How Cohen and Hilbert Fare on the Commonality and Causality Criteria

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This thesis titled
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Abstract

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How Cohen and Hilbert Fare on the Commonality and Causality Criteria (82pp.)

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In this thesis I assess how well two separate philosophical accounts of color fare on a range of criteria identified as important constraints on philosophical theories of color. The two main criteria I am interested in are those of commonality and causality. The two philosophical accounts of color I assess are those of Jonathan Cohen and David Hilbert. I argue that Cohen and Hilbert's accounts fall short of these two constraints in important ways. Cohen's account fails on the commonality criterion because it cannot identify any shared feature of color properties which do not share the same S or C values but which match nevertheless. Cohen's account fails on the causality criterion because Cohen's functional properties are not correlated with color experiences in the right way and therefore lack the right sort of causal powers to be considered colors.

Hilbert's account of determinate color properties fails on the commonality criterion since he draws color distinctions between objects which we would suppose to be the same color. Hilbert's account of color categories, on the other hand, fails on the causality criterion because, like Cohen's functional color properties, they are not correlated with color experiences in the right way and therefore lack the right sort of causal powers we would expect colors to have.

I conclude that a better philosophical account of color would be one which would take colors to be non-representational features of the visual field. It is then a simple matter to meet the commonality and causality criterion since color science (specifically the opponent process theory of Hurvich and Jameson) predicts that types of color experiences are directly correlated to types of neural events. This correlation between neural events
and colors in the visual field can be appealed to to satisfy both the commonality and the causality criteria.

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Chapter 1: Constraints on a philosophical account of color

In this chapter I identify several broad criteria any philosophical account of color should satisfy. These criteria are: (1) commonality, (2) causality, (3) consistency with ordinary color language, (4) preservation of the structural properties of color. The commonality criterion is intimately related to the phenomenon of metamers, so this section contains a treatment of the topic of metamers as well.

Commonality and Causality

Following the analysis of Yablo, Cohen identifies two criteria which any satisfactory metaphysical account of color must satisfy. The first is commonality, the second causality.1 The commonality criterion requires that there be some property had by all and only objects of the same color. The causality criterion requires that this property had by all and only things of a common color have the right kind of causal power-- more specifically, that this property actually endow objects with the same causal powers we would pretheoretically attribute to colors.

Commonality

Citing Yablo, Cohen explains commonality as follows: "our account of Fness should satisfy the platitude of commonality -- that Fness ... 'is shared by all and only

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Fs'."² In another essay, Cohen puts the commonality criterion this way, "we should prefer an account that vindicates the claim that ... [various physical objects of the same color] all share one and the same color."³

**The non-disjunction proviso**

Consider a paradigmatically disjunctive class, for example, the class of objects which are either planets or geese or can-openers. If we were to apply the commonality criterion to this class of objects, we would be asking, What is it that all and only things which are either planets, geese, or can-openers have in common? If no obvious property could be found which all and only these things had in common, we might resort to an appeal to the disjunctive property of being a planet, a goose, or a can-opener. What this should make clear is that appeal to disjunctive properties simply can't fail as a solution to the commonality criterion no matter how little the elements in the class under consideration have in common. Because of this result we should reject any proposed solution to the commonality criterion that resorts to disjunction. Call the rule that forbids appeal to disjunction the "non-disjunction proviso".

**Causality**

Cohen explains the causality criterion as follows: "our account of Fness should ... allow that Fness 'has F-ish causal powers'."⁴ Elsewhere Cohen endorses the causality

² Cohen, 2005, pg. 3

criterion by asserting that a good account of color should respect the "pre-theoretically plausible intuition" that "Colors endow things with their dispositions to look colored."\(^5\)

The relation between the commonality requirement and the causality requirement is this: the commonality requirement is the requirement that some property be identified which is shared by all and only objects of the same color. The causality requirement is that that property, once identified, should have the right type of causal power.

I will not offer a full account of causality in this paper. Rather I will simply suggest that one method for determining what causal powers a property has is to identify key questions about key phenomena which appeal to the property is able to explain. If the property plays an important role in the explanation of the key phenomena, and in answering the key questions, this counts as evidence that it has the right kind of causal powers. I think this method itself is uncontroversial. What is controversial is how to identify which questions and which phenomena should be considered "key".

**The common language/ common intuitions criterion:**

It is broadly acknowledged that no account of color will be consistent with all of our ordinary talk about colors. This is because our ordinary talk about color reflects inconsistent intuitions about color. This inconsistency is due to the fact that different

\(^4\) Cohen, 2005

users of color language have different ideas about what colors are and what the scientific facts about colors are.

While no philosopher can demand complete consistency with all types of ordinary language and common conceptions of color, any satisfactory philosophical account of colors must have a certain amount of consistency with ordinary color talk. As Hilbert puts it, "Although ... there is some dispute as to which truths about colors are central to our concept of color, at least some pre-analytic statements about color must come out true in any serious account of color."\(^6\)

Hilbert appeals to common language to support his view that colors are relatively stable, illumination-independent features of surfaces. Cohen appeals to common language in support of the views that (1) if two surfaces match to a normal observer under normal lighting conditions, then the two surfaces have the same color; and (2) external objects are the bearers of color properties.

When the common language criterion is not met, the account in question faces the charge of (1) revisionism or (2) changing the subject. Consider the following passage by Hardin as an example of how this criticism can be employed: "When somebody tells me that she has a theory about colors, I expect it to be a theory of yellow and green and the like, and if I get a story about spectral luminance or reflectance profiles, or whatever,... I feel cheated. No matter how brilliant her discourse, she has changed the subject."\(^7\) The point that Hardin is making is that in order for an account of color to be an account of

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color (as opposed to an account of something other than color), it can't depart too radically from common conceptions of color. At a bare minimum, it has to have enough in common with ordinary conceptions of color as to be recognizable as an account of color.

On the other hand, it must be recognized that whenever scientific facts conflict with common intuitions and common talk about color, the facts overrule the common intuitions. Indeed, many common ideas about color are simply based on false or confused ideas about color. Hilbert puts it this way, "If we build a large amount of colour lore and phenomenology into the concept of colour, then there will be no physical property to fit the bill."8

**Structural properties criterion**

The structural properties criterion is the requirement that a satisfactory metaphysical account of colors should allow that colors bear certain structural relations to one another. For example, orange is more similar to red than it is to blue. Blue is more similar to purple than it is to red. Hilbert has this to say about the structural properties criterion: "An analysis of color in which it is not true that orange is more similar to red than it is to blue seems not to be an analysis of color at all."9

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9 Hilbert, 1987, pg. 115
Metamers and Isomers

The commonality criterion runs up against the empirical difficulty of metamers. Hardin explains metamers as follows:

"Two light distributions that differ in their wavelength constituents but are indistinguishable in color for a given observer are said to be metamers for that observer. By extension, one can speak of objects that match in color (for a given observer) under a given illumination as matching metamerically (for that observer). If they match under all illuminations, they are said to match isomerically."

Following this definition, then, two or more objects are metamers (for viewer x) just in case (1) there is some illumination under which the objects will match for x, and (2) there is some illumination under which the objects will not match for x. By contrast, two or more objects are isomers (for viewer x) just in case they match under every illumination for viewer x.

The phenomenon of metamers shows that there is no easy solution to the commonality criterion suggested by our best scientific theories. Rather, science seems to show that there is no obvious physical property had by all and only objects of a single color. Whether or not this is the case will depend on what we take colors to be. But suppose we understand an object to be red just in case it looks red to a normal observer under normal lighting conditions. Suppose we gather up a diverse, representative sample of "red" objects. What our best scientific theories currently predict is that all the

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10 Hardin, 1988, pg. 28
11 Cohen, 2005, pgs. 7-8
techniques currently at the disposal of colorimetry, chemistry, and physics would be unable to find a single property had by all and only those objects.

These difficulties present themselves even for very narrowly defined color categories. For example, suppose we define the ultra-narrow color fire-engine-red as the color an object has if and only if it matches the color of Fire engine x under fixed viewing conditions C for normal observers. If we gather up a representative cross section of a wide variety of surfaces that exhibit the color fire-engine-red (e.g. fire engine x, accurate photographs of fire engine x, certain types of fruit, certain paintings of fire engines) and analyze these surfaces using all the techniques at the disposal of colorimetry, chemistry, and physics, we will still be unable to find any single physical or chemical property had by all and only surfaces which look fire-engine-red to normal observers under fixed viewing conditions C.

**Metamers and normal lighting**

Some metameric matches make more trouble for some theories than do other metameric matches. This is because some theories identify certain lighting conditions as necessary for deciphering an object's true color. For example, one popular theory (dispositionalism) has it that an object really is (e.g.) red only if it looks red under normal conditions. On this account any two surfaces which both looked the same shade of red under normal conditions would be considered a match regardless of whether or not they matched under some other conditions -- (e.g.) a blacklight. For theories which specify privileged viewing conditions under which an object’s "true colors" are revealed, the
phenomenon of metamers will only matter if the surfaces vary under those normal conditions. For example, suppose a theory counts either sunlight or incandescent light as sufficient for determining an object's true color. Then for this theory the only metamers that will present difficulties are those which match under one privileged condition (say sunlight) and fail to match under another privileged condition (say incandescent light).

The fact that "normal" lighting conditions are so often appealed to in accounts of colors makes the class of objects which vary in color under normal lighting conditions an especially important bunch of metamers.

**Hilbert on the nature and extent of the phenomenon of metamers**

Hilbert defines metamers as follows: "Two surfaces that are different in their dispositions to reflect light but that are visually indistinguishable are known as metamers."\(^{12}\) Since dispositions to reflect light can be represented as spectral reflectance profiles, we get the following definition of metamers: two or more surfaces are metameric if and only if they have different spectral reflectance profiles and are visually indistinguishable.

This raises the question of how to individuate spectral reflectance profiles - how to determine whether or not any two spectral reflectance profiles are significantly different. There are two major considerations in determining what differences are to count as significant: (1) whether they make an "obvious" difference in the shape of the

\(^{12}\) Hilbert, 1987, pg. 85
curve, (2) whether or not they make any difference to how the surface looks to certain viewers under certain conditions.

Two more related questions which have to be taken into account are: (3) Should the reflectance properties a surface has with respect to the extra-visible portions of the spectrum count as significant to the identity of the reflectance? (4) Should the way objects would look to some possible visual system be taken into account in determining whether or not two or more reflectances are significantly different?

On question (3), it seems clear that Hilbert does not think reflectance profiles need to be individuated based on how they reflect radiation from the extravisible portions of the spectrum. His position can be inferred from the following description he offers of metamers: "Metamers are objects with surface spectral reflectances that, although different, reflect the same amount of light within each of three wavebands corresponding to the sensitivity ranges of the human photoreceptors."13 Since radiation from the extravisible portions of the spectrum does not fall within any of the three "wavebands corresponding to the sensitivity ranges of the human photoreceptors", it would seem to follow that Hilbert does not consider it relevant to an object's spectral reflectance profile. (However, this point seems at odds with his odds with an implicit principle he seems committed to, a principle I call the isomeric principle. If we take the IP seriously, I argue, we must accept that there are real color distinctions to be inferred from the extravisible portions of surfaces reflectance profiles.)

13 Hilbert, 1987, pg. 108
The extent of the phenomenon of metamers (how common metamerism turns out to be) will depend on how narrowly reflectance types are to be individuated. The key evidence that Hilbert is committed to an especially fine-grained individuation of spectral reflectance profile comes in the form of an argument against color-distinction illusions.

**Hilbert's argument against color-distinction illusions**

Hilbert makes an argument against a certain form of dispositionalism on the grounds that it renders certain perceptions illusory even though they reveal real differences in the things perceived. On the view under attack by Hilbert, two objects are the same color just in case they match to a designated "standard observer". But, argues Hilbert,

"For any specification of the standard observer there will be people ... who will perceive slightly different [color distinctions than the standard observer]. Some things that look to be the same in color to the standard observer will appear different in color to some people. ... This sort of variation in the ability to perceive color distinctions has undesirable consequences for the dispositionalist view. ... The dispositionalist is forced to the view that [non-standard viewers] ... may suffer from color-distinction illusions ... and that these illusory perceptions may convey information about existing physical differences between the objects being misperceived."

The main reason Hilbert seems to have for rejecting that the non-standard observer he has in mind is suffering from an illusory perception is that the basis for his perception of the illusory color difference is a real physical distinction of the sort involved in vision. Therefore, it would seem fairly clear that a premise at work in Hilbert's argument is that any difference between two reflectance profiles A and B which

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14 The non-standard observer Hilbert has in mind is a fairly normal viewer.
could potentially result in a difference in perceived color by any observer \( x \) is grounds for regarding \( A \) and \( B \) to be different in color. This premise is perhaps more problematic than Hilbert realizes since it threatens his claim that metamerism is not all that common.

It is worth noting that the non-standard observer who Hilbert has in mind in his argument is not colorblind and is fairly normal. Presumably Hilbert chose this type of viewer for his argument to maximize its persuasiveness to the broadest possible audience. That said, it doesn't seem to me that changing his observer to a highly anomalous or colorblind human, real or possible would change the argument’s efficacy; and furthermore there seems no reason why Hilbert could object to this change. If any viewer whatsoever were able to notice a color difference between \( A \) and \( B \) based on any physical difference between \( A \) and \( B \)'s dispositions to reflect light we would seem to have grounds for regarding the perception as a non-illusory perception of a color difference. This premise suggests a principled way of individuating spectral reflectance types in cases in which the curves appear pretty much to match. Call this principle the isomeric principle:

\[
(\text{IP}) \text{ Two reflectance profiles are the same type if and only if they are isomeric to } x.
\]

I think the premise at the heart of Hilbert's argument gives us ground for interpreting '\( x \)' very broadly. And of course, the more broadly \( x \) is interpreted, the more fine grained the taxonomy of reflectance types becomes. I see no reason why we shouldn't interpret \( x \) as "any possible visual system. Thus (IP) becomes"
Two reflectance profiles are the same type if and only if they are isomeric to every possible visual system.

**Hilbert on the extent of metamerism**

Hilbert cites the work of Maloney and Wandell (MW) in an effort to show that "metamerism may not be all that common".\(^{15}\) Hilbert tells us that "Maloney and Wandell approach the problem of color constancy by "assuming that the function of color vision is the determination of the spectral reflectance of the objects in the visual field."MW's work aims at developing an algorithm that "recovers the spectral reflectances in a scene." They claim that "Under certain conditions it is, in fact, possible to visually obtain information regarding the reflectances of the surfaces in a scene." However, this is only possible if we assume that the spectral reflectances and illuminations are not "allowed to vary arbitrarily".\(^{16}\) Now this is a very strange thing for Hilbert to mention because I think it shows that Hilbert is committed to a different taxonomy of reflectance types than MW.

Note that the work of MW assumes that the only way it is possible to "accurately determine the reflectance of an object" is under conditions in which reflectances are not allowed to vary arbitrarily. This suggests that MW use a highly limited number of canonical profile types in their research and that any given profile is classified according to which of the canonical profiles it is closest to (presumably on the basis of some curve matching algorithm rather than the IP). On the other hand, I have argued that Hilbert is committed to the view that what makes any two profiles identical is (among other things)

\(^{15}\) Hilbert 1987, pg. 127
\(^{16}\) Hilbert, 1987, pg. 128
the fact that they are isomeric to certain visual systems. Let me clarify: what makes any two reflectance profiles the same is that they have the same curve. However, it might be that no two actual reflectance profiles have the exact same curve. Therefore we need to introduce principles like the IP to determine whether or not two curves which look the same to the naked eye or which both fit some curve-matching algorithm are close enough to count as the same.

If we accept a taxonomy of reflectance profiles that uses the IP as the basis for determining significant degrees of similarity, then we have accepted a taxonomy of reflectances in which reflectances are allowed to vary arbitrarily.

Many objects which are metameric by Hilbert's taxonomy of reflectances will not be metameric by an artificially limited taxonomy of reflectances. I think I have now shown that Hilbert is not justified in drawing the conclusion he does from the work of MW. Rather, given Hilbert's argument against color-distinction illusions (from which we infer the IP), we should be led to a suspicion that the phenomenon of metamerism is just as likely to be the norm as the exception.

**Worst case scenario**

In a worst case scenario for Hilbert the following situation obtains: (1) the great majority of color matches made by normal humans are metameric; (2) the color distinctions noticed by normal humans is a tiny percentage of the actual (invisible) color distinctions surrounding us in the world. This is a worst case scenario because this situation, together with his claims about the content of color perception may commit him
to the view that much of the content of everyone’s visual color experience is erroneous or illusory.

Having now introduced the phenomenon of metamers and many of the elements of Hilbert’s work, I will now turn to an assessment of how Hilbert and Cohen fare on the commonality criterion. This will be followed by an assessment of how Hilbert and Cohen fare on the causality criterion.
Chapter 2: Hilbert on the commonality criterion

In this section I consider how Hilbert and Cohen answer what I will call the commonality question, What is it that all and only objects of the same color have in common? I begin with Hilbert's answer because his account of colors is less abstract than Cohen's.

Hilbert argues that the determinate color of an object is its disposition to reflect light. This property can be represented as a spectral reflectance profile. Hilbert argues that color categories are anthropocentric kinds, any one of which can be represented as a simple mathematical formula having a specific range of values. In contrast, Cohen thinks that colors are functional, relational properties of objects.

The strong commonality criterion vs. the weak commonality criterion

Recall that the commonality criterion requires that some common property be found which is had by all and only things of a common "color". How Hilbert fairs on this criterion will depend on whether or not we adopt a strong or weak interpretation of the criterion. On the strong interpretation, we interpret the term 'color' which appears in the criterion as applying to a commonsense, pre-theoretical conception of color; on the weak interpretation we interpret 'color' as referring to the technical, post-analytic conception of color proposed by the account under review. Call the commonality criterion interpreted strongly the strong commonality criterion; and call the commonality criterion interpreted weakly the weak commonality criterion.
With this distinction in mind, I will show that Hilbert's account of determinate colors does not satisfy the strong criterion but does seem to satisfy the weak interpretation of the commonality criterion. Hilbert's account of color categories goes further to satisfy the strong criterion than his account of determinate colors.

**Determinate colors vs. color categories**

Hilbert distinguishes between determinate colors and color categories and offers a separate account of each. Hilbert identifies the individual color of any given object with that object's "surface spectral reflectance" which is "its disposition to reflect a certain percentage of the incident light at each wavelength."\(^{17}\) Hilbert thinks that a spectral reflectance profile provides a literal description of an object's color. On this view individual colors can be characterized as fine-grained, highly precise spectral reflectance profiles. Hilbert identifies color categories with "indeterminate" classes of spectral reflectances. When a creature sees that two objects differ in color, she sees that they have different spectral reflectance profiles. When a creature sees that two or more objects have the same color, she sees that they belong to a common class of reflectances which fits a "simple mathematical description."

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\(^{17}\) Hilbert, 1987, pg.65
Determinant colors and commonality

Hilbert's claim that individual colors are surface spectral reflectances, has the result that objects which appear to match exactly in color (to some observer(s) in some circumstance(s)) may not actually be the same color.

As I mentioned earlier, Hilbert would seem to be committed to the view that any difference in color between objects A and B which is detectable by any creature under any circumstances reveals a genuine difference in color between A and B so long as the apparent difference between A and B is due to a difference in reflectance profiles between A and B. Hilbert is committed to this view since he argues that any detectable difference between A and B which reveals a real difference in A and B cannot be considered an illusion. The result is that a great many things we would typically call the same color are not the same color at all.

The argument from photographic prints, I

The purpose of the argument from photographic prints is to drive home the point that Hilbert's identification of individual colors does not satisfy the strong commonality criterion. It does not do so because on Hilbert's view we must say that many or most photographic prints are not the same colors as the objects they represent. (The important point is that this goes for prints that we would tend to say match their subject exactly in color when viewed under some normal conditions.)

One case that I think is especially problematic for Hilbert is that of photographic prints. The process for mixing inks used in color photographs is designed to capture the
color of the photographed objects only when the photo is viewed under normal lighting conditions. As a result it is highly unlikely that the reflectance profiles found on the surface of any given photographic print will actually exactly match the reflectance profiles of the objects represented in the photo. We thus arrive at the counterintuitive result that even when a photograph seems to perfectly capture the colors of the objects it represents, it probably doesn't.

From this it clearly follows that Hilbert's account of determinate colors does not meet the strong commonality criterion.

The weak commonality criterion, on the other hand, is not especially difficult to meet. The weak criterion only requires that any two things which qualify as having the same color have some feature in common. This criterion is automatically met by Hilbert's definition of determinate colors: any two objects which have the same (technically defined) determinate "color" will have the same spectral reflectance profile. We are now in a position to see that the weak commonality criterion is quite weak indeed! -- so we can dispense with using it as a criterion for assessing accounts of color.

**Color categories and the commonality criterion**

Hilbert acknowledges that objects with different reflectance profiles often appear to match in color. Hilbert denies that this is an illusion and claims that when normals see things as matching, they are seeing that the matching objects are all members of a certain class of reflectances. Although the members of this class share "no interesting physical property", they do share some common property had by [almost] all and [almost] only
members of this class.\textsuperscript{18} The property they share is a property of their reflectances, viz. the property of satisfying a certain "simple mathematical description".\textsuperscript{19}

Hilbert puts it this way, "it is possible to give a simple mathematical description of the range of reflectances compatible with a given color perception .... For an object to be red on my account is for it to have a reflectance that falls within a particular class."\textsuperscript{20} If this claim is true, then Hilbert has gone part of the way toward satisfying the strong commonality criterion: he has identified some property had by all objects of a certain (pre-theoretical) color. However, it is crucial for Hilbert to identify not only some property had by all objects of a certain color; this property must also be had by only objects of that color. This second feature of commonality -- the "and only" clause is what makes the commonality criterion so hard to satisfy. Without this second requirement, Hilbert could satisfy the commonality criterion simply be developing a mathematical description which is satisfied by all reflectance profiles.

From the context in which the above quote appears, it seems clear that Hilbert thinks the "simple mathematical description" he cites does in fact do the work he needs it to do. What Hilbert seems to mean by his claim is the following:

"it is possible to give a simple mathematical description of the range of reflectances compatible with [all and only instances of] a given color perception."

Hilbert might be able to get away with a somewhat weaker version of the above claim, but he surely needs something like the part I have inserted in order to sustain two

\textsuperscript{18} Hilbert, 1987, pg. 110
\textsuperscript{19} Hilbert, 1987, pg. 111
\textsuperscript{20} Hilbert, 1987, pg. 111
conclusion he makes in his 1987 book. They are: (1) colors are reflectances rather than the spectral light distributions of the light reflected of the surface, (2) the structural properties of colors are properties of surfaces. (1) is beyond the scope of this paper. Concerning (2), Hilbert says it is a feature of his account that structural properties like the one expressed in the claim 'Red is more like orange than it is like blue' are rendered true. Another structural property of colors Hilbert would surely want to preserve is the exclusivity relation like the one expressed in the claim 'If a thing is red then it isn't yellow'. If Hilbert is to do this, then he will have to identify some property had by red things which is not also had by yellow things. To do this, he will need something like the clause I have added.

Unfortunately, with the all and only clause added, Hilbert's claim becomes empirically unsustainable. Hilbert relies upon Land's retinex theory to establish his critical result. But (as Hardin convincingly argues and Cohen echoes) Land was only able to secure this result by limiting his studies to normal viewers under highly constrained lighting conditions. If we are to render Hilbert's claim empirically respectable, we must further modify it to read as follows:

"it is possible to give a simple mathematical description of the range of reflectances compatible with [all and only instances of] a given color perception [for certain subjects S under certain viewing conditions C]."

Hilbert himself must have been aware of these difficulties since he openly acknowledges the dependency of apparent color on lighting conditions and visual system type.

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21 Hardin, 1988, Appendix
As the above modified claim indicates, what Hilbert can show is that given a fixed type of visual system and certain fixed lighting conditions, we can use subjects' color experiences as a guide to identify (e.g.) red objects. We can then examine the reflectance profiles of these objects and find a simple mathematical description which applies to all and only objects which appear red to people with the specified type of visual system under the specified lighting conditions.

Once we have developed the mathematical description satisfied by all and only things which look red to those viewers under those circumstances, we can create a machine which can determine whether or not any given object has a reflectance of this type.

We are now in a position to reflect on the extent to which Hilbert's account of color categories satisfies the strong commonality criterion. It does to this extent: insofar as there is some range of viewing conditions and some range of lighting conditions which can serve as a principled way to correctly identify the true colors of objects, then we can develop some mathematical description which all and only objects having that color share.

**Narrow vs. broad specifications of S and C**

If we specify the value of S very broadly any given object is most colors and it will be impossible to find some external property which can satisfy the "and only" requirement of the criterion. We will get the same result if we specify the C parameter
very broadly: every object will have very many colors and the "and only" requirement will not be satisfied.

On the other hand, if we specify the values of S and C very narrowly, we will get the desired result that every object has just one precise color. However, the drawback to narrow specifications is that we typically accept a broad range of illuminants as sufficient for revealing an object's color.

Thus, broad specifications of S and C result in any given object having very many different colors while narrow specifications of S and C result in any given object having only one color but that true color being ascertainable only under very constrained conditions.

Some people hold that an object is (e.g.) red if and only if it looks red to a normal person under normal lighting conditions. There are a number of things to note about these specifications: (1) some objects will vary dramatically in apparent color from one normal illuminant to the other, (2) the physical differences between different normal illuminants can be quite dramatic. (3) Whether or not we accept a given illuminant as normal has more to do with the contingent nature of the objects which happen to populate the world rather than with the physical properties of the illuminant: if the lighting preserves the apparent colors of most of the objects being illuminated, then we will accept the lighting as normal.

I conclude that Hilbert's account of determinate colors does not satisfy the strong commonality criterion but that his account of color categories does go some way toward satisfying the requirement.
Chapter 3: Cohen on commonality

In this section I consider how Cohen answers the commonality question, What is it that all and only objects of the same color have in common? Cohen argues that what all and only objects of the same color have in common is that they share a functional role of the form red for S in C. This property is a higher order property an object has in virtue of having some physical property or other that causes the object to look red for S in C.

Cohen's relationalism

Cohen argues for a view he calls color relationalism. Cohen's relationalism is an important element of Cohen's particular brand of functionalism since it constrains the form that color properties can take.

Color relationalism is the view that "color properties are relational". Cohen insists that color properties are always of the form "red for S in C" and that the view "that there is an unrelativized form of color properties lurking somewhere" is due to tacit relativization of color terms in common usage as opposed to a reference to some intrinsic property.22

The advantages Cohen sees to his relational theory of colors are the following: (1) the relational nature of colors is suggested by empirical phenomenology, (2) relationalism allows us to pay our dues to anthropocentrism inherent in ordinary color talk, (3)

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22 Cohen, 2003, pg.7
relationalism allows us to deal with certain puzzles which arise due to the phenomenon of metamers.\textsuperscript{23}

\textbf{Cohen's functionalism}

Cohen says, "Color functionalism understands colors as being constituted in terms of their functional roles."\textsuperscript{24} Cohen particular brand of functionalism is that of the role functionalism. Role functionalism is distinguished from realizer functionism in that the role functionalist claims that the functional role rather than just the realizers of that role can be appealed to satisfy the commonality requirement and the causality requirement. Cohen's role functionalism commits him to the following claims: (1) objects have the colors they do in virtue of satisfying a functional role, (2) color properties are identical to these functional roles, (3) these functional roles cause objects to look colored, (4) these functional roles are the objects of direct perception.

Cohen identifies the color of any given object with a certain functional property had by that object. Cohen insists that this property is of the form red for S in C. The extent to which this move satisfies the commonality criterion depends on how we fill in the parameters S and C. Cohen says that in common language, when color term appear in their unrelativized forms they are tacitly relativized to normal visual systems in normal circumstances. If Cohen is right about this, then what all and only "red" objects have in common is that they look red to normals under normal lighting conditions.

\textsuperscript{24} Cohen, 2003, pg.2
The extent to which Cohen's account satisfies the commonality criterion depends on whether or not all and only red things can be said to have the functional property of looking red to normals under normal lighting conditions. Here, the same considerations will apply to Cohen as applied to Hardin: the more narrowly one defines "normal viewers" and "normal lighting conditions" the better one satisfies the "and only" requirement. The more broadly one defines these parameters the better one satisfies the "all" requirement.

Two questions which must be asked about functional properties of the form red-for-normals-in-normal-conditions are the following: (1) are such properties disjunctive? and (2) are such properties visible? The second question has to do with the causality criterion so we will treat it more extensively in the section on causality.

Concerning (1), we should note that Hilbert devotes considerable effort to showing that the "simple mathematical description" met by all and only objects of the same color is not a disjunctive description. Cohen, however, makes no corresponding effort to show that the functional property of "looking red to normals under normal conditions" is not a disjunctive property.

My worry is this: perhaps the proper candidates for identification with color are more precise than red for normals under normal conditions. Perhaps the proper functional properties for identification with color are those like: red for Robert under incandescent light. If this were the case, then red for normals under normal conditions might only be definable as a disjunction like: {red for normals under incandescent light or red for normals under fluorescent light or red for normals under sunlight ... }. It won't due to
appeal to a disjunctive property in order to satisfy the commonality requirement because, as noted earlier, it can't fail.

I earlier mentioned the class of objects which are either planets, geese, or can-openers. Suppose that we agree to call all and only members of this class of objects "glicks". We could then say that what all and only these objects have in common is that they are all glicks. Does the fact that they are all "glicks" now provide a satisfactory answer to the commonality question, What do all and only planets, geese, and can-openers have in common? I think the obvious answer is that it does not. It does not due to say that all these things are glicks because the definition of 'glick' is the 'a planet, a goose, or a can-opener', and this is a disjunction.

**Normal viewing conditions are disjunctive**

Cohen says the following about the C variable:

"the color a thing looks to a single individual depends on all sorts of parameters of the viewing circumstance including ambient illumination, viewing angle and distance, other objects seen simultaneously, other objects seen previously, state of adaptation of the visual system, and so on." ²⁵

To make my worry in this case clear, let's focus just on the type of lighting included in the range of what might be considered normal conditions. Just as spectral reflectance profiles represent data about the dispositions of surfaces to reflect light, luminance profiles represent data about the composition and intensity of different types of light sources. Consider the following examples.

²⁵ Hardin, 1988, pg. 6
The image on the left represents the luminance profiles of sunlight and incandescent light. The image in the middle represents a luminance profile for the most common type of fluorescent light. And the image on the right represents a luminance profile for a black light.

The challenge is to define 'normal lighting conditions' in a way that (1) accepts fluorescent light, incandescent light, and sunlight as a normal but (2) excludes the black light, and (3) does this in a non-disjunctive way.

There are two strategies we could consider, the first physicalist, the second functionalist. We could follow the physicalist strategy adopted by Hilbert for defining classes of spectral reflectance profiles and try to find a simple, non-disjunctive, mathematical description which is met by all and only luminance profiles which are normal. Whether or not this can be done is an open empirical question.

The functionalist strategy would be to define normal lighting by reference to some functional role played by all and only normal lighting conditions. This would likely involve relativizing 'normal lighting conditions' to sets of specific types of objects and sets of viewer types. For example, we could say that a lighting condition $x$ is normal just in case it "preserves the color" of "normal objects" to "normal viewers".
The problem for the functionalist strategy is that it does not yield an informative understanding of normal lighting conditions if we define them as 'those conditions under which normal objects preserve their normal color'. This lack of informativeness means that we can't appeal to the fact that two lighting conditions C1 and C2 are both 'normal' to explain why the objects in the scene look the same color in both C1 and C2.

The circularity worry is the worry that our definitions of the various terms in the schema red for S in C should be informative. But if our request for definitions of 'red', 'S', and 'C' never terminate in a concrete, (preferably physical) property, we have grounds to make the circularity objection.

I am not claiming that it is impossible to give a definition of red for normals in normal conditions that is non-disjunctive, just that we have reasons against assuming that such a definition is guaranteed to be there. The point I have emphasized is the difficulty of giving a non-disjunctive physical definition of normal lighting conditions. However, lighting conditions are by no means the only variable which may be problematic for Cohen. Cohen points out that the C parameter includes not only "ambient illumination", but also "viewing angle and distance, other objects seen simultaneously, other objects seen previously, [and] state of adaptation." The same difficulty applies to these variables as well. And, of course there is also the S parameter which may be problematic since there is an indefinitely large number of different visual system types.

Cohen himself seems optimistic that someone like himself can easily generalize from "yellow for me in the kitchen" to "yellow for visual systems pretty much like my
own in viewing circumstances pretty much like those I typically encounter.”26 [Hopefully it can be easily seen that the latter means something like yellow for normals under normal conditions.]27 Cohen seems to reach the conclusion that such a generalization is possible because analysis of ordinary language suggests that our language is in fact tacitly relativized to such parameters.

Conclusion

Insofar as Cohen is right about the tacit parameters to which ordinary language is relativized, and insofar as the property Cohen seeks to identify with color is non-disjunctive, then Cohen's account does satisfy the strong commonality criterion. That is, if our pretheoretical understanding of 'red' really is red-for-normals-under-normal-conditions, and Cohen is right that all and only red things really do have the functional property red-for-normals-under-normal-conditions, and furthermore that red-for-normals-under-normal-conditions is non-disjunctive, then Cohen's account satisfies the commonality criterion. So far I have argued that we should be suspicious that red-for-normals-under-normal-conditions really does satisfy the non-disjunctive proviso. Next I will argue that we should be suspicious of the claim that our pretheoretical notion of red really coincides with the functional property red-for-normals-under-normal-conditions.

26 Cohen, 2004, pg. 20
27 I am using the term 'normals' and 'normal viewing conditions' to mean what Cohen uses the terms 'people pretty much like me' and 'circumstances pretty much like these'. I have changed the terminology for the sake of brevity and more general application. See Cohen, 2004, pg. 20.
Cohen and common language

Cohen thinks that in common language when the color terms are used in their unrelativized forms, they are tacitly relativized to "visual systems like our own and viewing conditions like those we typically encounter."²⁸ An alternative to Cohen's view about common language is that ordinary color language is best taken as referring directly to features of the speakers' visual experience.²⁹ We can explain the fact that ordinary color language seems to be relativized to normal viewers under normal conditions by the fact that (1) most people are normals, (2) most viewing conditions are normal, (3) color language evolved to suit the needs of normals, (4) most people are naive color realists and hold unenlightened theories about color.

However, even if we accept that Cohen is right that color terms always being relativized to visual systems and viewing conditions, then it becomes a mystery how we can talk about (1) color matches across visual system types and (2) color matches across viewing conditions.

The argument from photographic prints II

That it is possible to make color matches across wildly different viewing condition is most easily seen by once again considering examples from photography. It will suffice to consider cases in which photographic prints which may be said to accurately capture the color of the objects it represents. It will help to consider a concrete

²⁸ Cohen, 2004, pg. 14
case. Suppose that Jill and Jane go scuba-diving at night in search of a mysterious bioluminescent red squid. Suppose that when viewed close to the surface in sunlight, the squid looks grayish blue. However in very low lighting conditions, at depths of 2 or 3 more miles below the ocean, the squid emits a bright red light. Jill and Jane find a squid at this depth and take a number of photos, some of the squid, some of each other swimming with the glowing squid. They develop the photos and judge that the prints exactly match the colors they remember seeing when swimming with the squid. Jill points to the print and says "this is what the squid looks like at night in its native habitat".

When Jill says that the print matches the squid, I think that what she is saying could be paraphrased as follows: The color this print has now under these viewing conditions is the same color the squid had then under those viewing conditions. However, on Cohen's view, to say that the print and the squid are both red is to say (inter alia) that they are both red under normal lighting conditions. This is true of the photo of the squid, but not the squid. However, there is a perfectly clear, pretheoretical sense in which the squid matches the photo. But Cohen's system makes this match a mystery since he claims that all color terms are relativized to (inter alia) viewing conditions.

**Matches across visual system types**

According to the dominant view of colorblindness, (1) the color experiences of the colorblind are a proper subset of the color experiences of normals, (2) it is possible to generate simulations of how things look to colorblind.
There are many types of colorblindness. Let's consider monochromats, protanopes, and tritanopes. Monochromats are said to see only shades of gray. Protanopes are said to see only shades of yellow blue and gray. And tritanopes are said to see only shades red, blue, and gray.30

According to the dominant view, objects which look red, orange, yellow, and green to a normal will all look yellow to a protanope, while objects which look blue and purple to a normal will look blue to a protanope. Similarly, objects which look red orange or yellow to a normal will look red to a tritanope; and objects which look green, blue, or purple to a normal will all look blue to a tritanope. Finally, objects which appear any color at all to a normal will appear gray to a monochromat.

With this in mind, we can say that (1) objects which are blue for a normal will look the same color to a protanope and a tritanope; (2) objects which are gray for a normal will look the same color to a monochromat; (3) objects which are yellow for a normal will look the same color to a protanope; (4) objects which are red for a normal will look the same color to a tritanope.

Here is what Cohen says about errors in color ascriptions made by the colorblind:

"It is true that, if x looks red to S in C, then relationalism implies that x is red to S in C; so far, then, no error. However, if S or C lie outside the conditions for normality presupposed by our ordinary use of color language, then we can recognize a sense in which the way x looks to S in C can be erroneous; viz. that it does not match the way x

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looks to $S'$ in $C'$ where $S'$ and $C'$ are the sorts of perceivers and viewing conditions we take to be normal.\textsuperscript{31}

**Conclusion**

The question now is, how can we account for these matches using Cohen's system? It will be useful to consider how Cohen uses his appeal to relativization to deal with Averil's puzzle. Cohen appeals to differences in viewing conditions and visual system types to explain apparent differences in colors between objects which match under one illuminant but not another: "If ... colors are constituted in terms of relations to ... viewing conditions, then this is just what we should expect: changing the viewing conditions ... changes the color that each region manifests [italics mine]."\textsuperscript{32} My objection is this: Cohen says that changing the viewing conditions or the visual system type changes the color of the object. Cohen builds the viewing conditions and visual system types into the color properties themselves. Therefore, we should expect changes in color necessarily occur every time there are changes in $S$ and $C$. And since (at least) $C$ is so complex, we should expect minor changes in (say) viewing angle or luminance profiles of ambient lighting to result necessarily in color changes.

There are only two ways I can imagine Cohen accounting for how we can justify the intuition that these matches across visual system types and viewing conditions are color matches: (1) they are united by disjunction, or (2) the conditions or visual system

\textsuperscript{31} Cohen, 2004, 15
\textsuperscript{32} Cohen, 2004, 482
types which seem not to match are actually "pretty much" the same.\(^{33}\) I have argued that both of these routes is unacceptable.

\textbf{It's the 'red' parameter that matters, not the S or C}

Given the schematic 'red for S in C' (where 'red' stands for some color term), it is not clear why changing the S or C variable should change the 'red' variable at all. Indeed, the only time we should expect the color of an object to change as a result of a change in the corresponding color property is when the 'red' parameter changes. Similarly, whenever the 'red' parameter of one color property matches the 'red' parameter of another property, we are justified in asserting a match between the properties regardless of whether or not S or C also match. I take this to show that, contrary to Cohen's claim, there is an unrelativized color property lurking somewhere.

\textbf{Assessment of Cohen and Hilbert on commonality}

Cohen is right that there is a clear, pretheoretical sense in which anything which looks red to normals under normal lighting conditions is red. For example, the image of the glowing squid is red. However, he is wrong that these are the only things that can be called "red" pretheoretically. There is surely a sense in which color matches can be made across viewing conditions and visual system types as can be seen from the argument from photographic prints. I think these matches should be understood as color matches: The squid-under-water-at-night is the same color as the print-of-the-squid-under-sunlight.

\(^{33}\) I suspect that Cohen would reject that they are actually color matches. However, he might accept that these items 'match' in the sense that they evoke the same brain states.
Similarly, the red-patch-seen-by-a- tritanope is the same color as the red-patch-seen-by-a-normal. This leads to the view that Cohen falls short of meeting the commonality criterion because his account of pre-theoretical red as red-for-normals-under-normal-conditions falls short of capturing all the things we should want to count as red.

The same problem applies for Hilbert. Objects which are red for a tritanope (including things that are yellow for a normal) really are red in an important, (even anthropocentric!) sense. Yet Hilbert would have to maintain that many of the objects which cause red experiences in tritanopes are in no sense red.34

**Cohen's argument against Hilbert's specificationism**

Cohen makes an argument against specificationism on the grounds that it can't satisfy the commonality criterion for two reasons: (1) It doesn't meet a certain proviso Cohen identifies, and (2) it doesn't meet the non-disjunctivity proviso.35

Cohen calls Hilbert's method 'specificationism'. Cohen's argument makes reference to possible worlds. Cohen argues that by defining colors without essential reference to observers, Hilbert's analysis is unable to accommodate possible worlds in which the physical structures which play the redness role are different.

To illustrate Cohen's argument, we could imagine a world in which all the humans are tritanopes. Tritanopia is a rare form of colorblindness characterized by an absence of S cones. In this world everyone would see just three colors: red, blue, and

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34 The claim is that there is no room in his 1987 account for (say) objects which are yellow for normals under normal conditions being (genuinely, anthropocentrically, really) red for tritanopes.

35 Cohen, 2003, pg. 31
gray. In a world of tritanopes, objects which look red, orange, and yellow to the normal
denizens of the actual world all look red in the world of tritanopes. In a world in which
red was realized by the physical structures associated with red, orange, and yellow in this
world, we could not explain why a person sees something as red by appeal to the formula
offered by Hilbert.

I think Cohen's argument here is sound. My only objection is that Cohen would
not actually be in a position to say that the tritanopes in the possible world of tritanopes
are actually seeing the same red as normals in the actual world. This, because Cohen
would have to say that they are seeing red-for-a-tritanope rather than red-for-a-normal,
the latter being a different color than the former.

Cohen and Hilbert on the non-disjunction criterion

It is worth noting that Hilbert goes to great lengths to show that the elements of
his classes of spectral reflectance profiles are not united by a disjunctive property. Rather,
they are united by a simple mathematical description which is non-disjunctive. Hilbert
claims that the elements of the class of (e.g.) red things are united in the same way that
the elements of the class of (e.g.) things between 20 and 30 pounds are united.

By contrast, Cohen does very little to show that the color properties to which he
appeals in an effort to meet the commonality criterion are non-disjunctive. Cohen does,
however, specifically say that Hilbert fails on the commonality criterion. Here is what
Cohen says,

"One of the most explicit and vigorously defended forms of specificationism is
that of Hilbert (1987) ... on which colors are anthropocentric classes of spectral
reflectance distributions. ... We should prefer a functionalist over a
specificationalist theory of color because of an empirical result already
mentioned: there is no particular physical structure that is had by all and only red
things... Rather, the class of physical structures that are red, even in the actual
world, seems to form a rather heterogeneous collection from the perspective of
physical sciences; red is, in the standard jargon, multiply realized. ... if this appeal
to disjunction is to effect a principled, rather than an ad hoc, grouping - if we want
to know why one of the relevant material structures does count as a realization of
red but my grandmother does not, we need to explain why the various disjuncts
are all gathered together into the type identified with red.\textsuperscript{36}

Cohen does not make it entirely clear why he thinks that the anthropocentric classes of
reflectances identified by Hilbert as red must be united by disjunction. Hilbert himself
explicitly denies this. Hilbert say,

"[Many philosophers have supposed] that the only description one can give of the
information about the physical world obtained in any given color perception must
be [in the form of a disjunction] ... however, ... we can do much better .... than this
disjunctive view would indicate."\textsuperscript{37}

Hilbert's argument for this view is that the reflectance profiles identified with any
given color all admit of a simple, non-disjunctive mathematical description had by all and
only objects of that color.

There are two likely reasons certain thinkers might give for rejecting Hilbert's
claim that his anthropocentric classes of reflectance profiles are non-disjunctive: (1)
Hilbert is relying upon dubious scientific theories to support his claim. (2) Reflectance
profiles do not have the right sorts of causal power and Hilbert's account must be
modified in such a way that color properties are disjunctive. The idea behind this second
reason here is that the physical bases of the reflectance profiles do all the causal work and

\textsuperscript{36} Cohen, 2003, pg. 30
\textsuperscript{37} Hilbert, 1987, pg. 110
these physical bases of Hilbert's classes of reflectance profiles are disjunctive. Therefore, since the things which do all the causal work are disjunctive, we must conclude that the color properties are disjunctive.

The causal overdetermination worry applied to reflectances

This second reason for rejecting Hilbert's claim relies upon an argument Cohen attributes to Kim. The exclusion worry is this: if what causes the object to reflect the light it does is some property which is more basic that the object's reflectance, what causal work is left to be done by the reflectance itself?

Hilbert says this about the multiple realizability of reflectance profiles, "Fundamentally different physical mechanisms can result in objects that possess very similar dispositions to reflect light. The reflectance of an object is multiply grounded."\(^{38}\)

Thus, appeal to an object's spectral reflectance invites the further question of why the object has the reflectance it does. If we are to avoid a circular answer, we must point to the physical base which causes the surface to interact with light the way it does (e.g. the types of pigments the object has). This raises the causal exclusion worry which is not addressed by Hilbert in his 1987 book.

One conclusion would be that explanations which cite an object's reflectance are incomplete and that incomplete explanations do not reveal the true causal links involved in any given extended physical processes. On this view, we might claim that the reflectance properties of the object have predictive power but not explanatory power.

\(^{38}\) Hilbert, 1987, pg. 120
If we decide against the causal efficacy of reflectance profiles, then we might have to reject Hilbert's claim that color categories are not disjunctive. If we are convinced, however, that the reflectance profiles of an object are causally impotent and that the true candidates for identification with objects' colors are the physical bases of the reflectance profiles in question, then we will need a whole new argument concluding that there is some simple, non-disjunctive mathematical description satisfied by the base properties of the reflectances. Hilbert does not offer such an argument and admits that if we require that color properties be physically basic, then reflectance profiles cannot fit the bill.

The causal exclusion worry, however, cannot be urged by Cohen against Hilbert with consistency; Cohen himself rejects the causal exclusion argument. On Cohen's view, the relationship between the base property and reflectance property is that of determinate/determinable, and therefore explanations which cite the base property add nothing over explanations that cite the reflectance property except greater specificity. And, because of this, physical base properties don't compete for causal relevance with the functional/dispositional properties they realize.  

Hilbert himself does not argue against the exclusion worry and justifies his reduction by appeal to the actual scientific practice of offering explanations. Thus he points to the status of reflectance properties as properties actual scientists tend to regard as "perfectly respectable".

39 Cohen, 2005 pgs. 12-16
Conclusion

I must conclude (charitably) that Cohen has some reason other than the causal exclusion worry for regarding Hilbert's anthropocentric classes to be united by disjunction. However, it is a distinct possibility that the "empirical result" cited by Cohen is one which makes use of the causal exclusion worry to disqualify reflectances from consideration as the causes of color experiences.

So how well does Cohen fare on the non-disjunction proviso? I do not think Cohen fares well at all. Cohen thinks that all and only red things share a common functional property of looking red to normals under normal conditions. However, as I have argued, the term "normal conditions" conceals a massively disjunctive set of conditions.
Chapter 4: Causality

Preliminaries

Recall that the commonality criterion requires that some property be identified which is shared by all and only objects of the same color. The causality requirement is that that common property, once identified, should have the right type of causal power. This raises the question of how to determine the causal powers of any given property. I follow Cohen is supposing that causal power is linked to explanatory practices. Specifically, I suppose that intuitions about what explains what can be appealed to in delineating the causal powers of any given property. Thus, one method for determining what causal powers a property has is to identify key questions about key phenomena which appeal to the property is able to explain.

Key phenomena: seeing colors, color sorting behavior

The key phenomena I think appeal to color properties should explain are: (1) seeing colors and (2) color sorting behavior.

To explain what I mean by "seeing colors" it will be best to consider cases of this phenomena. Here goes.
Case 1: Billy is a color-normal. He looks at a ripe tomato in sunlight and has the type of experience which is the typical effect of normals attending to ripe tomatoes in sunlight, call it a red-feeling-experience.40

Case 2: Barbara is a tritanope. She looks at a ripe lemon and has the type of experience which is the typical effect of normals attending to ripe tomatoes in sunlight, a red-feeling-experience.

What we want is an account of color properties according to which (1) color properties are the causes of the red-feeling-experiences in these cases. Causing color experiences does not, by itself satisfy common intuitions about seeing colors because many properties which we would not typically consider color properties are involved in causing color experiences. For example, the angle at which an object is viewed may play some role in causing color experience, but it go against the common language/common intuition requirement that viewing angle be considered a color.

The additional requirement needed to rule out causally relevant properties of this sort is the requirement that (2) color properties be the direct objects of perception. The conclusion I draw from these considerations is that color properties are to be found somewhere among those properties involved in seeing colors which can plausibly be considered to be the direct objects of seeing.

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40 I borrow this terminology from Byrne and Hilbert.
The requirements that (1) color properties cause color experiences and (2) color properties are the direct objects of seeing together make up what I will call the visibility requirement.

**Color sorting behavior and the explanatory power of "the hues"**

To explain what I mean by color sorting behavior it will be helpful to consider the typical sorting behaviors associated with three different types of visual systems on a typical color matching test. The test and results I discuss are all my own inventions but are based on textbook accounts of colorblindness.

The following test asks the subject to sort surfaces a-u into distinct hue categories. (If this were a real test, each surface would match with respect to brightness.) Let's consider how three different people would be expected to perform. The first is a normal, the second a rod monochromat, and the third a protanope (a type of dichromat).

![Figure 2: Color sorting categories of three different visual system types](image)

The image on the left shows how a normal would sort samples a-u. The image in the middle shows how a rod monochromat would sort a-u. The image on the right show
how a protanope would sort samples a-u. The black outlines indicate that all the samples inside *match with respect to hue* for the subject. Note that I have labeled each color category. In the case of trichromats' matches, I have used standard English color terms.

But in the case of the abnormal vision, I have used Greek letters to indicate agnosticism about how to think of them and also to reflect the striking fact that there would seem to be no basic English color words for the color categories of the colorblind. For example, $\alpha$ is a monochromat's color category that would seem to be a disjunction of red, yellow, blue, orange, green, purple, and gray. However, it seems implausible to think that the single color which the monochromat sees when he looks at surfaces a-u is some alien color we should call "red-or-yellow-or-blue-or-orange-or-green-or-purple-or-gray". Similarly, it seems implausible to think that the color category $\gamma$ is some alien color we should call "blue-or-purple".

Determining what color terms to apply to $\alpha$, $\beta$, $\gamma$, and $\delta$ is an important component of answering the question: What is it like to be colorblind? How to answer this question is also related to the question of how to determine the type identity of color experiences involved in color vision. I maintain that determining the identity of $\alpha$, $\beta$, $\gamma$, and $\delta$ is an important scientific task with ramifications for accounts of color ontology.

The standard, textbook answer to which English color terms (if any) should be applied to $\alpha$, $\beta$, $\gamma$, and $\delta$ is the following: $\alpha$ is gray, $\beta$ is yellow, $\gamma$ is blue, and $\delta$ is gray.

It is important to note two things about the identity of these color-categories. (1) First, the results severely constrain how colorblind vision is simulated for color normals. (2) Second, the methodology involved is highly intuitive and hard to dispute.
To illustrate the first point consider how different a simulation of monochromatic vision would be if it were determined that (e.g.) \( \alpha \) is \textit{pink}. In that case a rendering of how monochromats see the world could not be produced using black and white paint or a black and white display monitor. If \( \alpha \) were pink, then a black and white simulation of monochromatic vision would be in error.

Concerning the second point, Hardin explains the methods for determining the type identity of colorblind color categories as follows:

"perhaps the [colorblind person's] hue experience is only formally similar to ours; perhaps what he sees is incommensurable with what we see. How could we know? We do know and in two ways. First, people do sometimes acquire [colorblindness] through accident or disease after they have learned the use of color language. Second, there are a few people who are [colorblind] in one eye and almost color normal in the other. They compare what they see through each eye, and their descriptions of what [the colorblind] see tally fairly well with what scientists had come to expect. ... [colorblind] vision is a degenerate case of normal color vision."

By "degenerate case" here, Hardin means that the color experiences of the colorblind are a subset of the color experiences as normals. Thus, there is an important sense in which \( \alpha \) is the same color as the normal's \textit{gray}. Similarly, \( \gamma \) is the same color as the normal's \textit{blue}.

**The many morals of color sorting behavior**

The first moral I want to draw from color sorting behavior is that what Hardin calls "the hues" (e.g. red, orange, yellow, blue, etc.) have important explanatory value beyond the confines of any particular visual system type. Appeal to red, orange, yellow, green, blue, purple, and gray not only play a role in explaining the sorting behavior of normals, but also in explaining the sorting behavior of the colorblind. For example, it is
blueness and yellowness that explain the sorting behavior of protanopes; and it is grayness that explains the sorting behavior of monochromats.

The second moral I want to draw from color sorting behavior is that the hues defy definition by ostension to external objects. For example, one cannot define blueness as the feature had by m, n, and o, but none of the other samples in the above test. Similarly, one cannot define grayness as the feature had by s, t, and u, but none of the other samples in the above test.

The third moral is that seeing any particular hue is not a matter of seeing certain matches and mismatches. For example, to see gray is not a matter of seeing that surfaces s, t, and u match one another but don't match the other surfaces. And seeing blue is not a matter of seeing that m, n, and o match one another but don't match the other surfaces. Crucially, any philosophical account of color should preserve the scientific result that protanopes “see blue” and monochromats “see gray”.
Chapter 5: Cohen on the visibility of colors

The overdetermination worry

The first issue to discuss when considering how Cohen fares on the causality criterion with respect to visibility is that of causal overdetermination. The causal overdetermination worry is this: since scientists have already identified the scientific causes of color experiences, and since functional properties are not the properties scientists have identified as causing color experiences, then functional properties cannot cause color experiences because other properties are already doing all the work we Cohen would assign to his functional color properties.

We have already discussed this issue in connection with Hilbert's reflectance profiles and the non-disjunction proviso. The overdetermination worry now threatens Cohen's claim that color properties are capable of causing visual experiences. Since I have already discussed causal overdetermination as it applies to Hilbert's reflectances, I will be content only to discuss Cohen on this issue in the causality section.

Recall that Cohen takes color properties to be functional roles of the form \textit{red for }$S$ \textit{in C}, for example \textit{yellow for normals under normal lighting}. These properties are higher order properties objects have in virtue of having some physical property or other that causes the object to look (e.g.) red for $S$ in C. The concern is that whenever objects have the higher order properties, they also have some lower level property identified by science as doing the causal work of producing color experiences. The worry is that there is no more work left to be done by the properties Cohen claims are the color properties, these higher order properties.
Cohen has the following to say about the causal exclusion worry as it applies to his proposed color properties and the visibility of color:

"[M]any philosophers have worried that dispositions -- as opposed to their categorical bases -- can't cause their manifestations. If they are right about this, then the present account won't allow that subjects can see dispositional properties (hence, given dispositionalism about color, won't allow that subjects can see colors), since it won't be possible for dispositions to look red (for S in C) to cause objects to look red (for S in C). This concern is only as good as the underlying assumption that dispositions are unable to cause their manifestations. ... the extant arguments for this assumption ... turn mostly on Kim-style considerations about the threat of causal overdetermination."\(^{41}\)

Cohen further states:

"The objection in question builds on the claim that, while manifestations of dispositions may be direct objects of our seeing, dispositions themselves may not. But ... since colors are ... paradigm examples of properties that can be direct objects of seeing, it follows that colors cannot be dispositions."\(^{42}\)

The reason Cohen responds to this objection to dispositionalism is presumably because the same objection threatens his own view since the objection can be applied more generally to the entire class of functional properties rather than just specifically to dispositions.

Here is what Kim says about causal overdetermination:

"When we are faced with two purported causes, or causal explanations, of a single event, the following alternative accounts of the situation are initially available: (a) each is a sufficient cause and is the effect is causally overdetermined, (b) they are each necessary and jointly help make up a sufficient cause (that is, each is only a "partial cause"), (c) one is a part of the other, (d) the causes are in fact one and the same but given under different descriptions, (e) one ... is in some appropriate sense reducible to the other, and (f) one is a derivative cause with its causal status

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\(^{42}\) Cohen, 2003, pg.25
dependent in some sense on the [other] cause. ... The general point I want to stress is this: the presence of two causal stories, each claiming to offer a full causal account of a given event, creates an unstable situation requiring us to find an account of how the two purported causes are related to each other. This is the problem of 'causal/explanatory exclusion.'

In one essay, Cohen opts for (f) from Kim's list. Cohen says,

"I don't see why the causal link between colors and color experiences might not be understood in terms of a weaker, more derivative sort of causation ... such that dispositions could be causes in this weaker sense." In another essay, Cohen cites a number of responses in the literature to Kim: "[1] the argument overgeneralizes and (unacceptably) threatens the possibility of causal explanation in terms of the kinds of special sciences quite generally speaking; [2] ... contrary to what proponents of such arguments often maintain, the multiple factors involved ... are not causally sufficient for the outcome... Indeed, nothing less than the total state of the universe at a time is causally sufficient for the outcome; but there seems no reason to fear causal overdetermination by a pair of factors each of which is not causally sufficient for the outcome."

I believe we can interpret Cohen's argument to rest on (f) and [2]. Since nothing less than the total state of the universe at a time is causally sufficient for the outcome, we have no reason to believe that the physical features of objects typically considered to be the principle causes of color experience are sufficient to cause the color experiences in question since as a matter of fact (Cohen would say) they are constantly conjoined with their derivative, functional properties. And who is to say that these derivative properties don't have some causal role to play? After all, they are part of the "total state of the

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44 Cohen, 2003, pg. 27
45 Cohen, 2009, pg. 12 (footnote)
46 Recall that Hilbert’s main defense for attributing causal power to reflectances despite their being non-basic was that reflectances are used in actual scientific practice and are well esteemed among scientists. Thus it would seem that Hilbert would respond to the overdetermination worry by option (1) from Cohen’s list.
universe" during every and only every experience of color. I think this is what Cohen has in mind when he articulates the relation of *causal relevance* (CR) that causes have to their effects.

Cohen articulates this relation of causal relevance in terms of partial determination or "P-determination" for short. Cohen first explains the relation of (full metaphysical) determination by pointing to two properties, one of which determines the other and both of which can be considered as causing a single effect (a bell to ring). The two properties are (P1) *being 1037 lbs* and (P2) *being over 1000 lbs*. We can take what Cohen says about how these two properties are related to define the relation of determination as well as to understand better what Cohen means by derivative causation.

Cohen says:

(1) "having [P1] is just a way of having [P2];"

(2) "explanations of [effects] that cite [P1] add nothing over explanations of effects that cite [P2] except greater specificity";

(3) "[explanation of effects that cite P1] don't add a second event that would then be a competitor for the title of causal relevance."\(^47\)

The sort of determination Cohen imagines holds between functional roles and their physical bases is not that of full metaphysical determination (as in the case of [P1] and [P2]), but one of partial determination (p-determination) which Cohen defines as follows:

\(^{47}\) Cohen, 2005, pg. 14
"one property p-determines another relative to certain constraints if x's exemplification of the first, together with the fact that those contingent constraints are met, make it the case that x exemplifies the second."\textsuperscript{48}

**Summary**

To summarize, then, Cohen thinks that color properties are second order properties-- properties an object has in virtue of having some lower order properties identified as responsible for causing color experiences. Cohen argues that the lower order properties p-determine the higher order properties. Since this relation of p-determination obtains between the lower order properties and the higher order properties, both the lower order and the higher order properties can be considered causes of color experiences. Thus, Cohen maintains that the higher order properties he identifies with colors can cause color experiences (because they are causally relevant) and are therefore visible.

**Analysis**

Cohen emphasizes that in certain explanatory contexts, citing the higher order properties is just as legitimate as citing the lower-order properties. However, it is important to note that there are some explanatory contexts in which citing the higher order property does not provide the same explanatory power as citing the lower order property. What Cohen needs to show is that in the explanatory contexts *relevant to establishing the right kinds of causal powers*, his higher order color properties are able to deliver the same explanatory power as the lower level properties which he denies are color properties.

\textsuperscript{48} Cohen, 2005, pg. 15
Although I agree that causal powers can be delineated by appeal to what explains what, I think Cohen's color properties fall short of having the explanatory we should want them to have. For example, Cohen's property blue-for-a-normal-under-normal-conditions is unable to explain the sorting behavior of both the normal and the protanope. Blueness simpliciter, on the other hand, can be appealed to to explain the sorting behavior of both the normal and the dichromat.

**Colors as the direct objects of perception**

In this section I consider whether the properties Cohen identifies as colors can be the direct objects of vision. Cohen holds that (1) colors are properties of external objects and (2) colors are the direct objects of seeing. I think that these two positions are impossible to reconcile in any plausible way with the results from comparative color vision experiments.

My position is that (1) colors are the direct objects of seeing; (2) when the colorblind “see blue” or “see gray”, blueness and grayness are the direct objects of their vision. (3) This blueness and grayness is the same blueness and grayness that color normals see. (4) Since blueness and grayness do not directly correspond to any particular features of the external world, we should reject Cohen and Hilbert's claim that colors are properties of the external world.

Cohen advocates an intentional understanding of color experience. I take this to mean that color experiences yield immediate knowledge of features of the external world. Cohen says,
"Given an intentional understanding of 'looks', the claim that the lemon looks yellow to me in the kitchen must mean that the lemon is visually presented to me in the kitchen as having some property. ... For the relationalist, the property in question is not the non-relational property yellow, but the relational property such as yellow for S in C. ... if we interpret 'looks' intentionally, [the relationalist] must be understood as saying that the lemon is visually presented to me in the kitchen as having the relational property yellow for S in C." 49

My objection to interpreting 'looks' intentionally when it refers to color experience is this: The nature of any given color experience can be exhaustively described within a color space which has a very limited number of discrete points. Cohen builds viewing conditions and visual system types into color properties which creates an explosion of color distinctions none of which can be distinguished from the other on the basis of vision. The fact that Cohen's system yields differences in color which cannot be distinguished on the basis of vision is, I take it, a violation of the visibility requirement.

One consequence of Cohen's theory is an explosion of colors. For any given point in color space, there are an infinite number of viewing conditions and visual system combinations which could result in an experience corresponding to that point in color space. This goes against a principle at work in color taxonomy that goes back at least to Munsell, namely, that if two regions are indistinguishable, they are to be assigned a similar color name.

**Munsell (and the finitude of color experience)**

The most celebrated effort to establish an exhaustive taxonomy of color experience is that by A.H. Munsell who developed the Munsell Color System between

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49 Cohen, 2004, pg. 19
1900 and 1905. Munsell aimed to develop a system which could precisely describe what he called "color sensations" but that I will call color experiences. According to Munsell, every color experience can be defined by reference to three properties: hue, saturation, and brightness. Furthermore, Munsell's system allows us to (more or less) exhaustively represent every possible color experience in a giant array of chips viewed under the following narrowly defined conditions: "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."\(^{51}\)

C.L. Hardin reports that under optimal conditions, a trained normal observer can discriminate about 10 million surface colors. Thus an exhaustive representation of normal color experiences would be constituted by a set of approximately 10 million Munsell chips, each of which could be assigned a unique location in the Munsell color solid.\(^{52}\) Although this may seem very large given the relatively small number of color terms in the English language, it is important to note that 10 million is a tangibly finite number. Recall that in a worst case scenario for Hilbert, virtually every physically different type of surface is its own color. We could therefore expect the number of distinct colors in the universe to be vastly larger than the number of color experiences which a normal human can enjoy.

\(^{50}\) Munsell, A. H. (1946), *A Color Notation*. Munsell Color, Baltimore, (preface) pg. 4
\(^{51}\) Quoted from Hardin, 1988 , pg. 68
\(^{52}\) Hardin, 1988, pg. 182
Note that on Munsell's view, every color experience known to normals can be assigned a location in color space on the basis of its apparent hue, saturation, and brightness as seen by a normal viewer. This can be done without reference to lighting conditions or the type of surface to which the color is attached. This makes arrays like Munsell's especially useful in talking about color experience. Here is what Munsell himself says,

"popular color terms convey different ideas to different persons. When used inappropriately they invite mistakes and disappointments, for they do not clearly state ... the three qualities united in every color which must be known to convey one person's color conceptions to another. Music is equipped with a system by which it defines each sound in terms of pitch, intensity, and duration, without allusions to the endless varying sounds of nature. So should color be supplied with an appropriate system."\(^{53}\)

The result is that Munsell designed a way of talking about color that allows color experiences to be described independently of any particular viewing conditions or visual system types. Though it is true that Munsell grounds the reference of his term to a particular physical array of paint chips viewed under a particular condition, once the system is learned, it can be used to describe a person's experience under any viewing conditions at all. The color space of Munsell can also be cited in explanations of how the colorblind see and in explanations of perceptual variation.

**Mentamers**

I am now in a position to make my objection more clear. Hardin says there are only about 10 million discriminable locations in normal color space. I have argued that

\(^{53}\) Munsell, 1946
under Cohen's view, any change in viewing conditions or visual system result in a change in color. The critical point I want to make is that this change of color happens regardless of whether or not the change in viewing conditions or visual system results in any visible change in nature of the color experience at all. The consequence is that Cohen's system must allow that there are (what I call) mentamers. Mentamers are color experiences which cannot be visually distinguished from one another. This violates the requirement that color be visible.

Recall the case of the glowing red squid viewed underwater at night and the photograph of the squid viewed under incandescent light. I maintain that the squid-as-seen-underwater and the photo-as-seen-in-the-store match with respect to color. Cohen, on the other hand, must maintain that the photo and the squid do not match since when viewed under the same lighting conditions the squid and the photo do not match. On Cohen's system the squid-glowing-underwater is a different color from the photo-of-the-squid-in-the-store. My objection is that this supposed difference in color cannot be seen because color experiences involved in viewing the squid under water are the same types of color experiences involved in viewing the photo under normal lighting.
Chapter 6: Hilbert on the visibility of Color

Causal exclusion

The first thing to note in considering how Hilbert fares on the causality criterion is that Hilbert, like Cohen, faces the charge that the properties he identifies as color properties are excluded from being causes of color experiences by other properties. In Hilbert's case, the charge is that the physical bases of the spectral reflectances do all the causal work and leave no work for the reflectance profiles themselves.

I have already discussed the overdetermination worry as it applies to Hilbert when considering the danger overdetermination posed to Hilbert with respect to the non-disjunctivity proviso. Therefore, there is not much more to say about this issue except to note that Hilbert would seem to be in a good position to appeal to option [1] from Cohen's list of possible responses to Kim's overdetermination argument. Recall that Hilbert points to the fact that reflectance profiles are "perfectly respectable" physical properties in the eyes of important visual scientists. Thus Hilbert could claim that Kim's argument [1] "threatens the possibility of causal explanation in terms of the kinds of special sciences quite generally speaking".

The next thing to note is that Hilbert's method for finding a property suitable for identification with individual colors would seem to give him an advantage over Cohen on the issue of causal overdetermination. Hilbert says, "it is obvious that the relevant physical property must be one that has to do with light, or the reflection of light, since these are the prominent elements in the causal chain leading to the perception of
colour."\(^{54}\) This method would seem to guarantee that the physical property selected for identification with objects' individual colors would have important causal power with respect to visibility. So much for causal overdetermination.

**Hilbert's account of seeing colors**

Recall that the scientific paradigm Hilbert accepts holds that "the function of color vision is the determination of the spectral reflectance of the objects in the visual field". Hilbert says that "when we learn the color of a thing, we have learned something about its spectral reflectance."\(^{55}\) Hilbert analysis recognizes at least two aspects to seeing color: (1) seeing color distinctions, and (2) seeing color matches.

Hilbert makes the following scientific claim which should figure in our account of (1) what we learn about the reflectances in a scene when we see color distinctions and (2) what we learn about the reflectances in a scene when we see color matches: "perceptions of difference in color generally impl[y] difference in reflectance while perceptions of color identity d[o] not generally establish identity of reflectance ... there is this asymmetry between perceptions of color sameness and color difference."\(^{56}\)

What this asymmetry would seem to show is that the appearance of color distinctions tend to reveal real differences in spectral reflectance profiles. So far so good for Hilbert's realism. Furthermore, the appearance of color matches would tend to reveal real similarities between reflectance profiles in cases in which isomers were seen as

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\(^{54}\) Hilbert, 1998  
\(^{55}\) Hilbert, 1987, pg. 129  
\(^{56}\) Hilbert, 1987, pg. 112
matching. This is also a good result for Hilbert's realism. However, there is one big problem for Hilbert's realism to be found in Hilbert's scientific claim: the appearance of color similarities can also conceal real differences between objects' spectral reflectance profiles.

We are now in a position to see why the "worst case scenario" for Hilbert mentioned earlier is such a bad thing for Hilbert. Recall that in a worst case scenario virtually every surface has its own unique color and the vast majority of perceived matches are cases of metamers. I think this is a distinct possibility given a very fine-grained taxonomy of reflectances based on the IP rather than a curve-matching algorithm. This is a bad scenario for Hilbert because Hilbert wants to maintain that seeing colors is to be understood as seeing physical features of the external world. However, if it turns out that the vast majority of perceived color matches are cases of illusion, then Hilbert's realism becomes untenable and he must abandon his realist paradigm in favor of irrealism. Indeed, I think the bulk of the analysis in Hilbert's 1984 book strongly supports an irrealist paradigm.

**Hilbert's closet irrealism [a caveat on irrealism]**

I have already mentioned that my own position is that of color irrealism. It is somewhat surprising that the strongest case I have found for color irrealism comes by way of reasoning through the premises at work in Hilbert's 1987 book, a book which argues for color realism.
Hilbert denies being an irrealist, however we are now in a good position to see why certain key elements of his account of color are more suggestive of color irrealism than color realism. The two elements are these: (1) Hilbert's argument against dispositionalism which establishes the IP as a principled way of individuating spectral reflectances and (2) Hilbert's account of colorblindness as both (i) a special case of metamers and (ii) a case of color-matching illusion.

I have already discussed Hilbert's argument against color-distinction illusions in section 1.2. Recall that I took Hilbert's argument as establishing that any difference in reflectance profiles A and B which could cause a difference in color experience in some individual x is grounds for regarding A and B as having distinct reflectance profiles.

**Colorblindness as a case of illusion**

Hilbert says the following about colorblindness,

"[On the dispositionalist view] any person who perceptually discriminates color differently from the standard observer will suffer from color illusions. The most familiar sort of difference is that found with color-blind individuals. Objects that appear different in color to the standard observer can appear the same in color to someone with color-blindness. In such a case the perception of sameness in color by the color-blind observer is illusory ... The physicalist analysis [e.g., Hilbert's analysis] of colors will also have the same consequence."\(^{57}\)

**Colorblindness as a special case of metamerism**

Hilbert identifies colorblindness as a special case of the phenomena of metamers in the following passage, "By applying the same sort of account the dispositionalist gives of color-blindness to all the phenomena surrounding metamerism, the physicalist [e.g.,

\(^{57}\) Hilbert, 1987, pg. 96
Hilbert] achieves a simplicity in his account that is not available to the dispositionalist."

Since Hilbert claims that (1) colorblindness is a special case of metamerism, (2) erroneous matches made by the colorblind to be cases of illusions, and (3) "applying the same sort of account the dispositionalist gives of color-blindness to all the phenomena surrounding metamerism". From this it follows that Hilbert's account must regard all metameric matches (including those made by normal humans in normal conditions) to be cases of perceptual illusions. This follows so directly that, ironically, Hilbert's 1987 work seems to make one of the strongest and most persuasive arguments for color irrealism in all the literature in the philosophy of color.

Summary

To summarize, then, Hilbert argues that erroneous matches made by the colorblind are to be understood as special cases of metamerism and that these matches are to be understood as illusions. It seems natural, therefore, to regard all metameric matches to be cases of illusion. It follows that a certain percentage of apparent color matches seen by humans conceal real physical differences and that these apparent matches misinform us as to the true nature of the surfaces spectral reflectances. In a worst case scenario, the majority of the content of normal human color vision is illusory and color should be regarded as largely an artifact of the visual system.

58 Hilbert, 1987, pg. 98
Desperate measures: Hilbert's "anthropocentric" realism

I have argued that Hilbert's account strongly suggests that a certain amount (possibly the vast majority) of the content of visual experience conveyed by apparent color matches should be understood as illusory. However, Hilbert himself tries to avoid this irrealist conclusion by claiming that there is genuine content about the external world revealed by color matches, even in the case of metamers.

Hilbert addresses two aspects of seeing colors: (1) seeing color distinctions and (2) seeing color matches. I think that Hilbert makes a strong case for apparent color distinctions revealing genuine physical features of the external world. He makes the case by asserting a strong correlation between apparent color mismatches and real color mismatches. However, I have expressed skepticism toward the claim that apparent color matches tend to directly convey information about physical features of external objects. Hilbert must show that there is something we learn about objects' reflectances when we see that they match-- even in cases in which they have distinct spectral reflectances.

Hilbert's move is related to what I imagine would be his solution to the commonality criterion. (Of course Hilbert himself is not explicitly concerned with the commonality criterion.) In the case of the commonality criterion, Hilbert says that what all and only objects of the same color have in common is that they share a common type of reflectance literally characterized by a certain "simple mathematical description". Satisfying this simple mathematical description makes it the case that they "reflect the
same amount of light within each of the three wavebands corresponding to the sensitivity ranges of the [normal] human photoreceptors.\textsuperscript{59}

Hilbert's 1987 work seems to have two inconsistent positions in it about metamers. The first position is that metameric surfaces do not really match and that when people see them as matching in color, they are suffering from illusions. The second position is that when people see that two metameric surfaces match, they are not suffering from an illusion but seeing that two surfaces share a certain \textit{type} of reflectance. Although the first position is a straightforward, logical consequence of Hilbert's claims, Hilbert disavows this first position and endorses the second:

"We should not ... be misled by the use of the term error to describe this sort of lack of precision in perception and measurement [e.g., the phenomenon of metamerism]. It is not that measurements and perceptions misrepresent the qualities that they purport to give information about..." \textsuperscript{60} "When we see than an object is a particular shade of green, we are not necessarily seeing that that object has some particular reflectance, but rather that it has a reflectance that has a particular property or falls into a particular class."\textsuperscript{61} "The existence of metamers [establishes] the limited wavelength resolution of the human visual system and as implying that vision only provides information about kinds of colors and not about fully determinate colors themselves."\textsuperscript{62}

The claim that perception of color is always perception of some color category rather than some determinate color is unwarranted in the case of perceptions of color distinctions. Hilbert specifically says that when we see that two objects don't match, we are entitled to conclude that they have different determinate reflectances. For the sake of

\textsuperscript{59} Hilbert, 1987, pg. 108
\textsuperscript{60} Hilbert, 1987, pg. 107. Hilbert is talking about length, but he means the case to generalize to color.
\textsuperscript{61} Hilbert, 1987, pg. 102
\textsuperscript{62} Hilbert, 1987, pg. 112
consistency, therefore, we must reject Hilbert's perplexing claim that "in perception we do not gain knowledge of determinate properties".

I am now in a position to offer an interpretation of Hilbert. I interpret Hilbert as claiming that when people see color distinctions, they are seeing that the surfaces in question have different determinate colors. And when people see color matches, they are seeing that the matching surfaces all fall within a common color category which can be described by a simple, non-disjunctive mathematical description.

If we grant that the colors include red, blue, green, etc. then what we should expect from Hilbert is a simple mathematical formula applying to surfaces in the external world which can explain the experience of red, blue, etc. I would suggest that we get such an explanation only when we have a direct correlation between the mathematical description of the external surface, and the experience of redness, blueness, etc. The problem Hilbert faces is that the experiences of redness, blueness, etc. are not directly correlated with his mathematical formulas except for normal humans. This would seem to imply that protanopes don't "see blue" and monochromats don't "see gray". But, as I have pointed out, this requires us to reject one of the most important results of comparative color vision research.

Further criticism of Hilbert

Another objection I have to Hilbert is that any two surfaces at all can be said to satisfy some simple, non-disjunctive mathematical description. Therefore, if we allow that a set of surfaces can "look blue" despite not satisfying the mathematical formula for
blueness which corresponds to surfaces which look blue to a normal, that creates an epistemic gulf between perception and things seen such that we must drop the claim that colors are the direct objects of seeing.\textsuperscript{63} We can't claim that when someone sees that two surfaces both look blue, she is seeing that they satisfy the mathematical description which defines anthropocentric blue. Rather we must say that she is seeing that they both satisfy some common mathematical description or other. But this is hardly something we must see to know because any two surfaces at all satisfy some mathematical description or other.

The moral I take from Hilbert's work is that colors are not features of the external world.

\textsuperscript{63} The claim that colors are the direct objects of seeing is Cohen's claim. I don't mean to be saying that Hilbert is inconsistent on this point.
Chapter 7: The correspondence between color properties and color experiences

Cohen’s properties

In this section I want to drive home the point that Cohen's color properties do not stand in the right sort of correlation to color experiences. My point is simple. An experience of blueness does not necessarily imply an awareness of the property blue-for-a-normal-under-normal-conditions. Similarly, an awareness of the property blue-for-a-normal-under-normal-conditions does not imply an experience of blueness. [And so on with all the other colors.]

To show that awareness of an object's functional color property is not necessary for color experience, we can appeal to a number of different empirical facts. One that immediately comes to mind is that of the color sorting behavior of infants and animals. Certain types of monkeys perform similarly on color sorting tests as normal humans. However, while a good argument can be made that the monkeys in question have the same types of visual systems -- and therefore the same types of color experiences--as normal humans, it would seem perverse to suppose that monkeys are aware that (e.g.,) sample a has the functional property of looking red to normal (humans) under normal conditions. The same considerations apply to dichromatic animals. Elephants would be expected to perform similarly to protanopes on color sorting tests. However, it would seem odd to suppose that the reason the elephant matches surfaces a-r is because he sees that they all have a the functional color property yellow for (human) protanopes. If the examples from animals are unconvincing, we need simply appeal to the fact that pre-linguistic human infants perform similarly to their full-grown counterparts on color
sorting tests. Thus, color-normal infants will replicate the sorting behavior of full-grown color-normal humans. It would seem beyond dispute that color-normal human infants have the same experiences in reaction to surfaces a-u. However, it would seem dubious to claim that the infants are aware of the functional color-properties of surfaces a-u.

To show that awareness of an object's functional color property is not sufficient for the color experience appealed to in appropriate explanations of sorting behavior can be seen from considering cases of the colorblind learning to replicate trichromatic behavior through different causal routes which nevertheless involve coming to an awareness of objects' functional color properties.

The colorblind must function in a world in which the dominant conventions are based upon trichromatic vision. One prime example is that of color-coded traffic lights. To a protanope, each of the three lights appearing in a typical traffic signal appear yellow. This does not mean, however, that protanopes cannot effectively interpret the message of each distinct light. Typically, the red-green colorblind rely upon the position of the light in the signal to determine the light's color and thereby the imperative signaled by the light. Knowing the position of the traffic light in the signal enables the colorblind to acquire an awareness of the light's functional role without thereby having the color experience which is crucial to explaining trichromatic sorting behavior. Of course examples of this sort can be generated ad nauseum.

To consider one further example, more obvious example, the colorblind can read the color terms which appear on the wrappings of crayons. Let's suppose that surfaces a-u were labeled with their appropriate English color terms. Well then, in that case, the
monochromat and the protanope would easily be able to duplicate the sorting experiences of the trichromat. Now, certainly reading the English color terms from the samples would enable the colorblind subjects to achieve an awareness of the functional properties of the samples. And this knowledge of the samples' functional properties would enable them to reproduce the typical trichromatic sorting behavior. However, in so doing, they would not be exploiting an awareness of the same thing the trichromat is exploiting when he takes the test.

**Hilbert’s properties**

Hilbert claims that when we see color matches we are seeing that the matching objects both share reflectances which are members of an anthropocentric kind. My argument against the causal efficacy of anthropocentric kinds will take the same form as my argument against the causal efficacy of functional roles.

My argument against Hilbert distinguishes between anthropocentric kinds and illusory kinds. My argument builds on a position I attribute to Hilbert which I take to be implicit in his 1987 book. The claim is that when the colorblind see surfaces as matching they are suffering from color illusions but that when color-normals see surfaces as matching they are acquiring an awareness that the matching surfaces both fall under a common anthropocentric kind.

I will begin by distinguishing between anthropocentric kinds and illusory kinds. Anthropocentric kinds are sets of surfaces which "reflect the same amount of light within each of three wavebands corresponding to the sensitivity ranges of the human
Because of this, they admit of a certain simple, non-disjunctive mathematical description had by all and only members of that anthropocentric kind. Each of the categories indicated by black outline in the diagram depicting trichromatic sorting behavior corresponds to an anthropocentric kind. For example, a b and c all belong to a common anthropocentric kind as do d e and f and so on.

Figure 3: Typical trichromatic sorting for samples a-u

On the other hand, illusory kinds are sets of surfaces which may not "reflect the same amount of light within each of three wavebands corresponding to the sensitivity ranges of the human photoreceptors," but which nevertheless match to some subject. For example, a-u are all members of an illusory kind which I have called $\alpha$. Similarly a-l are all members of an illusory kind I have called $\beta$, and m-r are all members of an illusory kind I have called $\gamma$.

I argue that the presence of an anthropocentric kind is neither necessary nor sufficient to cause color experiences which we appeal to to explain sorting behavior.

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64 Hilbert, 1987, pg. 108
Anthropocentric kinds are not sufficient for experiences of color matches

The presence of an anthropocentric kinds is not generally sufficient for causing experiences of color matches. To see this we must simply note that there are some creatures who will draw color distinctions between objects that normal humans would not. These creatures will draw distinctions where normal humans see no such distinction. (Although we can explain these creatures' matches by appeal to the hues, we cannot explain them by appeal to anthropocentric kinds.)

For some creatures, these distinctions will be based on sensitivity to extra-spectral electromagnetic activity, for other creatures, these distinctions will be based on sensitivities to different wavebands of the visible spectrum. Thus the fact that a set of surfaces are all members of a common anthropocentric kind is no guarantee that those objects will match in color.

Anthropocentric kinds are not necessary for experiences of color matches

To see that anthropocentric kinds are not necessary for experiences of color matches, we need only consider the cases of colorblindness we have already noted. For example, the protanope is able to experience a, d, g, and j as matching despite the fact that they do not belong to a common anthropocentric kind.

Conclusion

What I have shown is this: (1) There are important contexts in which the properties Cohen and Hilbert identify as color properties are unable to account for the
matches and mismatches made by humans. In Cohen's case it is matches and mismatches across visual systems. In Hilbert's case it is matches and mismatches made by the colorblind and non-trichromatic animals. (2) Hilbert and Cohen both must maintain that protanopes do not see blue and monochromats do not see gray, a position which puts them at odds with important results from comparative vision research.
Chapter 8: Conclusion of thesis

Color irrealism, visual field realism, qualia realism, type-type reductionism.

I have asserted that the following two views are incompatible: (1) color is a feature of the external world, and (2) color is directly perceptible. I have argued that one of these two must go. The strategy I prefer is to reject (1) while accepting (2).

Rejecting the view that colors are features of the external world may seem counterintuitive to many. However, the counterintuitiveness of the view is outweighed, I have argued, by the fact that there seems to be no feature of the external world which satisfies both the commonality criterion and the causality criterion. In the absence of such external features, it becomes plausible to suppose that colors are non-representational features of the visual field. Defending the view that colors are non-representational features of the visual field is beyond the scope of this thesis. However, this view does receive vigorous support from Christopher Peacocke. 65

Another strategy I support is that of identifying color properties of the visual field with brain states. The most promising account of such a reduction is found in the more recent work of Paul Churchland. 66 Churchland, following Hurvich, argues that there is a direct correspondence between types of opponent cell activity and types of color experiences. 67 The asserted correspondence promises to be a direct correspondence and it

65 Peacocke, 1984,
67 Hurvich, 1981
promises to explain the color sorting behavior of all humans, the colorblind and the non-colorblind alike.

If we accept that colors just are color experiences, then we can make use of the brain states hypothesized by Hurvich and cited by Churchland⁶⁸ to answer the commonality and causality requirement so as to meet the objections I make against Cohen and Hilbert so long as we acknowledge that colors are features of experience and not literally features of objects.

Let's consider how this view would respond to the motivating question behind the commonality criterion: What is it that all and only instances of redness have in common? Following Churchland, I suggest that what all and only instances of redness have in common is a certain mathematical description shared by all and only a certain type of brain state.

Next, let's consider how the irrealism I advocate fares on the causality criterion. The causality criterion requires that whatever is identified as satisfying the commonality requirement have the right sort of causal powers. This is no great problem on my view since every determinate instance of a given color experience is directly correlated with a brain state which occurs when and only when that color experience is present in the visual field. Therefore, by Cohen's criterion of causal relevance, we can cite the brain state as the cause of the visual experience.

⁶⁸ Churchland, 2005
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