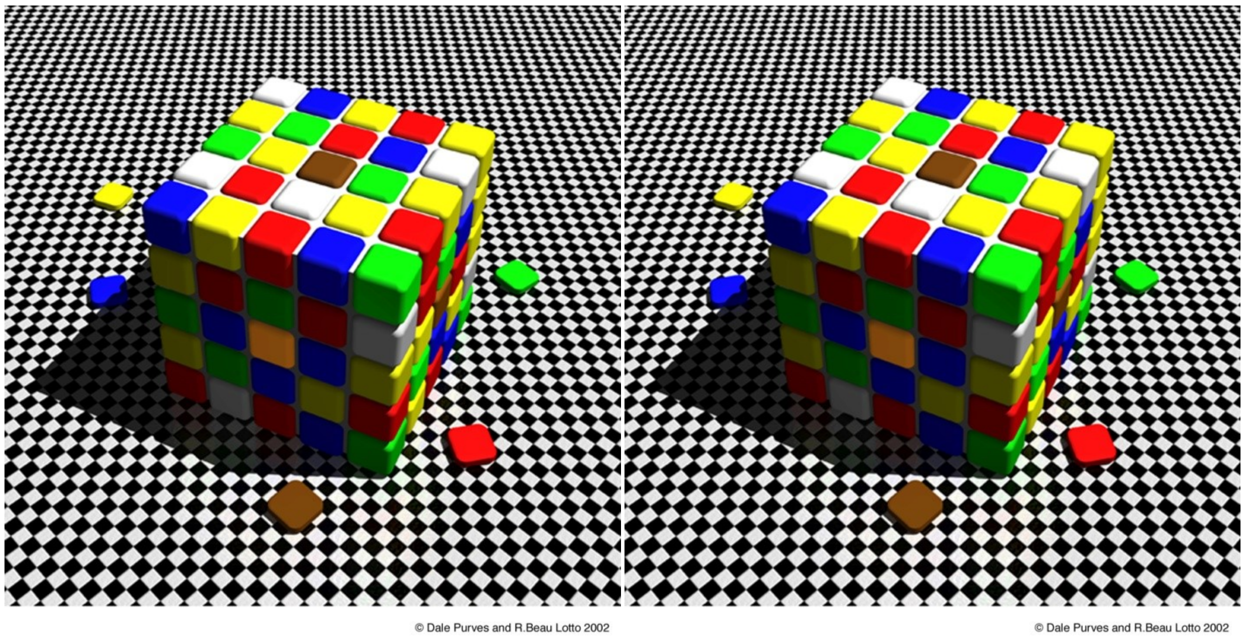
segments of Rubik's cubes A and B are phenomenally different. However, I will just focus on the two Segment Z's.

This is a Varying Illumination Case, but does the Relativist's argument apply? P1: Phenomenal-Difference Premise is satisfied. P2: Weak Representationalism Premise holds generally for experiences; so P3: Representational Difference is entailed. But what about P4: No Illusion Premise? It is at P4 that the Relativist's argument fails, and this partly turns on a re-evaluation of P1. Segment Z of Cube A and Segment Z of Cube B satisfy Cohen's original statement of P1: "There are multiple, psychologically distinguishable, perceptual effects… of a single [type of] color stimulus" (Cohen 2009:24). The Segments also satisfy Shoemaker's original statement of P1, where there is a difference in the phenomenal ways the segments look. For reasons given in Sections 3.2 and 3.3, both of these initial claims should be cast as claiming a phenomenal difference between experiences of the counterpart Z Segments.

However, as P1 is stated by Cohen and Shoemaker, it leaves open the extent of the difference and the extent of any relevant similarity. However, the extent of relevant similiarities and differences is important. First, consider if there were no color-ish phenomenal difference and a complete color-ish phenomenal sameness, for example if the comparison were between the Segment Z's of the Rubik's Cubes A and B in Figure 3.3.

Figure 3.3: Identical Rubik's Cube scenes

A **B**



From Lotto and Purves 2002[58]

In this variant of the Rubik's Cube Case, there is no phenomenal difference between experiences of the Segments. This should be a case in which we represent the colors of the Segments as the same and, since the Segments are the same in color, the relevant aspects of our experiences of them are perfectly veridical. And in such a case, there is no motivation, along the Relativist arguments discussed here, for invoking relativized properties in order to secure the veridicality of the experiences[59]. Whatever precisely is represented in such a case, there is no reason to think it is not the sort of property that the opponent of the Relativist might appeal to, like intrinsic surface properties.

Though I think it is extremely hard to deny that the experiences of the Segment Z's depicted in Figure 3.3 represent them as the same color and share a yellow-ish phenomenal

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[58] Reprinted from Lotto, Beau R & Purves, Dale (2002). The empirical basis of color perception. *Consciousness and Cognition*, *11*(4), 609-629. with permission from Elsevier.

[59] If the properties represented are relativized, they will be relativized for reasons unrelated to the Relativist's argument in Varying Illumination cases. So, the represented properties might still be relativized to, for example, perceiver-types, but this will be because of , for example, reasons related to spectrum inversion cases.

property, the Weak Representationalism of Cohen does not guarantee this, but it also does not rule this out. However, Shoemaker commits himself to phenomenal sameness entailing representational sameness. Generally, Relativist should not want to deny that, given this phenomenal sameness between experiences for a single viewer, at a single time, in the actual world, the experiences represent the same property of the Segments.

So now reconsider seeing Cubes A and B as depicted in Figure 3.2. There is a phenomenal difference between the experiences of Segment Z of Cube A and Segment Z of Cube B. However, there is considerable phenomenal similarity between the experiences of the Segments. The most plausible thing to say is that the Segments are represented as being somewhat similar (and so somewhat different), whereas in the case depicted by Figure 3.3 the Segments are represented as being the same. Since in the latter case, the experiences are perfectly veridical, in the former case, the most plausible thing to say is that the experiences are only imperfectly veridical. And, like with the case in Figure 3.3, the imperfect veridicality of the experiences is not in virtue of the representation of any illumination-relativized properties.

So while there is a phenomenal difference, satisfying Cohen and Shoemaker's first premise, the extent of the difference/similarity plays a crucial role. If the case depicted by Figure 3.3 is perfectly veridical, partly because of the phenomenal sameness exhibited by the experiences involved, then the Rubik's Cube Case is imperfectly veridical (and so partly illusory) because of the phenomenal similarity exhibited by the experiences involved. As a result, P4: No Illusion Premise is false of the Rubik's Cube Case and cases of imperfect Type-2 Color Constancy, generally.

Cohen and Shoemaker might object that, even in cases of Type-2 Color Constancy, which involve a color-ish phenomenal similarity, not an exact color-ish phenomenal sameness, and so involve some degree of color-ish phenomenal difference, the experiences are still without illusion. And to recover full veridicality, the representation of illumination-relativized properties is required. However, at this point we should consider why they claim, in the Varying Illumination cases they present, that the experiences are without illusion.

First let's consider Shoemaker. In discussing The Table Case, Shoemaker writes that "where the ways things of a certain color look are different in different circumstances…it may in some cases be right to say that in some of the circumstances an object looks to have a color it doesn't have; and this would allow the way it looks to be a color it is represented (correctly or incorrectly) as having. But this will not normally be true in the case of shadowed and unshadowed objects" (Shoemaker 2006: 462). Since Varying Illumination Cases not only involve variation in illumination intensity, but also involve variation in the chromaticity of the illumination, Shoemaker's veridicality claim should be extended to objects in variable illumination, generally. Shoemaker, however, does not provide further reasons for his veridicality claim. Maybe it is based in intuition. However, we have stronger, empirical reasons to think that color constancy cases like the Rubik's Cube Case do not involve perfect veridicality, but instead only imperfect veridicality.

As discussed in Chapter 1, there is an extensive area of vision science concerned with color constancy. It recognizes that without certain processing by our visual systems, our experiences would be much more illusory than they actually are. The Rubik's Cube Case exemplifies this. Recall from Chapter 2, Section 2.1 that without a color constancy mechanism, the experience of Segment Z of Cube B would have a gray-ish phenomenal property. An ordinarily-sighted person can have this gray-ish experience if she were to screen-off the surrounding segments with a monochrome obstruction. At this point, our constancy mechanism fails and we cease to exhibit the relevant color constancy. As discussed in Chapter 2, Section 2.2, this experience can be recreated if one views a figure with patch Z surrounded by a white region.

It fits in the empirical framework on Type-2 Color Constancy that the experiences of the Segments Z in the Rubik's Cube Case are partially veridical because of the phenomenal difference and similarity had by the experiences. The experiences being entirely without illusion does not. This provides stronger reasons for thinking that our experience of Cube B in the Rubik's Cube Case is imperfectly veridical than either intuition or some unspecified reason provides for thinking that the case if fully veridical.

Cohen, on the other hand, provides a reason for P4 which does not turn on intuition. In applying the Relativist's argument to Varying Illumination cases, Cohen discusses them in the larger context of cases of "intrapersonal perceptual variation," which include situations where one has "put on or removed tinted sunglasses, adjusted the lighting in a room, or been surprised by changes in the appearance of garments once removed from the flattering viewing conditions of the store" (Cohen 2009: 33). So suppose we take one such case, say a certain garment, and consider two experiences of two parts of the garment which differ phenomenally. Suppose the phenomenal properties of each experience are different because of the different viewing conditions each part is under. Given Weak Representationalism, the experiences of the relevant parts of the garment differ in the color properties they represent. After considering a potential privileged viewing condition which might support only one of the represented colors being represented veridically, Cohen proposes problems for such an approach.

He considers the viewing conditions that are specified in scientific and industrial contexts for viewing Munsell color chip samples as the privileged viewing conditions. The specifications state that “the samples should be placed against a dark achromatic background and ‘colors should be arranged under North Daylight or scientific daylight having a color temperature of from 6500 degrees to 7500 degrees Kelvin. Colors should be illuminated at 90 degrees and viewed at 45 degrees, or the exact opposite of these conditions’” (Hardin 1988, 68). If these are the right privileged viewing conditions, then when there are cases of surfaces under varying viewing conditions, and the experiences of the surfaces differ phenomenally, the surfaces in the above conditions will be represented veridically.

Cohen argues that surfaces under such viewing conditions still might not be veridically perceived. He claims the specifications leave out other aspects of the viewing conditions that surfaces might be in and which can cause phenomenally different experiences of those surfaces. Additionally, the specifications only concern surfaces, neglecting other colored entities. So there will be intrapersonal perceptual variation in which the above specification provides no guidance as to which experience is veridical.

What we should note about the cases of intrapersonal perceptual variation Cohen is referring to, and the proposed specification of viewing conditions, is their complexity. The specification specifies a number of different aspects of the viewing conditions: the surround of the target surface, the color temperature and chromaticity of the light source, and the angle at which the light hits the surface. And Cohen presses that any successful specification of viewing conditions for veridical perception should also include “the state of adaptation of the subject, other objects perceived by the observer prior to or after observation of the stimulus, … the relative proportions of the visual field occupied by the stimulus…[and] perceptual grouping [factors]” (Cohen 2009: 34). All these factors, supposedly, can lead to variation in experiences where the question of privileged veridicality arises.

In most experiences, there probably are variations in all these factors and more. And, subsequently, in most experiences, there probably are all sorts of phenomenal variations that are caused by such factors. Most experiences are very complex, and are not just a part of a single Varying Illumination case. But we should not try to deal with all these phenomenal differences caused by all these varying viewing conditions at once. Unless there is reason to think they are inextricably linked, we should proceed in a piecemeal fashion. Thus, at the moment, I investigate a case where two objects are as alike as possible except for the chromaticity of their illumination. And then the phenomenal difference that results is considered. Cases of phenomenal differences caused by intervening lenses, contrast effects, etc. should, if possible, be treated separately. Thus, we should not start by asking whether multi-faceted veridically-privileged viewing conditions can be specified from the most complex experiences. We should start simpler.

So, we return to the Rubik's Cube Case and consider one phenomenal difference because of one variation in the viewing conditions. In the Rubik's Cube Case, and Type-2 Color Constancy cases generally, there is good reason to think one representation is fully veridical over the others. Suppose in addition to Cube B which is under "blue" light, there are other Cubes, C, D, and E which are each under a different light. So, we have experiences of Z Segments of Cubes A, B, C, D, and E. According to Cohen, there is no non-stipulative reason for thinking that only one of the experiences represents fully veridically. And concluding they all misrepresent fully should be avoided if at all possible. But a well-motivated reason can be given for thinking that only one of the experiences represents fully veridically. The first thing to note is that every illumination differs to some extent from every other illumination. The exact specification of this, in terms of spectral power distributions, is not necessary for present purposes. But the lightings of Cubes B, C, D, and E all differ from the lighting of Cube A. And the lightings of Cubes A, B, C, D, all differ from the lighting of Cube E, etc. There is nothing special about the differences between the illuminations. Next, consider Figure 3.4.

Figure 3.4: Rubik's Cube Variations

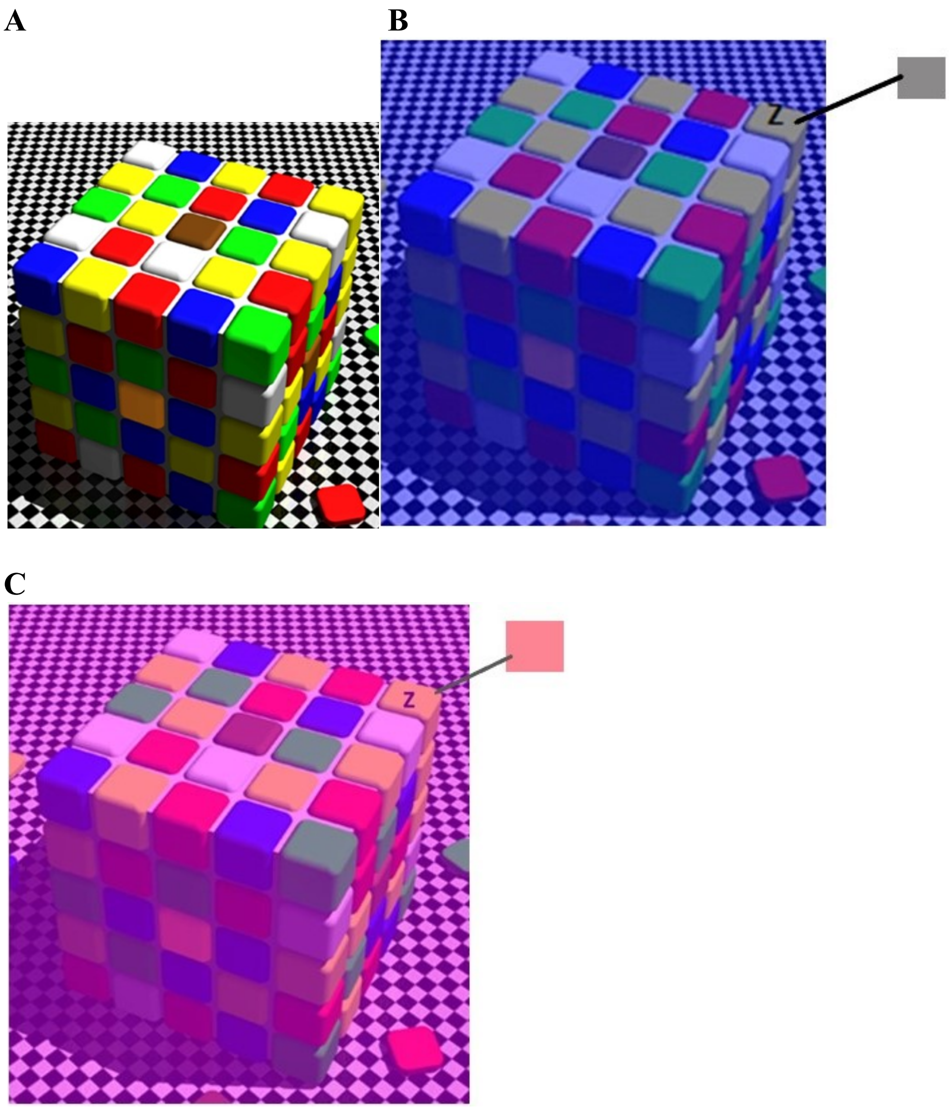
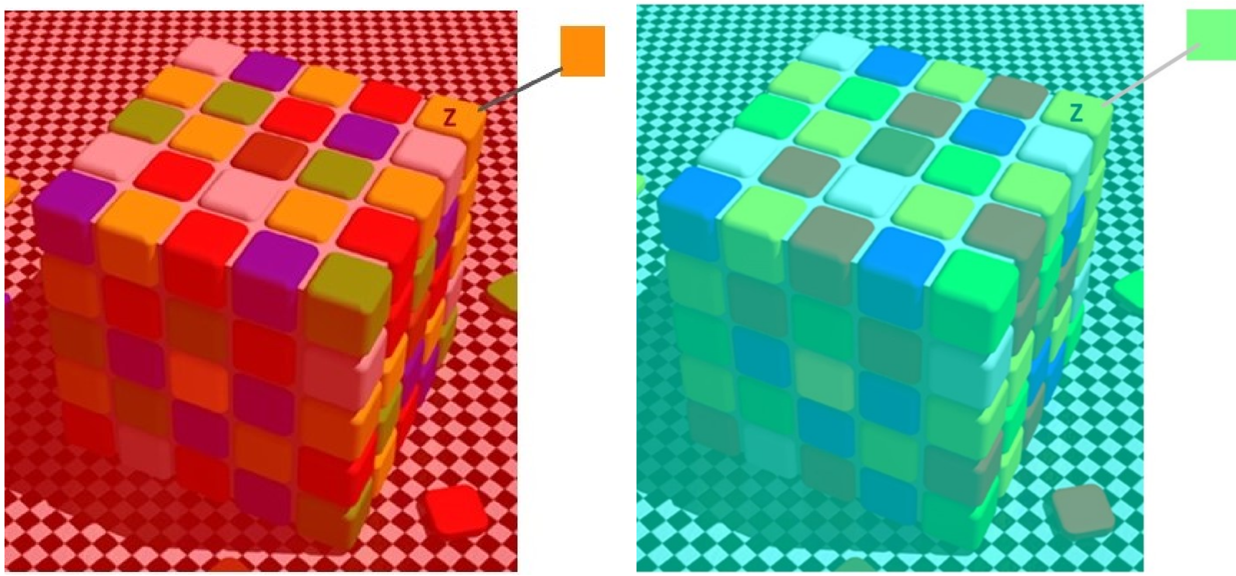


Figure 3.4, cont.: Rubik's Cube Variations

D **E**



Modified from Lotto and Purves 2002[60]

The experiences of each Z Segment of Cubes B, C, D, and E involves Type-2 Color Constancy. The yellow-ish phenomenal property of each experience of each Segment Z is similar to the phenomenal property of the experience of Segment Z of Cube A to a certain extent. The extent of this phenomenal similarity is greater than the extent of the similarity in the returns (and illuminances). This can be verified by consideration of the region to the right of each cube-depiction. The color-ish phenomenal property of one's experience of each of those regions is the phenomenal property of the experiences one would have of each Z Segment of Cubes B, C, D, and E, if one lacked a Type-2 Color Constancy mechanism. For each adjacent region, the extent of the color-ish phenomenal difference between one's experience of that region and Segment Z of Cube A matches the extent of the return (and illuminance) difference between that region's associated Z Segment and Segment Z of Cube A. For example, consider the adjacent region in

[60] Modified from Lotto, Beau R & Purves, Dale (2002). The empirical basis of color perception. *Consciousness and Cognition*, *11*(4), 609-629. with permission from Elsevier.

Figure 3.4C. The phenomenal difference between the experience of it and the experience of Segment Z of Cube A matches the return difference between Segment Z of Cube C and Segment Z of Cube A. In contrast, for each pair composed of a Z Segment and Segment Z of Cube A, the phenomenal similarity between the experiences of the pair is closer than the similarity between the illuminances of the pair. This shows that the phenomenal properties of the experiences of the Z Segments of B, C, D, and E "converge" on the yellow-ish phenomenal property of the Z Segment of Cube A. Instead of the phenomenal properties of the experience of the Z Segments being as they are in the experiences of adjacent regions (which provide what the constancy-free experiences would be like), the phenomenal properties are more yellow-ish.

This converging on yellow-ish contrasts with the relationship between the illumination differences that obtain between pairs of cubes. Consider the following pairs of illumination differences: the difference between Cubes A and B, the difference between Cubes A and C, the difference between Cubes A and D, the difference between Cubes A and E. Those differences are no more *unique* than these differences: the difference between Cubes B and A, the difference between Cubes B and C, the difference between Cubes B and D, the difference between Cubes B and E. The same applies for other pairs of illumination differences following this pattern. However, there is a unique relationship between pairs of differences between the color-ish phenomenal properties of the experiences of the Z Segments.

And this is what one should expect from the mechanism of Type-2 Color Constancy. Roughly, the purpose of color constancy is to resist the effect that confounding factors like illumination can have on the representation of surface color, given the inverse projection problem. The above variant of the Rubik's Cube Case is best explained by a constancy mechanism working to reduce the degree to which illumination chromaticities that deviate from the illumination chromaticity of Cube A cause the representation of the Z Segments to deviate from the pure yellow of the Z of Cube A . This is a well-motivated, non-stipulative reason for concluding that the color representation of Segment Z of Cube A is fully veridical, opposed to the color representation of the other Z Segments. The color representations of the others are not entirely veridical, but still somewhat, at least compared to experiences lacking Type-2 Color Constancy.

So not all Varying Illumination Cases satisfy the Relativist's argument, and so there is not sufficient reason to think that the experiences in those cases involve illumination-relativized properties. Some Varying Illumination Cases involve Type-2 Color Constancy which undercuts the need for illumination-relativized properties in such cases. We can also ask whether cases of Type-1 Color Constancy undercut the need for illumination-relativized properties. Until more is understood about Type-1 Color Constancy, it is hard to say. Recall that, in Type-1 Color Constancy, reflectance-identical surfaces are under different illumination. The experiences of the two surfaces differ phenomenally. The extent of this phenomenal difference is to the same extent as the extent of the difference between the returns reflected from the surfaces. The returns differ to the extent that they do because of the extent of the difference in the illumination of the surfaces. The claim is that the surfaces, despite having phenomenally different experiences, look the same in color. However, as was discussed in Chapter 1, it is unclear what this sameness in looks amounts to. For example, are the relevant experiences phenomenally the same? Most relevantly for present purposes, it is unclear whether this sameness is associated with a representational sameness, whether this sameness is a phenomenal sameness or something else[61]. So it is unclear whether the Relativist's argument applies.

[61] If there is a sameness in looks but no phenomenal sameness, and there is a representational sameness, then there would need to be a significant modification in standard forms of Representationalism.

As noted earlier, in *The Red and the Real* Cohen discusses color constancy. In discussing Paper Matches and Hue-Saturation Matches, he cites Arend and Reeves (1986) and Arend et al. (1991), the experiments discussed in Chapters 1 and 2. Additionally he cites Troost and deWeert (1991), Cornelissen and Brenner (1995) and Bauml (1999). Some of these latter experiments reproduced Arend and Reeves original results and also added variations to the original experiments. However, Cohen seems to think that the color constancy of these experiments (Type-1, as I call it) only involves *judgments* that reflectance-identical surfaces under varying illumination are the same in color; he only claims that subjects have "the judgment that there is one color rather than two in cases of simultaneous and successive color constancy" (Cohen 2009: 54). He does not claim that the surfaces look the same in color, that there is perceptual sameness, or that there is a common experiential content represented of the surfaces. Thus, his view of color constancy seems to be a construal of Type-1 Color Constancy in which there is only a judgment that there is a sameness in color. So if Type-1 Color Constancy is as Cohen describes in his later view and it is a category of Varying Illumination cases, then it does not avoid the Relativist's argument for the reasons Type-2 Color Constancy does.

In summary, cases of Type-2 Color Constancy are instances of Varying Illumination Cases for which the Relativist argument does not apply. Thus, there is insufficient reason for thinking the experiences involved represent illumination-relativized properties. Type-1 Color Constancy might satisfy the Relativist's argument, though. Next, I will argue that, in general, there are insufficient reasons for thinking the Relativist argument applies to cases in which reflectance-identical surfaces are under varying illumination.

3.4.2. Against the Relativist's Argument in Varying Illumination Cases

If the preceding is correct, not all Varying Illumination Cases satisfy the Relativist's argument. However, for Varying Illumination Cases which are not of Type-2 Color Constancy, the Relativist's argument might apply. This class might include Cohen's later apparent view of color constancy. In general, we can ask whether there are any Varying Illumination cases which satisfy the Relativist's argument and which therefore involve experiences that represent illumination-relativized properties.

If the Relativist's argument applies to a case, a more specified P1: Phenomenal Difference Premise would be required. In such a case the color-ish phenomenal difference between experiences of the relevant surfaces would need to be to at least the same extent as the illuminance difference between the surfaces. This is unlike cases of Type-2 Color Constancy, where the extent of the color-ish phenomenal difference between experiences of surfaces is less than the extent of the illuminance difference between the surfaces. As we saw in an attempt to apply the Relativist's argument to cases of Type-2 Color Constancy, there is no need for represented illumination-relativized properties to secure imperfect veridicality.

As the argument would continue, given P2: Weak Representationalism, a more specified P3: Representational Difference follows, where the extent of the representational difference is the same as that of the phenomenal difference. The issue, then, turns on P4: No Illusion Premise. Why think that in such a case, the experiences are without illusion? Again, we will consider Shoemaker and Cohen separately. However, the general challenge to P4 in such a case is that there are illusions which are similar to the sorts of cases they claim are not illusory. There are visual illusions, and there are visual illusions caused by the lighting conditions of some scenes. It should be a considerable mark against any view that entails otherwise. And many color illusions caused by illumination result from a failure in color constancy. To review, in such illusions reflectance-identical surface are under differing illumination. The returns reflected from the surfaces differ to the same extent that the illumination differs, as a result of the physics of light. The constancy-free visual system produces experiences based solely off of the returns, so the system produces experiences that differ in color-ish phenomenal properties. And this difference is to the same extent as the difference in the returns and thus is to the same extent as the difference in the illumination. So, in terms of phenomenology, the return difference, and the illumination difference, these color illusions are the same as the experiences that Shoemaker and Cohen argue are veridical. Why would Shoemaker and Cohen's experiences be veridical?

Shoemaker's reasons for P4 are not clear. If the reason is intuition, it is not very strong in the face of the empirical matters. However, maybe Shoemaker's reason for P4 is not based in intuition. In discussing The Table Case, Shoemaker writes that "where the ways things of a certain color look are different in different circumstances…it may in some cases be right to say that in some of the circumstances an object looks to have a color it doesn't have; and this would allow the way it looks to be a color it is represented (correctly or incorrectly) as having. But this will not normally be true in the case of shadowed and unshadowed objects" (Shoemaker 2006: 462). Maybe Shoemaker thinks that if such an ordinary, arbitrarily-chosen case like the Table Case involved an illusion, then situations where objects are under varying illumination would be illusory, generally.   But surely objects under varying illumination are not normally represented as having colors they do not have. So an arbitrary case like the Table Case is veridical.

However, again making an empirical appeal, once imperfect Type-2 Color Constancy is recognized, widespread color illusion because of variation in illumination is avoided. In Shoemaker's Table Case, we do not know enough about it to determine whether the color-ish phenomenal difference between experiences of the relevant surfaces is to at least the same extent as the illuminance difference between the surfaces. This might not be its character, and instead the relationship between the phenomenal difference and the illumination difference might be that of imperfect Type-2 Color Constancy. But if it is not a case of Type-2 Color Constancy, its veridicality can be denied without there being widespread illusion: there are plenty of cases of Type-2 Color Constancy, if not other forms of color constancy[62].

On the other hand, Cohen also faces the challenge of explaining why some cases of an object being under varying illumination, where the experiences differ in phenomenal properties to an extent that is at least the same as the extent of the difference in the illumination, are illusory while some cases are not. The reason, again, turns on Cohen's acceptance of P4. So we turn to Cohen's no-privileged-variant argument for P4: given the different properties represented of the differently illuminated surfaces, there is no non-stipulative reason why one illumination-condition and one property representation is veridical. And, as the argument continues, since misrepresentation of all the properties should be avoided if at all possible, we should conclude that none of the representations are illusory. However, there is a well-motivated, non-stipulative reason for thinking that only one of the representations is veridical. We can turn to a case of illusion, since surely there are some, to see why.

I will start with a stick-in-water illusion. If there is resistance to this case, another illusion will do, for the points I will make are quite general. From most viewing angles, a stick partly in and partly out of water is represented as bent. See Figures 3.5A and B. This is because as the light reflects off of the stick, travels through the water and crosses the water-air interface, it bends as a result of the different refractive indexes of the air and the water. Differences in the direction light travels before reaching the eye pose an inverse projection problem, one which our visual system has not evolved a constancy mechanism to accommodate, though maybe some

[62] Future work argues for forms of color constancy besides Type-1 and Type-2.

creatures' systems have[63]. Therefore, for humans, as the relative position between us and the stick changes, the representation of the stick's shape illusorily changes. However, compare Figure 3.5C and Figure 3.6. Figure 3.6, a picture of a stick out of water, provides the experience one would have if one were viewing the stick out of water. If one were viewing the actual stick, of the various properties experience represents of the stick, one is straightness. Figure 3.5C, a picture of a stick in water, provides the experience one would have if one were viewing, at a particular angle, the stick in water. Experience also represents this stick as straight. And the stick in water is straight. So, from most viewing angles, the stick is illusorily represented as bent or broken. However, there is an angle at which the stick's shape is represented as it actually is. This veridical sweet-spot exists at this viewing angle because, roughly, even though the water and air have different refractive indexes, from the right angle, the path of the light does not bend at the interface of the media but is the same as the path the light would take if it were reflected from a stick out of water. In such a circumstance, the water does not "obstruct" the visual system's determination of object shape given the incoming light.

Figure 3.5: Stick in water

A

B

C

[63] Some have argued that the Archer fish has such a constancy. See for example Schuster et. al. (2004).

Figure 3.6: Stick out of water

If Cohen were to run his no-privileged-variant argument on the stick-in-water illusion, it would fail. Between the experiences of stick A, B, and C, there is a curvature-ish phenomenal difference. The experience of A has one bent-ish phenomenal property. The experience of B has another bent-ish phenomenal property. And the experience of C has a straight-ish phenomenal property. With Weak Representationalism, there are three different curvature properties represented of the sticks. Is one privileged as the only one veridically represented? Yes. It is the representation of straightness. The reasons are empirical: it is at the viewing angle of scene C that the light reflected off of the stick travels through the water and the air in the same manner that it travels through the air alone, unbent. And when the light travels through the air alone, the viewing conditions of the scene depicted by Figure 3.6, we experience the stick's curvature veridically. Since scene C delivers the same input to the visual system, the visual system outputs the same experience as the experience of the stick out of water. The fact that scene C's viewing conditions allow for the light to travel in the same way it does in the scene depicted by Figure 3.6 does not *necessitate* that the representation of stick C as straight is veridical. However, it does provide well-motivated, non –stipulative reasons for thinking the representation is veridical.

Veridical sweet-spots amongst sequences of illusions and veridical experiences are also present with respect to color representation. Suppose a surface is red (and so has a particular surface spectral reflectance). Suppose that two regions of the surface differ in the chromaticity of their illumination. Region A is illuminated by a light that emits equal amounts of energy at all wavelengths, and region B is illuminated by a light that emits more light at a certain range of wavelengths- call it "blue" light. Suppose a subject seeing the surface has an experience of one region and an experience of the other. The experience of A has one phenomenal property, the experience of region B has another, and the phenomenal properties differ to the same extent that the illuminations differ. Given Weak Representationalism, there are two different color properties represented of the surface. Is one privileged as the only one veridically represented? Yes. It is the color representation of the experience of region A. The reasons are empirical: for an equal energy illuminance of the right ("normal") intensity, the spectral power distribution of the return will be the same as that of the surface spectral reflectance. The lighting conditions of region A are such that the illumination's chromaticity does not "obstruct" the features of the reflectance. This is analogous to the way the viewing conditions of stick C do not obstruct the path of the light reflected off the stick. Therefore, there are well-motivated, non-stipulative reasons for thinking that the color representation of region A is the veridical representation.

Thus, in cases where the represented color difference is to the same extent as the extent of the difference in the illuminance of the relevant surfaces, there is good reason to think one color representation is privileged as veridical. Therefore, in such cases Cohen's reasons for P4 fails, and the argument for illumination-relativized properties is insufficient. Since Shoemaker's P4 also lacks support, his argument for Relativism in such cases is insufficient.

3.5. Conclusion

In this chapter, Relativism about Varying Illumination Cases was presented. Such views attempt to recover veridicality in such cases by finding two different instantiated properties of the differently-illuminated surfaces which experiences represent[64]. The properties, they claim, are illumination-relativized properties. I have argued that veridicality in Varying Illumination Cases involving Type-2 Color Constancy is secured via the represented color similarity of the differently-illuminated surfaces. Thus there is no need for illumination-relativized properties in such cases. Additionally, I have argued that, in cases more promising for the Relativist's approach, Cohen and Shoemaker's reasons for thinking that the relevant experiences are not illusory are insufficient.

[64] Or the view attempts to recover veridicality in such cases by finding two different instantiated and represented properties of the common color of the differently-illuminated surfaces.

CHAPTER 4: INFORMATIONAL TELEOSEMANTICS AND THE PROBLEM OF PROXIMAL STIMULATION

4.1. Introduction

The preceding chapters of the dissertation were largely concerned with the *what* of color constancy- what is it (or what are they, if there are different types). In particular, we looked at whether color constancy involves a similarity in how things look, a similarity in phenomenal properties of the relevant experiences or a similarity in how things are judged to be. This chapter turns to the question of *how* color constancy is accomplished (whatever exactly color constancy is). Thus, the discussion will center on color constancy mechanisms, characterized at an abstract, computational level. The target around which the discussion of constancy mechanisms will take place will be recent advances in naturalistic theories of sensory representation.

The chapter starts by explaining Karen Neander's Causal-Informational Teleosemantic account of perceptual representation which grounds perceptual representation in the response functions of the visual system. The persistent Distality Problem is introduced and the threat it poses for the theory's ability to secure determinate representations is explained. To solve this problem, Peter Schulte appeals to the perceptual constancies found in visual systems.

I, however, argue that there is a common picture of perceptual constancies that Schulte bases his argument on which is mistaken, and a more accurate view undercuts Schulte's strategy for solving the Distality Problem. My argument starts in Section 4.3 with a type of illusion that lacks an adequate explanation. In Section 4.4, by appealing to a well-established Bayesian approach to constancy, I propose an explanation of such illusions. Finally in Section 4.5, it is argued that this feature of the workings of constancy-involving visual systems undermines Schulte's solution to the Distality Problem.

4.2. Informational-Teleosemantics and the Distality Problem

This section introduces Karen Neander's recent and extensive project to naturalize mental intentionality, the problem it faces, and Peter Schulte's proposal on how to solve the problem while maintaining the core of Neander's theory.

4.2.1 INFORMATIONAL-TELEOSEMANTICS

Karen Neander's psychosemantic theory, as expounded in *Toward an Informational Teleosemantics* and her recent book A Mark of the Mental, aims to provide an account of perceptual representation. Suppose that a perceptual representation's producing system functions to respond to X. The rough idea of the account is that the content of such a perceptual representation is X. She characterizes her view as an informational-teleosemantics because it purportedly reconciles both informational and teleological approaches to mental content. While teleosemantic theories were characterized to focus on the effects of representations in determining the representation's content, informational theories were thought to focus on the causes or co-occurring conditions of representations in determining the representations content. Neander's hybrid view incorporates input-oriented, informational views by involving responses and it incorporates output-oriented, teleological views by involving functions (Neander 2013: 22).

Neander's theory of mental content begins with a simple version and expands, adding qualifications to accommodate prima facie challenges. One such challenge- the Distality Problem, and its accommodation, will be the focus of this paper, but we will start with the simple version of her theory- causal-informational teleosemantics (CT):

> CT: A sensory-perceptual representation, R, which is an (R-type) event in a sensory perceptual system (S), has the content *there's C* if and only if S has the function to

> produce R-type events in response to C-type events (in virtue of their C-ness). (Neander 2017: 151)

To unpack this, first consider the left-hand side of the bi-conditional. Sensory perceptual representations include things like visual experiences, auditory experiences, and experiences in the other sense modalities. They have intentional content, representing the world as thus and so. Unlike beliefs, they have nonconceptual content in that one can have a sensory perceptual representation without having a concept of the components that make-up that content. In Neander's theory sensory perceptual representations are not only sensory experiences but are also subpersonal states like certain brain states.

The right-hand side of the bi-conditional involves the functions systems have. The type of function employed here is a response function- a function "to respond to something by doing something" (Neander 2017: 126). In the case of perceptual systems, they have the function to respond to states and conditions (potentially internal or external to the organism) by producing certain types of states or events. For Neander, functions are understood aetiologically, in terms of "what traits of the type did in the past that contributed to the inclusive fitness of ancestors, and which as a result caused that type of trait to be selected" (2017: 129). This means that a trait has the function to ϕ iff (1) traits of this type have ϕ-ed in the past and (2) doing ϕ in the past "caused that type of trait to be selected [by natural selection]" (Neander 2017: 129). For an example from Schulte:

> [Z]ebra stripes have the function of deterring parasitic insects (Caro et al. 2014). According to the aetiological conception, this function ascription is correct if (1) earlier tokens of the type *zebra stripes* … have deterred parasitic insects and (2) the fact that earlier tokens of the type *zebra stripes* have deterred parasitic insects helps to explain why zebra stripes were selected for, i.e. why the striped pattern was favoured by natural selection over rival patterns, thus becoming dominant in the ancestor populations of today's zebras, and remaining dominant from then on. (Schulte 2018: 352)

Specifically, a sensory-perceptual system has a certain type of function- a response function, which is a function to produce certain states in response to certain events. So a sensory-perceptual system has a response function to produce R-type states in response to C-type events iff earlier sensory-perceptual systems produced R-states in response to C-events and the fact that earlier sensory-perceptual systems have produced R-states in response to C-events helps to explain why the sensory-perceptual system was selected for. As with many aspects of Neander's theory, responding is understood causally such that "to respond to something…is to be caused by something to do something" (Neander 2017: 127). So, a sensory-perceptual system responds to C-event types by being caused by those event types to (in the relevant cases) produce R-states.

The qualification "in virtue of their C-ness" will be relevant in Section 4.5 and so discussed then.

Neander uses CT to explain the content of a state in the brains of frogs which is often discussed in the psychosemantics literature. Certain neurons in the optic tectum of the visual system of such frogs activate under certain conditions. When they activate, they cause the frog to engage in prey-catching behavior, which includes "orienting toward the stimulus; stalking or approaching it; fixating it or viewing it with both eyes from front on, which allows binocular vision; and lunging at it and extending the tongue or snapping the jaw" (Neander 2017: 102). The neuronal activation in the optic tectum, i.e. the activation in T5(2) cells, is usually caused by prey moving into the frogs field of view. But it is also produced when anything small, dark, and elongated which is moving parallel to its axis of elongation comes into the frog's visual field. Let's call such an object *SDM,* for small, dark and moving (Neander 2017: 156). Neander argues that the content of the frog's perceptual state is that there's something small, dark and moving.

Why CT delivers this result will be addressed in Section 4.5. For now, let's assume Neander is right.

4.2.2 The Distality Problem

A long-standing problem in the psychosemantics literature requires that Neander modify CT. As it stands, CT does not rule out T5(2) states representing certain patterns of retinal stimulation or arrays of spectral returns. This is the Distality Problem. In its general form, the problem concerns ruling out the more proximal causes of psychological representation from being represented. In the case of T5(2) activation, it is caused by prior brain states, which are caused by the stimulation of retinal cells, which are caused by certain arrays of incoming light, which are caused by the joint interaction of spectral reflectances, illuminances, and transmittances. And Neander accepts that the visual system has the function to respond to all these things since "responding to variations in patterns of light that hit the retina is the means by which a visual system responds to visible features of distal objects. And…if a system was selected for doing one thing *by* doing another then it was selected for doing both" (Neander 2017: 219). For example the frog's visual system was selected for producing T5(2) states in response to SDM objects by producing T5(2) states in response to certain arrays of incoming light. So it was selected to do both and so has both response functions, and so, by CT, represents both SDM objects and certain arrays of incoming light. Similar lines of reasoning for other conditions/states, both more proximal and more distal than the properties of objects like color, size, shape and motion, leads to substantial indeterminacy in the content of representational states, like T5(2). Thus Neander qualifies CT.

Essentially, the supplement to the theory states that, though the frog's visual system has many response functions because it has many functions to produce T5(2) activation in response to each link in the causal chain reaching back to the distal state, it is the response function that the system performs by performing all others that determines the content of T5(2). In general,

> R [a sensory-perceptual representation] refers to C rather than the more proximal Q if the system responsible for producing Rs was adapted for responding to Qs (qua Qs) by producing Rs as a means of responding to Cs (qua Cs) by producing Rs, but it was not adapted for responding to Cs as a means to responding to Qs (Neander: 222).

Thus, T5(2) states represent the property of being SDM rather than properties of incoming, reflected light because the frog's visual system was adapted for producing T5(2) states in response to some pattern of incoming, reflected light as a means of responding to SDM objects by producing T5(2) states, but it was not adapted for responding to SDM objects as a means of responding to some pattern of incoming, reflected light. This qualification to CT seems to rule out too-proximal states as the contents of representations like T5(2) states.

However, Peter Schulte argues that Neander's qualified CT still falls to the Distality Problem. More specifically, the qualified CT is in conflict with Neander's preferred contents-low-level properties like color, shape, size, etc. For example, discussing the frog, Neander claims "its perceptual processing in the detection of prey concerns the size, shape, motion, and motion relative to shape of the stimulus" (Neander 2013:32). Schulte provides a case in which the representation of Neander's preferred property is preempted by the representation of another, more distal, property. This occurs because the former property figures in a state or event which the visual system has the function of responding to by activating T5(2) as a means of responding to a state or event with the more distal property by activating T5(2). Schulte gives the hypothetical case of a "tectal state T that initiates prey-catching behavior and […] is normally produced by the toad's visual system if and only if a tiny red moving object […] is present" (Schulte 2018: 358). The toad has evolved to catch and eat a type of tiny red insect because of its need for potassium. When the insect eats potassium-rich food, and thus becomes a potassium-rich food source, it turns red. "[P]otassium-richness … is causally relevant for producing the insects' red surface color" (Schulte 359). Having a potassium need, the toad has evolved, we can suppose, to try and catch the insect only when it is red. By Neander's qualified CT, the toad's visual system has the function to produce T in response to a tiny red object being present, but it also has the function to produce T in response to a potassium-rich object being present. And it has the function to produce T in response to a tiny red object being present as a means of producing T in response to a potassium-rich object being present. Thus, Schulte concludes that "T has the content <there is a potassium-rich object>, a result that is in conflict with Neander's view that (basic) perceptual states represent the surface features of objects" (Schulte 359).

As a result of this problem for Neander, Schulte attempts to solve the Distality Problem in a different way, while maintaining a causal-informational teleosemantics which is very similar to CT. His plan is to do this by appeal to perceptual constancies. In canonical fashion, Schulte appeals to the fact that at least some perceptual states for at least some organisms "track" certain constant properties, like size, shape, motion, brightness, and color, under variation in external and internal conditions which produce variation in proximal stimulation. This perceptual "tracking" characteristic of perceptual constancies is enabled by constancy mechanisms (Schulte 360). Schulte leaves details about these mechanisms open. Though not explicit about what is meant by his use of "tracking," it is plausible that he means a notion of representational sameness. That is, a visual system tracks invariant properties of the environment despite changes in proximal stimulation that results from changes in external and internal conditions by producing invariant representations. This conclusion is supported by Schulte's discussion of toads exhibiting size constancy. As he writes, "the system produces tectal states which 'track' the real size of objects, not the size of their retinal images. For instance, the toad's visual system normally produces +T5(2) in response to an elongated object with a height of 1 cm when the object is rather distant…as well as when the object is very close…despite the fact that the vertical size…of the object's retinal image is 2° in the first case and 32° in the second" (Schulte 361). Thus, it is safe to conclude that, for Schulte, it is the sameness in representation that is operative in perceptual constancies.

Schulte then goes on to argue that we can secure determinate representation, not by allowing many functions and privileging one as grounding representation, as Neander does, but instead by ruling out all but one function. Taking the toad case as an example, Schulte argues that since perceptual constancies deliver sameness in representational states when distal properties remain unchanged despite changes in proximal stimulation, "there is no single type of retinal stimulation pattern which normally causes the toad's visual system to produce T5(2) activation […] Hence, the only external state that qualifies as a normal cause of T5(2) excitation, i.e. as a cause that is always present in normal situations, is the distal state…" (Schulte 2018: 361). Schulte concludes that "the toad's visual system has the function to generate +T5(2) tokens in response to [SDM] objects, but not the function to generate +T5(2) tokens in response to any particular type of proximal stimulus" (Schulte 361). To evaluate Schulte's view, this argument needs to be unpacked.

To clarify what Schulte could mean by the claim that "there is no single type of retinal stimulation pattern which normally causes the toad's visual system to produce T5(2) activation…Hence, the only external state that qualifies as a normal cause of T5(2) excitation, i.e. as a cause that is always present in normal situations, is the distal state," let's return to the basic version of CT and connect normal causes and normal situations with functions. It will be assumed that Schulte's idea of normality is the same as Neander's since he will be extending her theory to incorporate constancies. Neander states that "the normal cause…is the triggering cause implicated in the response function" (Neander 2017: 136). According to CT, if Y represents X then Y has the relevant response function with respect to X. If there is this response function, there was a time when X caused the visual system to produce Y and this fact helps explain why the visual system was selected for. So there was a circumstance, the function-conferring circumstance, in which the visual system gained this function and X was the triggering cause in that circumstance. So, the normal cause of a representational state is the triggering cause in the function-conferring circumstance. And normal circumstances are those circumstances which are sufficiently similar to the function-conferring circumstance.

In terms of functions, Schulte's argument claims that there are a host of present-day, state tokenings which are of the same representational type. And each of these tokenings is the result of the same response function of the visual system. And each of these tokenings represents the same distal property. However they differ in the proximal stimulations that are causal intermediaries between them and the instance of the distal property. And whatever exactly it is that makes these states have the content that they do, it is not in virtue of their sharing all the same proximal stimulation with each other or with the state which was tokened in the function-conferring circumstance. Call this Lack of Proximal Correlation. Any particular proximal stimulus is not as correlated with the representational state as the distal state is.

To conclude that a constancy-involving visual system does not have the function to produce some constancy representation in response to any proximal stimulus, Schulte seems to assume that a visual system can have the function to respond to something by producing some representational state only if that something is present in all productions of that representation and is present in the function-conferring circumstance. That is, the Lack of Proximal Correlation excludes the proximal from being part of the response functions which involve constancy representations and so excludes the proximal from being represented.

The Lack of Proximal Correlation Principle is a principle commonly held, in some form or other, in discussions of perceptual constancies. For example, discussing and endorsing Dretske's points on constancy in *Misrepresentation* (1986), Sterelny writes, "The stable correlation, Dretske points out, is between concept and [distal] object, not between concept and its sensory intermediaries [i.e. proximal stimulation]" (Sterelny 1990: 121-122). Though, given the times, Sterelny is using "concept" as a part of the content of visual experience, he is endorsing the Lack of Proximal Correlation Principle. From this he concludes, "So concepts are concepts of those objects, not sensory intermediaries," a conclusion very similar to Schulte (Sterelny 1990: 122).

In what follows, I will argue that, in a way, the Lack of Proximal Correlation Principle is right, but in another way, it is wrong. And it is the way in which it is wrong that creates a problem for Schulte's solution to the Distality Problem.

However, before I begin to build the case against the Lack of Proximal Correlation Principle, I present a quick challenge to Schulte's solution to the Distality Problem. Schulte's solution claims that a perceptual representational state has determinate content only if it employs constancy mechanisms. He notes that some states, like the magnetosome states of the *Spirochaeta plicatilis,* made popular by Dretske (1986), might seem to challenge this. However, Schulte is ready to either deny that "primitive states like the one just mentioned are representations" or accept that they are representations but claim "their content is indeterminate" (Schulte 2018: 362). However, he recognizes that "representational states with determinate […]

content [which are also] products of sensory systems which do not employ constancy mechanisms […] would indeed constitute a serious problem for my proposal" (Schulte 2018: 362). But, he thinks there are no such states.

However, it seems that our experience of a stick partly in and partly out of water is one such state. From most viewing angles, a stick partly in and partly out of water is represented as bent. See Figures 4.1A and B. This is because as the light reflects off of the stick, travels through the water and crosses the water-air interface it bends as a result of the different refractive indexes of the air and the water. Differences in the direction light travels before reaching the eye pose an inverse projection problem, one which our visual system has not evolved a constancy mechanism to accommodate, though maybe some creatures have[65]. Therefore, for humans, as the relative position between us and the stick changes, the representation of the stick's shape illusorily changes. Though we lack a constancy mechanism that overcomes the affect that light-bending as it passes through media with different refractive indexes has on the representation of shape, we still seem to determinately represent the shape of the stick at various viewing angles.

Figure 4.1: Stick in water

A **B** **C**

[65] Some have argued that the Archer fish has such a constancy. See for example Schuster et. al. (2004). Though, if what has been proposed so far in the dissertation is correct, it is far from clear whether the fish exhibits even Type-1 constancy or whether the fish is able to compensate for the effect of difference in transmittance refractive properties only in extra-experiential ways.

Figure 4.2: Stick out of water

While each experience of the stick seems to lack at least one shape constancy, as a whole, each experience represents many properties, many of which result from constancies. And our visual system, as a whole, employs many constancy mechanisms. So maybe Schulte can salvage his view by appealing to these facts, recovering determinate content as long as there is substantial constancy in an experience or visual system as a whole. I won't press this because the point I wish to make against Schulte concerns the Lack of Proximal Correlation Principle. Essentially, I wish to argue that even if Schulte is right that there are no "representational states with determinate […] content [which are also] products of sensory systems which do not employ constancy mechanisms" or even if, counterfactually, it were the case that all representational states with determinate content employed constancy mechanisms, his solution faces a larger problem. Schulte's view of perceptual constancies misunderstands the relationship between the perceptual output and the proximal causes.

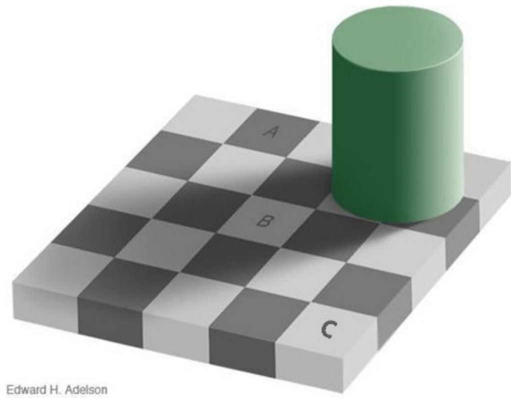
In what follows, I will argue, focusing on color constancy, that the picture of perceptual constancy enshrined in the Lack of Proximal Correlation Principle is mistaken and a more accurate view undercuts Schulte's strategy for solving the Distality Problem. In Section 4.3, I return to illusions, which are what constancies are supposed to offset, and argue that there is a type of illusion that needs a different explanation. In Section 4.4, I present a well-established approach to how constancies are accomplished by the visual system. This will allow for the, previously lacking, explanation of certain illusions. In Section 4.5, I argue that this feature of the workings of constancy mechanisms undermines Schulte's view.

4.3. Different Types of Illusions

The first step is to take a closer look at the connection between illusions and color constancy. Two basic features have already been mentioned. First, because of the inverse projection problem, a visual system is liable to produce color illusions as a result of variations in illumination. To avoid this, a color constancy mechanism might be employed. Additionally, Section 2.4 of Chapter 2 addressed how experimenters in color constancy often use, for practical reasons, simulations. In a given experiment, the simulation does not exhibit color constancy. However, the scene that the simulation is meant to be a simulation of supposedly does, and the simulation can be used in lieu of the scene. This experimental method assumes that if the returns of the simulation and the scene are the same, then the simulation and the scene induce the same phenomenal experiences. The experience of the scene is veridical while that of the simulation is illusory. Now it is time to take a critical look at the assumptions of this method.

As a note, for simplicity in this chapter, I will identify phenomenal properties with representational properties. In addition, the only type of color constancy of concern will be Type-2 color constancy, even though much of what is written plausibly applies to other types of color constancy.

Figure 4.3: Adelson's checkershadow illusion



From Adelson (1995)

In Chapter Two I argued that there is a real checkerboard which produces the same return as Figure 4.3 and induces the same phenomenal experience, but exhibits color constancy. Figure 4.3 involves an illusion because B is represented illusorily as Middle Gray when it is actually Dark Gray. Since B is represented as Middle Gray, it is represented as more similar to C than it actually is. As the argument went, if there is a real checkerboard with checkers B' and C' which are counterparts of Figure 4.3's patches B and C, then the represented similarity between B' and C' is the same as the represented similarity between B and C. B is represented as more similar to C than the similarity between their colors or reflectances. And this makes for illusion in Figure 4.3. However, B' is represented as more similar to C' than the similarity between their returns and illuminances. And this makes the representation of B' less illusory than it would be for an experience lacking color constancy.

But what is the significance of two objects differing in their distal properties, but with the same return, which induce experiences which are phenomenally the same? We can return to the inverse projection problem for clarity. For an individual who does not have a color constancy mechanism, two surfaces of the same reflectance-type which are under different illuminations reflect different types of returns. These differing returns are the only information about distal properties that the visual system has. Thus, a constancy-free visual system will produce experiences that differ in represented color and so will produce illusions. However, when there is color constancy, there is visual color-sameness despite the difference in returns.

Additionally, there is, one might say, Reverse Color Constancy when two surfaces which differ in reflectance are illuminated in such a way that their returns are the same, but the surfaces are represented as different, in the right way. For example, a visual system produces reverse color constancy when a white object and black object are represented as white and black, respectively, even though the first is in dim light and the second is in bright light such that their returns are the same. A constancy-free visual system would produce experiences representing the objects as the same in color. Without a reverse color constancy mechanism, sameness in returns guarantees sameness in experiences. Analogously, without a color constancy mechanism, difference in returns guarantees difference in experiences. Thus, in cases where a subject lacks reverse color constancy and the same return is caused by different reflectance-types this yields at least one illusory experience.

At first pass it might seem that Figure 4.3 and the real checkerboard involve a failure in reverse color constancy. Between Figure 4.3 and the real checkerboard, the returns are the same and this yields a sameness in phenomenal experience of the two, though they differ in reflectances and illumination. And the experience of the figure is illusory. However, the illusion is not the result of a lack of reverse color constancy. If there were a failure of reverse color constancy, it would be the real checkerboard that is illusory while the figure would be veridical. The reason turns on veridical sweet-spots. We've seen that even a constancy-free perceptual system can get things right sometimes. For example, in the stick in water case, from most viewing angles, the stick is illusorily represented as bent or broken. However, there is an angle at which the stick's shape is represented as it actually is. Compare Figure 4.1C and Figure 4.2. This veridical sweet-spot exists at this viewing angle because, roughly, even though the water and air have different refractive indexes, from the right angle, the path of the light does not bend at the interface of the media but is the same as the path the light would take if it were reflected from a stick out of water.

Veridical sweet-spots are present with respect to color representation, also. Suppose a surface is red (and so has a particular surface spectral reflectance) and the person viewing the surface lacks color constancy. As a result, for most illuminances, varying in their chromaticity or intensity, and subsequent returns, the subject's experience will be illusory with respect to color. However, for an equal energy illuminance of the right ("normal") intensity, the spectral power distribution of the return will be the same as that of the surface spectral reflectance. Therefore, the subject's experience will represent the surface veridically. As a result, even subjects lacking color constancy veridically represent color when the illuminance is equal energy and of the right intensity. However, for our experiences of Figure 4.3 and the real checkerboard, it is the figure which is illusory for us. If we lacked color constancy in this case, the figure, a colored patchwork under normal lighting (roughly equal energy light of the right intensity) would be represented veridically (a veridical sweet-spot for us), while the part of the real checkerboard in shadow would be represented illusorily. Thus, something other than a lack of reverse color constancy explains the illusory experience of Figure 4.3. So, individuated by their causes, there are at least two illusions. Type-1 illusions are caused by a lack of constancy or reverse constancy. Type-2 illusions are caused by something else.

The next sections argue for an explanation of Type-2 illusions which is based in empirical proposals of the mechanism of color constancy. As it will turn out, Type-2 illusions are the result, not of the lack, but of the presence of color constancy.

4.4. Constancy Mechanisms and the Constancy-Illusion Tradeoff

As was seen above, Type-2 illusions lack an adequate explanation. In this section I lay out the very popular Bayesian approach to constancy mechanisms and argue that such an approach provides a plausible explanation of Type-2 illusions. It is argued that Type-2 illusions are a price the visual system pays for employing a constancy mechanism to avoid Type-1 illusions.

4.4.1. Bayesian Modeling of Constancy Mechanisms

As discussed throughout the dissertation, the input to the visual system underdetermines its distal causes. Assuming that the visual system provides information about, and our experiences represent, distal properties, the visual system produces output under input-uncertainty. A leading way to model credences, other mental states, and decision-making under uncertainty is with Bayesian Decision Theory. In a natural extension, Bayesian Decision Theory (BDT) has been employed to model the mechanisms by which color constancy is achieved.

BDT begins with subjective probability (Strevens Ms). Often when one is uncertain which of a number of possible states of affairs obtains, one might think some of those possible states are more likely, some less likely, or some equally as likely as others. Consider the flip of a fair coin. If we call the possible states of the coin (turning up heads and turning up tails) that one entertains "*hypotheses*" and use numbers to designate the extent to which one believes the coin will end up in one state or the other, then, most would believe there is a 50% chance the coin will turn up heads and a 50% chance the coin will turn up tails. These levels of expectation for the two hypotheses are *subjective probabilities*. An agent's subjective probabilities are reflected by a *probability function*, p, from each hypothesis, h, to a real number p(h). Sometimes the subjective probability is assigned to a hypothesis conditional on some other event occurring. This reflects a *conditional probability* of a hypothesis, h, given another event, e, written as p(h|e).

Bayes's Rule prescribes a relationship between what one's subjective probabilities should be, conditioned on a particular type of event- new evidence. When new evidence arises, one should update ones credences in light of the new evidence. Thus, where $p^2(\,)$ is the subjective probability at some later time and p( ) is the subjective probability at an earlier time, Bayes's Rule can be written as:

$$p^2(h) = p(h|e) \qquad \text{Equation (1)}$$

Bayes's Rule is expanded with *Bayes's Theorem*:

$$p(h|e) = p(e|h)p(h)/p(e) \qquad \text{Equation (2)}$$

This tells us that p(h|e), which is called the *posterior probability*, equals the product of the initial subjective probability before the evidence is encountered (p(h), i.e. *the prior probability*) and the probability of the evidence given the hypothesis (the *likelihood*), divided by the probability of the evidence.

According to a rapidly increasing body of theorists in vision science, particularly in the study of color constancy, Bayes's Theorem models how the visual system deals with the uncertainty in sensory input. Before we consider how Bayes's Theorem is applied here, some simplifying idealizations need to be made. First, I will idealize that the retinal photoreceptors are "transparent" meaning that it is as if the visual system has direct access to the return and isn't hampered by the limitation of only 4 receptor-types. In reality, there is no such direct access and one must consider more than the information loss that occurs because of the interaction between illuminances, surface spectral reflectances, transmittances, and other distal factors. Instead, the post-receptoral visual system draws on the responses of the retinal mosaic of photoreceptors. However, because of the way the photoreceptors respond to light, the properties of the return are confounded such that two different returns can produce the same photoreceptor responses. So there are at least two informational collapses, one in the production of the return and another in the response of the retinal cells. The problem worsens in that "there is at most one photoreceptor at each retinal location […so] the visual system must combine information [from photoreceptors across the retina]" (Brainard 2009:2). This is a third layer of informational collapse[66]. Noise is an additional problem the visual system faces, including noise in the visual system and photon noise (Mamassian et.al 2002). To avoid these difficulties, which are not required to make my case, the idealization makes it as if there is no difference between retinal input to the visual system and the return input. However, the Bayesian framework arguably has the resources to accommodate all these forms of input uncertainty and ambiguity.

Second, issues with the experience of spatial features of the scene, like spatial constancy and the extent of the field of view are neglected. It is assumed the experience is spatially veridical and color constancy isn't relevantly dependent on the processing of spatial features. Thus, the only challenge to vision is the confounding of illumination and reflectance in the return array.

With these idealizations, we can return to Bayes's Theorem in the context of constancy mechanisms. Where does the uncertainty arise? Suppose there's the return caused by a black

[66] Idealizing from these two informational collapses means idealizing from two classes of metamers. In general metamers are ignored in this paper.

surface reflecting an equal energy, normally-intense light. This same return can also be the result of a surface that is just slightly less black (and more white) and an illuminance that is just slightly less intense. This move can be repeated again and again until the surface is white and the illuminance is very low in intensity. All the steps in this sequence yield the same return. Thus the return ambiguity is quite extensive. And each illuminance-reflectance pair is equally likely to produce the given return. Because there are many illumination-reflectance pairs that can produce the given return, the visual system is acting under uncertainty and thus making Bayesian calculations would be quite useful.

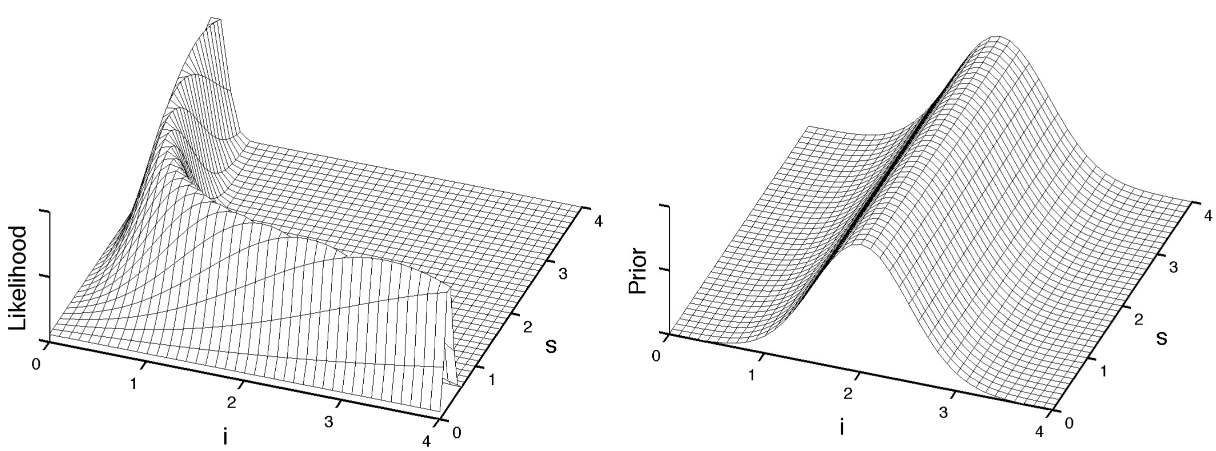
To begin to model constancy using BDT start with a single small surface with a homogenous surface spectral reflectance, illuminated by a single illuminant, which reflects a return which is the product of only the reflectance and the illuminance. The illuminance is specified by a single number i and the surface reflectance is specified by s. Thus, the return is r = (i)(s). The return is the proximal input to the visual system which confounds the illuminance and the reflectance. In Equation (2), the return is the evidence. If we suppose for the time being that the output of the visual system is some information about the reflectance and the illuminance, then the alternative "hypotheses," to which the visual system will assign probabilities, as formalized in the posterior probability, concern illumination-reflectance pairs.

Because of the way a single return can be produced by many different illumination-reflectance pairs, a probability can be assigned to the chance that a given return is produced by any illuminant-reflectance pair. As was seen, the same return can be produced by a black reflectance under an equal-energy, normally-intense illuminance or a white reflectance under a less intense illuminance. However, a red surface reflectance and a blue illuminance could not produce this return. The likelihood, expressed as $p(r|i,s)$, captures these facts. For a return, it assigns a probability to the return being produced by each illumination-reflectance pair. For some illumination-reflectance pairs the likelihood is zero. But some illumination-reflectance pairs have a likelihood of equal probability, in which case the visual system faces uncertainty. The likelihood formally captures the ambiguity in the return.

In the context of the processing of the visual system, the likelihood usually takes the form of a discreet probability mass function or a continuous probability distribution function. Thus, if i and s are real numbers, they determine a two-dimensional space where any point in that space is a return. A third dimension, orthogonal to the i and s dimensions, represents the likelihood p(r|i,s). See Figure 4.4A. Surfaces and slopes in this space illustrate the differing probabilities. The highest "ridges" or "plateaus" in the space represent the highest likelihoods of equal probability. For our purposes, it does not matter what likelihood is represented by Figure 4.4A. The important point is that the lowest regions represent zero probability and the ridge represents the highest likelihoods which are of equal probability.

Figure 4.4: Likelihood and prior functions

A **B**



From Brainard 2009[67]

From the point of view of the visual system, only given the return-information available in a likelihood like the one depicted in Figure 4.4A, when there is a ridge, the visual system has no "reason to choose" one illumination-reflectance pair over another. However, the Bayesian framework addresses how to resolve the uncertainty in the likelihood, yielding a posterior that, ideally, has it that one pair is more probable than the rest. This turns on the prior.

The prior tells the probability of any illumination-reflectance pair, independent of the return. Figuratively, it reflects the "assumptions" the visual system makes about distal properties. For example, a visual system might employ a prior that reflects the system's assumption that the illuminance is most likely in the range of lighting found in natural daylight. Thus, the probabilities of those illuminances would be higher than other illuminances. For a geometric construal, consider Figure 4.4B. It represents that all reflectances are equally probable but certain illuminances are more probable, particularly as one approaches $i = 2$. (This is not the prior that would reflect the assumption that the illuminance is most likely in the range of lighting found in natural daylight. The figure is just used for illustrative purposes.)

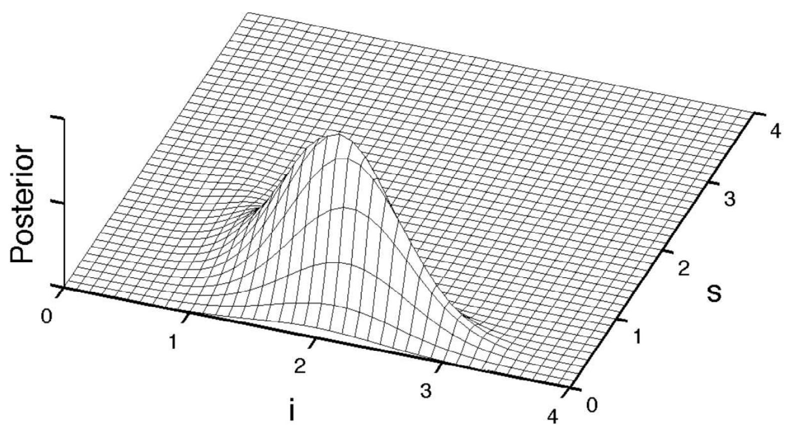
With the prior and likelihood in hand, Bayes's Theorem requires multiplying them. In effect the prior "shifts the peak of the posterior away from the peak of the likelihood (Mamassian 2002: 20). This yields something proportional to the posterior probability. The factor $p(r)$ ($p(e)$ in Equation 2) , in the vision science contexts, plays the role of normalizing the posterior so that the total probability is one. Thus we have the equation for the probability a visual system assigns to illumination-reflectance pairs, i and s, given a return-input, r.

$$p(i,s|r) = p(r|i,s)p(i,s)/p(r) \qquad \text{Equation (3)}$$

[67] Reprinted from Brainard D. H. (2009). Bayesian approaches to color vision. In Gazzaniga M., editor. (Ed.), *The cognitive neurosciences* (4th ed., pp 395–408) Cambridge, MA: MIT Press with permission from The MIT Press.

Graphically, when r yields the likelihood represented in Figure 4.4A, and Figure 4.4B is the prior the visual system employs, Figure 4.5 represents the resulting posterior. In effect the prior has reduced the uncertainty in the likelihood to yield a most probable distal configuration of illumination and reflectance.

Figure 4.5: Posterior function



From Brainard 2009[68]

A final step is required since, on the one hand, the outputs of the visual system are not usually probabilistic, whether they are beliefs about distal properties, actions directed towards distal properties, experiences representing distal properties, or some other outputs, and on the other hand the posterior is a probability distribution. A single "hypothesis" must be chosen via a decision rule[69] (Mamassian et. al. 2002). In the vision science literature, the single illuminance-reflectance pair is usually either the most probable value according to the posterior, i.e. the

[68] Reprinted from Brainard D. H. (2009). Bayesian approaches to color vision. In Gazzaniga M., editor. (Ed.), *The cognitive neurosciences* (4th ed., pp 395–408) Cambridge, MA: MIT Press with permission from The MIT Press.
[69] The decision rule is meant to pick out the illumination-reflectance pair which maximizes the expected utility to the subject. Thus, each possible hypothesis is specified a gain and loss by the gain function and so, given the posterior, each hypothesis is associated with an expected utility. A hypothesis will be outputted relative to systems balancing of gains and risk (Mamassian, et.al. 2002 ; Geisler and Kersten 2002).

maximum of the posterior, or the mean of the posterior (For example, see Brainard and Freeman 1997). For present purposes, which decision rule is used does not matter.

This provides the rough outlines of how BDT is employed in various areas of vision science including perceptual constancies. Some complications need to be added to this account. Earlier it was assumed that Bayesian color constancy was being applied to one small surface with a single reflectance, illuminance, and return. However, in realistic visual cases, the constancy mechanism must be extended across the field of view. Thus there will be an array of distal surfaces, each with its own reflectance, illuminance and return. Also, there is a return array- an expanse of contiguous regions where each region has a chromaticity and luminance which is the product of the reflectance and illuminance of a reflecting region of the distal scene. Thus the visual system would employ a more complex Bayesian system that incorporates all of this.

4.4.2. An Example of Bayesian Color Constancy

An example of Bayesian Color Constancy will be used to argue against Schulte's solution to the Distality Problem. However, before I turn to this central example of Bayesian color constancy, it would be useful to get a simple concrete example on the table.

So let's retain the assumption of one small surface with a single reflectance, illuminance, and return. Suppose illuminances/illuminants have a maximum intensity of 10, in some unit of measurement. And suppose reflectances also have a maximum intensity of 10, in some unit of measurement. White objects have reflectances close to 10, black objects have reflectances close to 0, and grays are naturally distributed in between. Suppose there is some small surface which is nearly white, with a reflectance of 9, and which is in very dim lighting of 2. By r= (i)(s), the return is 18.

But many illuminances and reflectance pairs, (i,s), can produce a return of 18, including (9,2), (6,3), (3,6), and (2,9). So there is a likelihood, p(r| i,s), which assigns equal probability to a return being caused by any pair of illuminances and reflectances which multiply to 18. How might a visual system deliver an experience representing the surface as white, at least approximately, despite the uncertainty in the return?

Suppose the visual system in question belongs to a mole which lives in an environment where the lighting remains very dim, around a 2. If the light in the mole's environment remains sufficiently constant around 2, it could be evolutionarily advantageous to evolve a prior which assigned a very high probability to 2, so which, geometrically speaking, steeply declines from this peak of 2, zero-ing out at 1.5 and 2.5. If this is the prior, then the peak of the posterior would be shifted from the broader peak of the likelihood. This posterior assigns the highest probability to illuminance-reflectance pairs around (2, 9).

Now, suppose the environment continues its historical pattern, maintaining a very dim lighting around 2. If this is so, then when the surface color darkens to 6, yielding a likelihood which assigns equal probability to the return being caused by all illuminance-reflectance pairs whose product is 12, our mole will experience color constancy. The prior assigning the highest probability to an illuminance of 2 will reduce the uncertainty in the likelihood, yielding a posterior which assigns highest probability to a reflectance of 6. Here we have a simple example of a Bayesian color constancy mechanism.

Now I turn to the central example of a constancy mechanism which can be subsumed under the Bayesian framework. This constancy mechanism will provide a counterexample to the Lack of Proximal Correlation Principle. The example I will give is a simplified version of a more complicated constancy mechanism that might be employed by actual animals, and has at least been proposed as such.

Two complications need to be made to the simple Bayesian color constancy employed so far. In the above presentation of the Bayesian approach to color constancy, the Bayesian algorithm was $p(i,s|r) = p(r|i,s)p(i,s)/p(r)$. The visual system was trying to solve for illumination and reflectance. However, many models of color constancy do not take this form. There are models which work by "discounting the illuminant". On the extreme, these models propose that, at least with respect to the experiences being investigated, the visual system only represents the surface color of things, not the illuminance or the illuminant. The idea is that the illumination is a confounding factor, a distraction to the visual system's aims, and needs to be done away with. This has consequences for the Bayesian algorithm proposed. For example, Brainard and Radonjic (2014) describe the work of Brainard et al. (2006) as assuming "that observers, in effect, use a specific Bayesian algorithm to estimate the illuminant and then discount the effect of this estimated illuminant" (549). The effect being discounted is the confounding effect the illuminant has on the visual system's detection of the reflectance.

Alternatively, some employ the Bayesian framework in the way it was originally presented here, assigning probabilities to both the illuminance and the reflectance[70].

The example that follows will involve a Bayesian algorithm which also discounts the illuminant. It is not meant to be an accurate model of our processes of color constancy, only a possible example of a constancy mechanism. This leaves open whether there are experiences that represent illumination and whether there are additional computations which estimate illumination.

[70] See, for example, Allred and Brainard (2013).

The second complication concerns advancing beyond the processing of the return, illuminance, and reflectance of a single, small surface. The example will involve multiple surfaces, instead. However, the idealization of a flat, viewer-facing surface will be maintained.

Let's make some psychophysical assumptions: the maximum reflectance intensity is 10 units of some measure. The maximum illuminance/illuminant intensity is 10 units of the some measure. The example will only involve achromatic colors, intensities and luminances, so I will assume the reflectances, returns, and illuminances have chromaticities of equal-energy at each wavelength. Suppose there are surfaces A and B. A has a reflectance of 10. B has a reflectance of 5. The entire scene is illuminated by a diffuse, even, equal-energy light so that all surfaces have an illuminance with an intensity of 6. Suppose this illumination has the intensity of normal daylight. Thus, the return of A is 60 and the return of B is 30. Suppose to us, and anything else that represents the scene veridically, A looks white and B looks middle-gray.

Let's consider a Constancy-Free Subject who does not employ a constancy mechanism, and assume that under these conditions, she enjoys a veridicality sweet-spot. Recall from the case of the stick in water from Section 4.2, that even a subject without a particular constancy mechanism represents veridically sometimes. We lack a constancy mechanism that offsets the effects that multiple intervening media with different refractive indexes have on the proximal stimulation. So from many viewing angles we misrepresent the shape of the stick in water. However, at the right viewing angle, there is a veridical sweet-spot. Therefore, it is plausible that the Constancy-Free Subject viewing the scene under equal-energy, normal light would also have a veridical sweet-spot, representing the figure as a normal human viewer would. So she represents A as white and B as middle-gray.

Now, suppose at some later time, t2, the original uniform illuminance is halved to an intensity of 3. Thus, the luminances of the returns of A and B are halved, to 30 and 15 respectively. Without a color constancy mechanism, the Constancy-Free Subject's experience corresponds to the return. As a result, the Constancy-Free Subject has an experience in which the represented color of A and B is half of what it was at t1[71]. A is represented as middle gray, and B is represented as a dark gray.

What color constancy mechanism might provide achromatic color constancy for the scene? I will consider an early hypothesized constancy mechanism called The Highest Luminance is White Assumption (Gilchrist 2006; Foster 2011). The basic idea is that, given a return array which corresponds to the regions of some distal surface that reflects that return array, the regions of the surface that reflect returns with the highest or most intense luminance are represented as white. The represented achromatic colors of the other regions of the distal surface are scaled according to their relative return luminances. The Highest Luminance is White mechanism provides color constancy for the scene at t2. Even though the illumination of the scene uniformly changes at t2, the relationship between the return luminances of surfaces remains the same. So by following this "assumption" the visual system will continue to represent A as white and B as middle-gray.

The Bayesian modeling of color constancy can incorporate The Highest Luminance is White Assumption in the form of, one might say, The Highest Luminance is White Prior. To see this, first, matters must be complicated beyond the simple Bayesian modeling applied only to a single small surface with a single reflectance, illuminance, and return. We need at least two surfaces, A and B. So the likelihood will involve a probability distribution for multiple regions. We can consider a simple case in which the return, illuminances, and reflectances of each region

[71] Idealizing for simplicity that color represented falls off linearly with return luminance.

are independent and have no effect on one another[72]. The likelihood will assign, to each surface, probabilities to a return being produced by each reflectance and illuminance. At t2, A's return of 30 has equal chances of being caused by any reflectance, s, which, when multiplied by the value of the illuminant equals 30. So, for example, it is equally probably that the reflectance is 10, where the illuminant is 3, or 3, where the illuminant is 10, or 8, where the illuminant is 3.75. Similar points apply to the likelihood of B at t2. So what we want is a prior which, when combined with the likelihood, produces a posterior which adjusts the likelihood such that the highest probability is assigned to a reflectance of 10 for A and a reflectance of 5 for B.

We saw in the mole case that its visual system assumed that the environment is fairly dark, and thus it employed a prior which assigned highest probabilities to illuminance-reflectance pairs which had illuminances around 2. Qualitatively described, what prior might a visual system employ which captures The Highest Luminance is White Assumption? The higher a surface's reflectance-intensity and illuminance-intensity, the higher its return-luminance since the product of the former values equals the return-luminance. So the prior will reflect that, for example, the surface with the highest reflectance-illuminance product has the highest probability of being white. And the surface with the next highest reflectance-illuminance product will have the highest probability of being a gray proportional to how much lower its product is compared to that of the highest product. Generally, the prior compares the illuminance-reflectance products across surfaces. Then, the probability it assigns to an achromatic color for each surface is proportional to the rank of that surfaces illuminance-reflectance product, relative to the illuminance-reflectance product of all other surfaces.

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[72] This simplifying assumption would be violated in more complicated circumstances in which there are, for example, inter-object reflections.

So given a likelihood that assigns equal probability to A's illuminance-reflectance pairs of (10,3), (3,10), (8, 3.75), (3.75, 8), etc. and to B's illuminance-reflectance pairs of (5, 3), (3,5), (3.75, 4), (4, 3.75), etc. the prior shifts the posteriors probability distribution away from that of the likelihood. Since the prior compares the illuminance-reflectance products between A and B, and A has the highest products, the posterior assigns the highest probability to A being white (having a reflectance of 10) and so assigns the highest probability to A having the pair (3, 10). Since B's illuminance-reflectance products are half of A's, the posterior assigns the highest probability to it being middle gray (having a reflectance half of 10), and so it is assigned the highest probability of having the pair (3, 5).

As noted earlier, since this is an illumination-discounting mechanism, at some point in the computation of the output, the illumination is dropped, leaving only the representation of surface color. Where this occurs is not relevant for present purposes.

So, at t2 when the illumination of A and B halves uniformly, and the returns of A and B halve, a Constancy-Free Subject's color representations halve. However, for the Constancy-Having Subject whose visual system employs The Highest Luminance is White Prior, A continues to be represented as white, and B continues to be represented as middle gray.

4.4.3. The Explanation of Type-2 Illusions

However, a visual system that employs the Highest Luminance is White Assumption/ Highest Luminance is White Prior as its sole constancy mechanism will cause illusions in some circumstances. The mechanism works to deliver color constancy only when the illumination is uniform across the scene. Also, the mechanism delivers color constancy only when there is a white surface. Suppose that at t3, A and B, respectively having reflectances of 5 and 2.5, are illuminated by a 6-intensity illuminant. If the entire scene consisted of A and B, then the relationship between their luminances is the same as that of the scene at t1. At t3 A still has the highest return-luminance and B's return-luminance is still half of A's. Thus, A will be represented as white and B will be represented as middle-gray. Thus, this Constancy-Having Subject would be subject to a color illusion. However, the Constancy-Free Subject experiencing the scene at t3, whose visual system represents veridically when there is equal-energy, normal lighting, would have a veridical-sweet spot, experiencing A as middle-gray and B as a darker gray.

Here we have a case of a Type-2 illusion in the illusion had by the Constancy-Having Subject. The illusion is not because of a lack of color constancy with respect to the scene at t3, where the visual system treats a return as if it were caused by whatever reflectance is compatible with an equal-energy illuminant of normal intensity. Instead, the illusion results from the particular assumption/prior that the Constancy-Having Subject's visual system employs- Highest Luminance is White Assumption/ Prior. This shows that constancy mechanisms can have trade-offs. They can avoid representing one scene illusorily, in the way that this prior does with the scene at t2. However, that very mechanism causes an illusion with respect to the scene at t3. And we see that the Constancy-Having Subject's illusory experience of the scene at t3 is avoided by the Constancy-Free Subject. Thus, sometimes the use of one color constancy mechanisms comes at a cost, leading to an illusion that the Constancy-Free Subject isn't subject to. Call this phenomenon The Cost of Constancy. It explains why the Constancy-Having Subject's experience of the scene at t3 is illusory. In general it provides a plausible explanation of Type-2 illusions and our illusory experience of Figure 4.3. The Adelson checkershadow illusion, which we have in Figure 4.3, is the result of the particular prior that our visual system employs in providing color constancy with respect to the real checkerboard. However, a Constancy-Free Subject experiences Figure 4.3 veridically.

Having introduced Bayesian approaches to color constancy mechanisms, I have provided The Highest Luminance is White Assumption/Prior as an example of a constancy mechanism which will be employed in what follows to argue against the Lack of Proximal Correlation Principle and Schulte's solution to the Distality Problem.

4.5. Against the Lack of Proximal Correlation Principle

As was seen above, Type-2 illusions are plausibly explained by the particular type of constancy mechanism that a visual system uses to avoid Type-1 illusions. Thus, there's the Cost of Constancy phenomenon: by avoiding some Type-1 illusions, a visual system gains some Type-2 illusions. In this section, I argue how the above points about constancy mechanisms undercut the Lack of Proximal Correlation Principle, at least in one sense. The claim will be that there are perceptual constancies where there is some aspect of the proximal stimulation which is as correlated with the representational state as the distal is. This, in turn, challenges Schulte's solution to the Distality Problem.

First, recall that the Distality Problem arose, in part, because of the fact that "responding to variations in patterns of light that hit the retina is the means by which a visual system responds to visible features of distal objects. And…if a system was selected for doing one thing *by* doing another then it was selected for doing both" (Neander 2017: 219). So the visual system has a response function for each proximal state in the causal chain from the initial distal cause to the final representational effect. However Schulte denies that, for constancy-having representational states, the visual system has all of these proximal response functions. This is because of the Lack of Proximal Correlation Principle and the assumption that a visual system can have the function to respond to something by producing some state only if that something is present in all productions of that state and is present in the function-conferring circumstance. Thus, according to Schulte, the proximal is excluded from being part of the response functions of constancy-involving representations. As I will argue, the problem with this is that there are two ways to think of the proximal. In one way, the Lack of Proximal Correlation Principle is true, in the other way, it is false.

Return to the Highest Luminance is White Assumption/ Highest Luminance is White Prior. We saw that, for the Constancy-Having Subject viewing surfaces A and B at t1, if the illumination were to reduce by half at t2, the subject's experience would still represent A as white and B as middle-gray. If the illumination were to change again, at t3, to twice the original, the content of the experience would still be the same. The constancy mechanism tells us something about what such a visual system is responding to. Corresponding to each co-planar region of the flat scene, there is a region of the return array which is, heuristically, the projection of the scene onto a 2-D surface right before the viewer. When the illumination of the scene uniformly changes, the absolute values of the return-luminances of each region of the return array change. However, there is a property of the return array which remains the same. This is the relative luminance values between the regions of the array, a relational property of the regions. Under scene changes like the one at t2, this property of the return array remains invariant as the reflectances of the distal surfaces remain invariant.

Through this simple constancy mechanism the challenge for Schulte arises. Schulte, expressing the Lack of Proximal Correlation Principle, claimed that the distal state is the only external state that qualifies as a normal cause (i.e. a triggering cause implicated in the response function) of the representational state because "there is no single type of retinal stimulation pattern which normally causes the toad's visual system [or any constancy-exhibiting visual system] to produce [the relevant representations]" (Schulte 361). Recalling that I am making the simplifying assumption that we can identify the return with the retinal or proximal stimulation, we can see from above that this is not the case. If we are only considering variations in particular returns of the return array, where those returns are specified in terms of absolute values of luminances, it is true that between the Constancy-Having Subject's veridical representations of A and B at t1 and t2, there is no common return/proximal stimulation. However, those constancy-involving representations produced by the Highest Luminance is White Assumption do involve a single *type* of return as each representation is tokened across differing specific returns. It is just that what is in common across representation tokenings is a higher-order property of the return, a property of the luminance properties of the return. Thus, when understood in terms of the return, characterized most specifically, the Lack of Proximal Correlation Principle is true. However, at the proper level of abstraction, the Principle is false for visual systems employing constancy mechanisms like Highest Luminance is White Assumption[73].

One might worry that, though there are various properties instantiated by a token return-array input, these high-level properties are not causally relevant and only the low-level properties of the return are. Therefore, Schulte is right after all. However, Neander's causal-informational teleosemantics, as captured by CT, claims that these high-level properties are causally relevant. And since Schulte responds to the Distality Problem from within CT, the problem still stands.

To see that high-level properties are relevant according to CT, let's return to the end of the thesis. CT states that systems with response functions respond to "C-type events…in virtue of their C-ness" (Neander 2017: 151). In this way, the causation involved in Neander's

[73] This problem for the Lack of Proximal Correlation Principle is present even if the simplifying assumption which identifies the return with the retinal stimulation is dropped. There will be higher-order properties of properties of retinal cells. The account just becomes more complicated.

psychosemantics is property-sensitive (159). Roughly, Neander cashes out property-sensitivity in the following way: Amongst simultaneously co-instantiated properties of an object, the instantiated property which causes the relevant representation to be produced by a perceptual system is the property for which, if only it were instantiated, the representation would have occurred, and if it weren't, but competing properties were, instantiated, then the representation would not have occurred (271).

As introduced in Section 4.2, Neander appeals to this property-sensitive causation in order to argue that tectum representations represent low-level surface properties instead of properties like being food, being nutritious, or being a fly. Return to the toad example. When the fly flies past, causing T5(2) activation, between being a fly, being food, and being SDM, which property is causally relevant? Applying the above principle of property-sensitive causation: If the object that flew past were a bee-bee and so not a fly or food but still SDM, then T5(2) activation would occur. But if it had been a frog-food fly which was not SDM, then T5(2) activation would not have occurred. Thus SDM is causally relevant in the response function. Therefore, only those properties and not being a fly or being frog food enter the content of T5(2)[74].

This property-sensitive causation extends to the proximal. At some level, the proximal has to be the causal intermediary between the representation and the distal state. But is it the absolute values of luminances at each region in the return array that are causally relevant, or is it a higher-order property captured by the Bayesian prior that is causally relevant? Let's consider this with respect to the Highest Luminance is White Prior and the higher-order property that it turns on. Applying Neander's account of property-sensitive causation, if the return had

[74] See Green (2018) for discussion of Neander's use of property-sensitive causation and potential problems it creates for her preferred perceptual contents in cases of representing succession and motion.

instantiated that higher-order property but not the same absolute chromaticity and luminance, the experience would have occurred. Typing experiences by what they represent, this is true because this is just what happens as the situation changes from t1 to t2 to t3. The higher-order property of the return is invariant under some changes in the absolute value of the return.

Now for the second counterfactual: if the return array had instantiated the same absolute luminances but not the same higher-order property, then the experience would not have occurred. This is true because the absolute luminances of the regions of a return array necessitate the higher-order properties and relations between those regions. For example, if the higher-order relation between two return regions is *being of different luminance values*, this supervenes on the absolute luminance values of the related regions. So the antecedent of the conditional is impossible. So, this latter conditional is true vacuously. Therefore the relevant proximal cause is the relational property of luminance values that is reflected by the prior. Thus the visual system of the Constancy-Having Subject has the function to produce representations in response to higher-order properties of returns. Therefore, Schulte has not avoided perceptual states representing the proximal and the distal, which results in a proliferation of representations in seemingly determinate representational states. And so the Distality Problem is not resolved.

The case of the Constancy-Having Subject who employs the Highest Luminance is White Assumption is a challenge if it is merely a metaphysically possible, but not an actual, instance of color constancy. Schulte, and Neander, are providing a *constitutive* account for representation in terms of response functions, etc. So the possibility is a sufficient counterexample. But maybe one might doubt the possibility of such a case, for example thinking that the mechanism is too impoverished or simple. However, given the Cost of Constancy phenomena in actual cases of constancy, actual, complex constancy mechanisms plausibly turn on higher-order properties of proximal stimulation.

We have Type-2 illusions. A plausible explanation, at least as I argued, is that we have a constancy mechanism that faces the Cost of Constancy. Our visual system employs some mechanism in order to avoid Type-1 illusions with respect to shadowed checkers in real checkerboards. However, whatever the constancy mechanism is, and the prior that it employs, it results in a Type-2 illusion of Figure 4.3. Though current vision research is far from understanding the constancy mechanism and prior we employ, that we and the Constancy-Having Subject face the Cost of Constancy suggests that there is some complex, higher-order property of returns which is causally responsible for our tokenings of the experience we have upon viewing the real checkerboard and Figure 4.3. At the very least, this is an open question, requiring highly recherché investigation and so cannot yet be ruled out. But the representations of the checkerboard are certainly determinate and involve color constancy, so Schulte is not in a position to conclude that the determinate representation is because of the experiences being produced without sharing a common higher-order property of the proximal stimulation.

4.6. Conclusion

Neander's Causal-Informational Teleosemantics aims to ground perceptual representation in the response functions of the visual systems. However, the visual system seems to have numerous functions to respond to the intermediary links in the causal chain from the pre-theoretic objects of perception to the produced perception. This Distality Problem threatens the theory's ability to secure determinate representations when those representations are the final result of a long causal chain. To solve this problem, Schulte appeals to the perceptual constancies found in visual systems and argues that the visual system does not have a proliferation of response functions with respect to the intermediate causal links since such links are not present in all productions of the perceptual representations.

I argue that the common picture of perceptual constancy enshrined in the Lack of Proximal Correlation Principle which Schulte bases his argument on is mistaken and a more accurate view undercuts Schulte's strategy for solving the Distality Problem. My argument starts with a type of illusion that lacks an adequate explanation, then, by appealing to a common Bayesian approach to constancy, I propose it is the presence of constancies that cause such illusions. The price a visual system pays in avoiding one type of illusion by employing a constancy mechanism is another type of illusion. This feature of the workings of constancy-involving visual systems suggests that there is some aspect of the proximal stimulation that is not less correlated with the representational state than the distal. This, in turn, challenges Schulte's attempt to rule out the visual system having more than one response function. Thus, Schulte's solution to the Distality Problem is undermined.

BIBLIOGRAPHY

Adelson, Edward H. (1995). Checkershadow Illusion. [Computer rendering]. Retrieved from http://persci.mit.edu/gallery/checkershadow

Allred, S. R., & Brainard, D. H. (2013). A Bayesian model of lightness perception that incorporates spatial variation in the illumination. *Journal of Vision*, *13*(7), 18-18.

Arend, Lawrence, and Adam Reeves. (1986). Simultaneous color constancy. *JOSA A*, *3*(10), 1743-1751.

Arend, Lawrence E., Adam Reeves, James Schirillo, and Robert Goldstein. (1991). Simultaneous color constancy: papers with diverse Munsell values. *JOSA A*, *8*(4), 661-672.

Bäuml, K. H. (1999). Simultaneous color constancy: how surface color perception varies with the illuminant. *Vision research*, *39*(8), 1531-1550.

Bradley, Peter, & Tye, Michael. (2001). Of Colors, Kestrels, Caterpillars, and Leaves. *The Journal of Philosophy, 98*(9), 469-487. doi:10.2307/2678495

Brainard, David H., & Freeman, William T. (1997). Bayesian color constancy. *JOSA A*, *14*(7), 1393-1411.

Brainard, D. H., Brunt, W. A., & Speigle, J. M. (1997). Color constancy in the nearly natural image: I. Asymmetric matches. *Journal of the Optical Society of America A*, 14, 2091-2110.

Brainard, David H. (2003). Color appearance and color difference specification. *The science of color*, *2*, 191-216.

Brainard, David. H., Longere, P., Delahunt, P. B., Freeman, W. T., Kraft, J. M., & Xiao, B. (2006). Bayesian model of human color constancy. *Journal of Vision*, *6*(11), 10-10.

Brainard D. H. (2009). Bayesian approaches to color vision. In Gazzaniga M., editor. (Ed.), *The cognitive neurosciences* (4th ed., pp 395–408) Cambridge, MA: MIT Press

Brainard, D. H. & Radonjić, A. (2014). Color constancy. In The New Visual Neurosciences, Werner J. S. & Chalupa, L. M. (eds.), MIT Press, Cambridge, MA, 545-556

Breckenridge, Wylie (2007). *The Meaning of ``Look''*. Dissertation, New College, University of Oxford

Buchsbaum, Gershon. (1980). A spatial processor model for object colour perception. *Journal of the Franklin institute*, *310*(1), 1-26.

Byrne, Alex & Hilbert, David R. (1997). Colors and reflectances. In Alex Byrne & David R. Hilbert (eds.), *Readings on Color, Volume 1: The Philosophy of Color*. MIT Press.

Byrne, Alex & Hilbert, David R. (1997). *Readings on Color, Volume 1: The Philosophy of Color*. Cambridge, MA, USA: MIT Press.

Byrne, Alex (2003). Color and similarity. *Philosophy and Phenomenological Research* 66 (3):641-65.

Byrne, Alex (2009). Experience and content. *Philosophical Quarterly* 59 (236):429-451.

Byrne, Alex. (2016). Hill on mind. *Philosophical Studies*, *173*(3), 831-839.

Byrne, Alex & Hilbert, David R. (2017). Color Relationalism and Relativism. *Topics in Cognitive Science* 9 (1):172-192.

Caro, T., Izzo, A., Reiner Jr, R. C., Walker, H., & Stankowich, T. (2014). The function of zebra stripes. *Nature communications*, *5*, 3535.

Chalmers, David. (Forthcoming). Three Puzzles About Spatial Experience. In Pautz, A. and Stoljar, D. *Themes from Ned Block*.

Chisholm, Roderick M. (1957). *Perceiving: A Philosophical Study*. Cornell University Press.

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

Cohen, Jonathan (2009). *The Red and the Real: An Essay on Color Ontology*. Oxford University Press UK.

Cornelissen, F. W., & Brenner, E. (1995). Simultaneous colour constancy revisited: an analysis of viewing strategies. *Vision research*, *35*(17), 2431-2448

Dretske, Fred (1986). Misrepresentation. In R. Bogdan (ed.), *Belief: Form, Content, and Function*. Oxford University Press. pp. 17--36.

Foster, David. H. (2003). Does colour constancy exist?. *Trends in cognitive sciences*, *7*(10), 439-443.

Foster, David H. (2011). Color constancy. *Vision research*, *51*(7), 674-700.

Geisler, Wilson. S., & Kersten, Daniel. (2002). Illusions, perception and Bayes. *Nature neuroscience*, *5*(6), 508.

Gilchrist, Alan. (2006). *Seeing black and white* (No. 40). OUP USA.

Green, E. J. (2017). Psychosemantics and the rich/thin debate1. *Philosophical Perspectives* 31 (1):153-186.

Hardin, C. L. (1988). *Color for philosophers: Unweaving the rainbow*. Hackett Publishing.

Helmholtz, H. v. (1924). *Helmholtz's Treatise on Physiological Optics*. Rochester, N.Y., The Optical Society of America.

Hilbert, David R. (2005). Color constancy and the complexity of color. *Philosophical Topics* 33 (1):141-158.

Hilbert, David R. & Byrne, Alex (2008). Basic sensible qualities and the structure of appearance. *Philosophical Issues* 18 (1):385-405.

Hilbert, David R. & Byrne, Alex (2010). How do things look to the color-blind? In Jonathan Cohen & Mohan Matthen (eds.), *Color Ontology and Color Science*. MIT Press. pp. 259.

Hurlbert, A. C. (1998). Computational models of colour constancy. *Perceptual Constancy. Why things look as they do*, 283-322.

Jackson, Frank (1977). *Perception: A Representative Theory*. Cambridge University Press.

Jackson, Frank (2006). The knowledge argument, diaphanousness, representationalism. In Torin Alter & Sven Walter (eds.), *Phenomenal Concepts and Phenomenal Knowledge: New Essays on Consciousness and Physicalism*. Oxford University Press. pp. 52--64.

Johnston, Mark (M.S.) The Manifest. Chapter 5. Draft available here (http://www.nyu.edu/gsas/dept/philo/courses/consciousness97/papers/johnston/chap5.html)

Judd, D. B., & Wyszecki, G. Color in Business, Science and Industry, ed. 2, New York, 1963.

Kalderon, Mark Eli (forthcoming). Color and the problem of perceptual presence. *Dialectica*.

Land, E. H. (1959). Color Vision and the Natural Image. Part I. In *Proceedings of the National Academy of Science* (Vol. 45, pp. 115-129).

Land, E. H. (1959). Color vision and the natural image part II. *Proceedings of the National Academy of Sciences*, *45*(4), 636-644.

Levinson, Jerrold (1978). Properties and related entities. *Philosophy and Phenomenological Research* 39 (1):1-22.

Lotto, Beau R & Purves, Dale (2002). The empirical basis of color perception. *Consciousness and Cognition*, *11*(4), 609-629.

Malacara, Daniel. (2011, August). Color vision and colorimetry: theory and applications. Bellingham, WA: SPIE.
Maloney, Laurence T. (1999). Physics-based approaches to modeling surface color perception. *Color vision: From genes to perception*, 387-416.
Mamassian, Pascal., Landy, Michael., & Maloney, Laurence. T. (2002). Bayesian modelling of visual perception. *Probabilistic models of the brain*, 13-36.
Martin, Michael G. F. (2010). What's in a look? In Bence Nanay (ed.), *Perceiving the World*. Oxford University Press.
McCann, J. J., McKee, S. P., & Taylor, T. H. (1976). Quantitative studies in retinex theory a comparison between theoretical predictions and observer responses to the "color mondrian" experiments. *Vision research*, *16*(5), 445-IN3.
Matthen, Mohan (2010a). How Things Look (And What Things Look That Way). In Bence Nanay (ed.), *Perceiving the World*. Oxford University Press. pp. 226.
Matthen, Mohan (2010b). Color Experience: A Semantic Theory. In Jonathan Cohen & Mohan Matthen (eds.), *Color Ontology and Color Science*. MIT Press. pp. 67--90.
Neander, Karen (2013). Toward an Informational Teleosemantics. In Dan Ryder, Justine Kingsbury & Kenneth Williford (eds.), *Millikan and Her Critics*. Wiley. pp. 21--40.
Neander, Karen (2017). *A Mark of the Mental: A Defence of Informational Teleosemantics*. Cambridge, USA: MIT Press.
Noë, Alva. (2004). *Action in perception*. MIT press.
Palmer, Stephen (1999). *Vision Science: Photons to Phenomenology*. MIT Press.
Pautz, Adam (2007). Intentionalism and perceptual presence. *Philosophical Perspectives* 21 (1):495-541.
Pautz, Adam (2010). Review of Jonathan Cohen, *The Red and the Real: An Essay on Color Ontology*. *Notre Dame Philosophical Reviews* 2010 (3).
Peacocke, Christopher (1983). *Sense and Content: Experience, Thought and Their Relations*. Oxford University Press.
Russell, Bertrand (1912/1999). *The Problems of Philosophy.* New York: Dover Publications, Inc.
Sainsbury, Mark (2008). A puzzle about how things look. In Mm Mccabe & Mark Textor (eds.), *Perspectives on Perception*.
Schulte, Peter (2018). Perceiving the World Outside: How to Solve the Distality Problem for Informational Teleosemantics. *Philosophical Quarterly* 68 (271):349-369.
Schuster, S., Rossel, S., Schmidtmann, A., Jäger, I., & Poralla, J. (2004). Archer fish learn to compensate for complex optical distortions to determine the absolute size of their aerial prey. *Current Biology*, *14*(17), 1565-1568.
Shoemaker, Sydney (1994). Phenomenal character. *Noûs* 28 (1):21-38.
Shoemaker, Sydney (2003). Content, character, and color. *Philosophical Issues* 13 (1):253-78.
Shoemaker, Sydney (2006). On the Way Things Appear. In John Hawthorne (ed.), *Perceptual Experience*. Oxford University Press. pp. 461--480.
Speaks, Jeff. (2015). Is phenomenal character out there in the world?. *Philosophy and Phenomenological Research*, *91*(2), 465-482.
Sterelny, Kim (1990). *The Representational Theory of Mind*. Blackwell.
Strevens, Michael, (Ms.). Notes on bayesian confirmation theory.
Thau, Michael. (2002). *Consciousness and cognition*. Oxford University Press.
Troost, J. M., & De Weert, C. M. (1991). Naming versus matching in color constancy. *Perception & psychophysics*, *50*(6), 591-602

Tye, Michael (2000). *Consciousness, Color, and Content*. MIT Press.
Tye, Michael (2012). Cohen on Color Relationism. *Analytic Philosophy* 53 (3):297-305.
Wandell, Brian A. (1995). *Foundations of vision* (Vol. 8). Sunderland, MA: Sinauer Associates.
Zeiner, Katharina & Maertens, Marianne (2014). Linking luminance and lightness by global contrast normalization. *Journal of vision*, *14*(7), 3-3.