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Revelation and Normativity in Visual Experience

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I A problem to start

Suppose Figure 1 depicts stimuli from an experiment on shape discrimination, where the subjects are asked to point out the best circle.

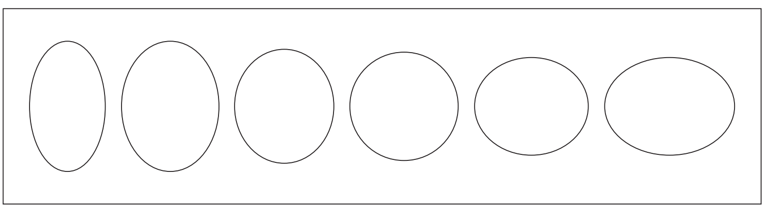

Figure 1. *Stimuli from a hypothetical shape-perception experiment. See the main text for further explanation.*

Now suppose that Figure 2 shows stimuli from a color-discrimination experiment where the subjects' task is to pick the purest green — green that is neither yellowish nor bluish — in other words, is *unique* green.

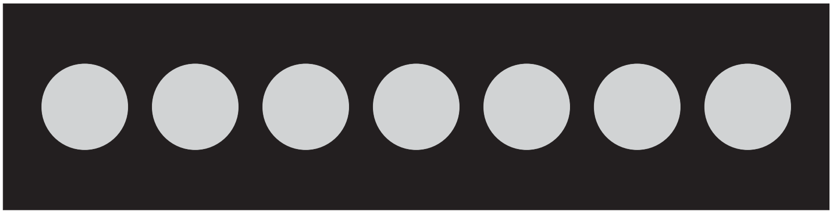

Figure 2. *Stimuli from a hypothetical color-vision experiment. See the main text for further explanation.*

In both these tasks there are individual differences between different subjects. However, notice that in the shape-discrimination case there is exactly one correct response: the best circle is the fourth from the left. In the color case it is not obvious, to put it mildly, that there is exactly one correct response. One color-normal subject may find that the purest green is the third from the left, whereas another may choose the fifth from the left, and still another may pick the fourth. Who is right, and who is wrong? More importantly, why is there this difference between shape perception and color perception?

A traditional explanation that dates back to Aristotle is that we access color in one perceptual modality only, whereas shape we perceive via two different modalities: visual and tactile. Two independent modalities make possible a verification of our percepts (say, percepts of a given stimulus in one modality by those of the same stimulus in another modality) which is not possible for qualities accessed in one modality only.

According to the Lockean tradition, our ideas of shapes resemble shapes in ways our ideas of colors do not resemble colors. This difference could also be used to derive an explanation of the present puzzle. However, on a recent anti-Lockean proposal, there is a fact of the matter which object color is unique green because being, say, unique green is a property as independent of observers as is being circular or being rectangular.

In what follows I shall advance a view that is closer to the Lockean than to the Aristotelian approach, and which is motivated by recent ideas in cognitive psychology and psychophysics. According to it, in the above example, there is an observer-independent fact of the matter which figure is the best circle, whereas there is no observer-independent fact of the matter which color is unique green (*mutatis mutandis* for other shapes and colors). However, this difference has nothing to do with how many modalities give us access to shapes versus colors. Rather, it is due to how stimulus properties are represented within a single modality. Veridicality could apply to the distribution of color percepts over physical color stimuli if we represented colors in more complex ways than we actually do (e.g., similarly to the auditory representation of sounds), still within one modality only. Moreover, veridicality would not apply to the distribution of shape percepts over the shapes if shapes were perceptually represented in much simpler ways than they actually are — even if they were represented in a number of different modalities.

II Revelation in color perception

One variant of philosophical realism has it that our visual experience reveals to us the very essence of color. In order to know immediately, and exactly, what properties the colors are, all one needs is to see them. However, even though colors exist independently of observers, what perception reveals about them cannot be revealed by any other means — not, at least, via language (Johnston, 1997, 138; Campbell, 1997, 178-9; McLaughlin, 2003b, 97; Russell, 1912, 47; Strawson, 1989, 224; Byrne and Hilbert, 1997a, 2003; Stroud, 2000). One can learn empirical facts about color via scientific inquiry, but such facts alone will never teach one the essential nature of color, nor is the knowledge of such facts needed to grasp the essential nature of color via perception. To summarize: (1) color vision reveals the essence of colors, and (2) nothing else can reveal the essence of colors.[1]

Thus we have one notion of revelation: we can call it *primitive revelation*.[2] I find primitive revelation a profoundly mistaken idea, because of its agnosticism about color, and also because it seems to imply that colors are not the canonical causes of our experiences of color.[3] For color science can surely describe the physical properties that are the canonical causes of color experience. But color science also makes it clear that color perception does not reveal the essence of those properties in any obvious way.[4]

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1 Campbell (1997, 178-9) uses the term 'transparency' to mean what I mean by 'revelation' here. I follow McLaughlin (2003b) in using 'transparency' and 'revelation.'

2 The term 'primitive revelation' is my invention. In it, 'primitive' refers to primitivism, a philosophical theory of object color. At the heart of that theory is the notion of revelation as I just characterized it. For exposition and discussion of primitivism see Campbell, 1993; Smith, 1993; Yablo, 1995; McGinn, 1996; Johnston, 1998; Stroud, 2000. Note also that Tye (2000, 26-32, 54-60, 149-50, n.4 on 167; Tye, 1995, 169, 174) has a philosophically more attractive approach to revelation that I shall briefly discuss in section IX below.

3 Though some would deny this: see in particular Campbell, 1997. See, however, Tye (2000, 149) for an objection to Campbell's view.

4 Not everybody would agree to this claim. Byrne and Hilbert (1997, 2003), and Tye (2000, ch. 7) formulate a view of color that (1) attempts to be consistent with the findings of color science, (2) assumes that colors are the canonical causes of color experience, (3) claims that colors can be adequately captured by scientific concepts (4) argues that object colors crucially determine what it is like to see them, and so in this most important sense comes close to the idea of primitive revelation. However, McLaughlin (2003b), and Jakab (2001, 2003a, 2003b, Jakab and McLaugh-

In what follows I am going to offer an alternative notion of perceptual revelation, one that is arguably true of some perceptual modalities — though not of color perception. My alternative notion, I claim, is consistent with our knowledge about the psychology of perception, and I hope it will also help to clarify some issues about perceptual representation.[5]

The outline of this paper is as follows. Section III draws the reader's attention to certain differences between the perception of shape and that of color, and introduces an alternative notion of revelation. Section IV supports the claims of Section III with some psychological data and reasoning. Section V outlines the two main brands of physicalism about color, and the difference between them that is most important in the context of this paper. Section VI argues against one of them, the so-called absolutist version of color physicalism, and for the other, relativist approach. Section VII considers some lines of defense for color absolutism. Section VIII formulates the key claims of this paper, namely how the notion of revelation proposed in Section III makes color relativism plausible while preserving the idea that relativism about shape would be absurd. Finally, Section IX adds two brief considerations in the hope of further clarifying my point.

Here are some termionological remarks. I shall use the terms 'color,' 'color category,' 'narrow shade,' 'determinate,' 'determinable' to designate object-color properties (for the latter two terms see Byrne and Hilbert, 1997b, 266-7, 276-8, 280-1). To refer to the relevant perceptual states I shall use the terms 'perceptual color category,' 'perceived narrow shade,' 'color percept,' 'unique hue experience,' and 'binary hue experience.' Of these, 'perceived narrow shade' and 'color percept' mean the same. Color percepts or perceived narrow shades are perceptually determinate color experiences, perceptions that we get when looking at particular colored surfaces on particular occasions. For instance, we never perceive a surface that is *red, full stop*: we always perceive some determinate shade of red. Unique hue experiences and binary hue experiences (see below for explanation) are different types of color percepts. Narrow shades, on the other hand, are specific color stimuli

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lin, 2003) argue that both Tye's and Byrne and Hilbert's views fail right on the first count — they cannot be made consistent with findings about color perception. For more on (primitive) revelation, see McLaughlin (2003b, esp. sections 1, 2, 7, 18).

5 John Kulvicki recently published an article the core idea of which is quite close to that of the present paper. We both point out a similar contrast between visual representation of shape and that of color. However, Kulvicki and I present the idea in quite different ways, and, due to our different views on the nature of color, we draw quite different conclusions from it. We arrived at similar views independently.

corresponding to color percepts. Narrow shades do not have discriminable sub-shades — they are probably best characterized in terms of metamer sets (see Finlayson and Morovic, 2000a, 2000b). A metamer set that is a narrow shade is such that any two subsets of it would look indistinguishable in color.[6] In Byrne and Hilbert's terms, narrow shades are determinates, whereas broader or narrower color categories are determinables, under which many different narrow shades or determinates belong.[7]

III Perception of color and perception of shape: A difference

It is just as resonable to distinguish colors from what it is like to see them as it is to distinguish shapes from what it is like to see them — at least because physical stimuli and corresponding percepts are distinct in both cases. There is also no doubt that shapes are the canonical causes of our shape percepts (visual or tactile). Correspondingly, the most natural view about color vision is that colors are the canonical causes of color percepts. That is, in anything like 'broadly normal' or 'optimal' conditions of perception it is shapes that evoke our shape percepts, and it is colors that evoke our color percepts.

However, here is a difference between the perception of shape and that of color. Philosophers have been obsessed with the following questions: what is color in objects? Are external objects colored at all? If yes, are colors the canonical causes of our perceptions of color? A number of different answers have been proposed to these questions (Byrne and

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6 We have to take into account that metamerism is both illumination-dependent and observer-dependent. I'll address this problem below.

7 For instance, the broad color category green includes many shades of green with differing lightness, saturation, and chromatic composition (i.e., only slightly yellowish or bluish greens we might still classify as green). Physically, the color category green corresponds fairly well to surfaces that reflect or emit or transmit light dominantly between 500 and 600 nm, and little light between 400-500 nm and 600-700 nm. Olive greens (i.e., dark, less saturated greens) mostly correspond to surfaces whose reflectance or emittance or transmittance is low overall, but still it is relatively higher in the middle of the visible spectrum. Narrow shades of green correspond to metameric sets of surface reflectances, transmittances, or relative energy distributions of light emission (Byrne and Hilbert, 1997, 266; Finlayson and Morovic, 2000a, 2000b), but each member of such a set has the more general characteristic of the broad category green.

Hilbert, 1997, Vol. I, 2003; Hardin, 1988; Hilbert, 1987; Thompson, 1995, 2000; Stroud, 2000; Tye, 2000, ch. 7; Jackson, 2000; Hilbert and Kalderon, 2000; Akins and Hahn, 2000; McLaughlin, 2003a,b; Matthen, 2001).

There is no parallel problem for the notion of shape and shape perception. When one asks: 'What are the shapes of objects?' we can reply: 'Shapes are types of spatial distribution of matter.' We also have abstract shape concepts designating these types. We can readily describe shapes: regular ones by the concepts of Euclidean geometry, irregular ones by those of analytic geometry: sets of points or equations that specify the relations among the numerical coordinates of points that are part of the object to be described. Although it may get tedious sometimes, everyday language can also convey a lot of detail about irregular shapes.

The disanalogy continues. Our abstract concept of shapes in general, and an exact characterization of many particular shapes, arose from visually perceiving (and manipulating, e.g., drawing) shapes, plus intellectual reflection. Ancient Greeks did not have empirical science,[8] nor did they need it for coming up with Euclidean geometry. After the birth of Euclidean geometry it took a long time until others formulated non-Euclidean geometries, which made assumptions that contrast with perception-driven intuition (e.g., changing Euclid's fifth axiom). Apparently, visual perception happens to be the most powerful source of our concepts of shape. We can of course acquire abstract concepts of shape without having vision, as do congenitally blind people. Even though vision is a very powerful, and the most typical, means of learning about shape, it does not seem necessary that we learn shape concepts through vision.

The corresponding story about color is entirely different. Color perception plus intellectual reflection alone never gave us a non-controversial notion of object color. Indeed, philosophical reflection on our perception of color sparked the very debate about color that I just mentioned. That is still an ongoing debate. On the other hand, empirical science (color science and psychophysics) taught us a whole lot about the canonical causes of color experience — surface reflectances, color signals, spectral sensitivities of the photoreceptors, and the like. Science taught us concepts that color perception and intellectual reflection, not conjoined with empirical methods, were unable to teach us. In particular, color perception and reflection alone never gave us ideas like color

8 By this term I mean *sophisticated and mathematized experimental* sciences (physics, chemistry, biology, etc.). In contrast to the Greeks, the method of reasoning in Old Babylonian geometry was empirical in a more general sense, its concepts being rather rudimentary compared to the Euclidean system (Hoyrup, 1998, 2002).

is the same as, or is intimately related to, surface reflectance, relative energy distribution of emitted light, and so on.

Note, however, a distinction. Even ancient Greeks, Romans and medieval thinkers were aware of the fact that surfaces modify the incoming light and that that process is largely responsible for their color (Aristoteles, 1984, 793b1-794a1; Gage, 1993, 139-41; Wade, 1998, 120; Zemplén, 2004). Thus it is reasonable to assume that color perception together with intellectual reflection can give us a rough and ready idea of what *colors in general are*. But this idea is not very precise and, most importantly, it does not extend to an exact characterization of particular colors. In contrast, shape perception plus intellectual reflection can lead us to exact and largely uncontroversial characterization of particular shapes. That is, the contrast between shape and color is brought out best by questions like 'What is it to be rectangular?' or 'What is it to have a shape resembling the coastline of Italy?' on the one hand, and questions like 'What is it to be red?' or 'What is it to be yellow?' on the other.

Another refinement is this. What I am claiming is that there exist levels of description (e.g., geometry, analytic geometry, and vernacular) at which it is possible to characterize particular shapes in perceiver-independent terms, based on perception and intellectual reflection only. In contrast, there does not exist any level of description at which particular colors can be characterized in perceiver-independent terms, based on just perception and intellectual reflection. For any perceiver-independent characterization of particular colors one needs color science.

In what follows I shall assume that colors *are* the canonical causes of color experience. I shall also assume that colors exist and that they are physical properties of environmental surfaces. For support of these assumptions, I rely on the literature that defends physicalism about color (especially McLaughlin, 2003a, 2003b; Jackson and Pargetter, 1997, 2000, but see also Hilbert, 1987; Byrne and Hilbert, 1997b, 2003; Tye, 2000, ch. 7). With these assumptions at hand I can reach the conclusion that empirical science teaches us facts about the nature of color (and especially that of particular colors) that color perception plus intellectual reflection were unable to teach us.

On the contrary, as I argued, shape perception plus intellectual reflection were able to teach us the essence of shapes in general, and also the essence of particular shapes. No empirical inquiry was necessary for this achievement. Now consider the following principle:

> [Conceptual revelation] Stimulus property P is revealed in perception iff perceiving some object having P *as P* plus intellectual reflection together can lead us to a conception of P's essence in

perception-independent terms, that is, a conception that does not make reference to our perception, or experience, of P.[9]

As I argued above, conceptual revelation is true of shape perception. On the other hand, it is not obvious, to put it mildly, that it is true of color perception. If what color science can teach us includes the essential nature of color, then the essential nature of color is not accessible just to color perception and intellectual reflection — because what color science teaches us (about wavelength distributions, surface reflections, and so on) is not so accessible. On the other hand, assuming that color science cannot teach us the essence of color one could argue that conceptual revelation is true of color perception. But the best argument in favor of such a claim would be to come forward with a relatively uncontroversial philosophical theory of color that includes an exact characterization of particular colors in perceiver-independent terms[10] (like Euclidean geometry characterizes shapes) and that does not rely on the findings of color science. Unfortunately, there is no theory up to date that comes anywhere close to this requirement.[11]

At this point, the following question arises: what psychological difference between shape perception and color perception is responsible for the fact that shape perception conceptually reveals its own canonical causes (which are no doubt the shapes) whereas color perception does not conceptually reveal its own canonical causes (which, I assume, are the colors)?

9 Again, the emphasis is on specific stimulus properties, not highly generalized ones. Substitute for P something like being rectangular (as opposed to having shape), or being unique red (as opposed to being colored). The principle should work at both levels of generality in order for conceptual revelation to obtain in a perceptual modality. As I argued in the main text, what really makes the difference between shape perception and color perception is the level of specific properties.

10 That is, in terms that are *non-question-beggingly perceiver-independent*. Primitivists like John Campbell or Barry Stroud would claim that 'red' refers to a property whose essence does not include any reaction of perceivers. Since this claim is not generally agreed upon (to put it mildly: see among others Hardin, 1988; Shoemaker, 1994; Peacocke, 1997; Block, 1999; McLaughlin, 2003b), 'red' does not appear to be a non-question-beggingly perceiver-independent term to characterize particular colors.

11 Physicalist views of color that I endorse below (Jackson and Pargetter, 1997, 2000; McLaughlin, 2003a, 2003b) do not satisfy this requirement, nor is this their goal. For instance, on McLaughlin's approach, the perceiver-independent characterization of colors does rely on the findings of color science. Moreover, McLaughlin explicitly denies that color perception is revelatory with respect to colors.

IV Reason for the difference

Certain variants of perceptual representation, simpler as they may be than conceptual representation, already satisfy the most general requirements of compositionality (Fodor, 1987, 1998). Indeed, these forms of perceptual representation constitute simple grammars with a finite number of elements plus rules of combination. The rules allow the elements to be assembled into complexes. The elements are shareable: one and the same element can occur in different complexes. The system is productive: a finite number of elements can give rise to an arbitrarily large set of complexes. It is also systematic (in Fodor's sense): even small subsets of the elements may be combined in different ways each standing for a different state of affairs. Just as whoever can think John loves Mary can also think Mary loves John, whoever can see, or imagine, that an apple rests on a leaf can also see (in appropriate circumstances), or imagine, that the same leaf rests on the same apple.

One important difference between conceptual and perceptual representation is that while conceptual representation can apprehend a great variety of entirely different relations, perceptual representation can only apprehend rather limited realms of relations. For instance, despite their compositionality, visual representations of shape and space can apprehend spatio-temporal relations only. However, a very important feature is that the information conveyed by perceptual compositionality is available to the conceptual faculty: we can report on the details of perceived shapes and spatial layouts.

For another example of perceptual compositionality, note that the auditory system performs a crude Fourier analysis on its acoustic input — complex soundwaves. Moreover, the output of this analysis is, to a certain degree at least, accessible to higher cognition. It is possible to discern component tones in musical chords, different instruments in the sound of an orchestra, or a cricket's chirping as leaves rustle in the wind. This complexity, that is already present in the auditory representation of relatively short-duration and more-or-less constant acoustic events, plus appropriate intellectual effort (including the practicing of music), was sufficient for developing the abstract system of music theory.

In contrast with visual perception of shape and space, perceptual representations in a number of modalities do not satisfy the above-mentioned general criteria of compositionality. Heat sensations, for instance, do not combine into arbitrarily complex structures. There exists only a limited set of heat sensations the distribution of which appears continuous, changing gradually from very cold to very hot, with a rather small number of easy-to-memorize, discrete categories of felt temperature. There seems to be no way in which heat sensations could combine with each other, resulting in more complex perceptual representations.

Perceived color is another example. Particular colors are represented in the visual system as points in color space — a three-dimensional perceptual similarity space. Even though there may be tens of thousands of color perceptions that are discriminable from one another by a subject with normal color vision, there is at most a very limited degree (if any) to which color percepts can combine with one another to constitute complexes.[12] This is so despite the fact that color stimuli (for instance, surface reflectance distributions) could in principle be represented in much more complex ways than they actually are by trichromatic color vision (e.g., if we had many cone types with differing spectral sensitivities; see Sec. IX). It may also be a matter of degree whether compositionality is present in different perceptual modalities.

Elsewhere I formulated this idea more precisely, proposing a definition of representational atomism for perceptual states (Jakab, 2000). There I suggested that a perceptual state is non-atomic (complex) if, on undergoing it, (1) the subject can decipher (and indicate, for instance verbally report) constituents in it, and (2) the deciphered constituents can be undergone on their own, as separate experiences. Auditory perceptions of chords and their constituent tones is an example; so are perceptions of particular shapes in a complex scene. This personal-level analysis was accompanied by a sub-personal one; there the idea was that processes that operate on certain perceptual representations can decompose them into simpler elements, or constituents, and this complexity can then be reflected in other formats of representation into which the original perceptual format is transformed (most importantly propositional, or linguistic format). Representationally atomic perceptual states are those which do not satisfy criteria (1) and (2), and, correspondingly, are not treated by their processors as complexes.

The conclusion I suggest is that certain modalities can generate perceptual states with constituent structure, whereas in other modalities only representationally atomic percepts can arise. Let us take a look at empirical data and theories of shape perception and color perception to support this distinction.

Computational theories of vision offer two general approaches to the representation of shapes. One account proposes a decomposition of complex shapes into *volumetric primitives* (basic three-dimensional

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12 Here I mean complexes that are still singular color percepts. When one perceives orange, that may be understood as a perceptual combination of the percepts red and yellow, since what appears orange appears simultaneously reddish and yellowish. However, seeing a red stripe and a yellow stripe next to each other does not constitute a single color percept, but includes two separate color percepts.

shapes like cylinders with varying height and diameter), and assumes that the visual representation of complex shapes uses primitive (atomic) symbols standing for volumetric primitives, and complex representations that arise as combinations of the primitives (Marr, 1982; Marr and Nishihara, 1978; Biederman, 1987, 1990; Wallis and Bülthoff, 1999). The representations of shape primitives are thought to constitute a generative system of representation in which the rules of combination are fairly simple and flexible, somewhat similarly to the combination of Lego blocks (Wallis and Bülthoff, 1999). These approaches have been criticized on the grounds that there is insufficient neurophysiological evidence for a volumetric-primitive-based coding in the visual brain. Another line of critique was that whereas these models predict largely viewpoint-independent shape recognition, in actual fact several studies have revealed viewpoint-dependent recognition, even using simple shapes.

These weaknesses, especially the view-dependent effects, led to a view-based approach to object recognition (Bülthoff and Edelman, 1992; Tarr and Pinker, 1989). In general, this theory proposes that objects are represented as collections of 2-D views rather than configurations of 3-D shape primitives, or other kinds of 3-D models. View-dependence in object recognition is most noticeable for unfamiliar objects, and objects typically seen from a particular viewpoint (Wallis and Bülthoff, 1999; Palmer et al., 1981; Edelman and Bülthoff, 1992), whereas for familiar objects, recognition is view-independent. This is also reflected in the evolving neuronal code (Schyns, 1997; Schyns et el., 1998; Miyashita, 1988; Kobatake et al., 1998; Logothetis and Pauls, 1995).

This combination of view-dependent and view-independent effects suggest that view-based approaches of visual object representation have to be supplemented by a feature-based neuronal/representational code (Wallis and Bülthoff, 1999). After seeing novel shapes or objects from one viewpoint, often enough we can quickly recognize them from a substantially different angle of view. As Wallis and Bülthoff argue, this can happen only if the views that constitute the representation of the object comprise a collection of many subfeatures. At the level of neuronal coding, objects are represented by coordinated activity patterns of many feature-selective neurons in the inferotemporal cortex. The represented features are typically local, extending to small regions of an object (e.g., light and shade, color and form of a part of a complex shape), but they can also be more global characteristics like the object's outline. Feature representations exhibit size and viewpoint-invariance, as is typical of neurons in the inferotemporal cortex. New combinations of these neuronal feature-representations can be recruited to uniquely represent a completely new object. Wallis and Bülthoff (1999) contend that this model can account for results obtained in mental rotation experiments, a case that has been viewed as a proof of 3-D object-models in the visual system.

For another perspective, Palmer (1999, ch. 8) reviews the following classes of theories of visual shape representation.

(1) Representation by templates. Templates are unstructured shape representations, for instance, a shape's template can be the conjunction of receptors excited by that shape in a visual receptor field, surrounded by receptors not excited. These receptors together constitute a receptive field whose receptors are connected to a single specific-shape detector cell. Even though templates must be used at some point of visual processing, this very likely cannot be the whole story about visual shape representation.

(2) Representation by Fourier spectra. On this approach, images are analyzed into Fourier components: sinusoidal gratings at different spatial frequency, orientation, amplitude and phase. Shape properties can then be described in terms of such Fourier components. Despite its strengths, this approach fails to account for figure-background division, recovering part structures from holistic images, and three-dimensionality in visual representation.

(3) Features and dimensions. Shapes can be represented in multidimensional spaces with *feature dimensions* defining axes of the space. Object shapes are mapped to points in multidimensional spaces. Alternative approaches used hierarchically organized discrete features instead of continuous dimensions. (Features can include numbers and types of lines, angles, free ends, global symmetry, closed portion, and so on.) This approach can be strengthened by using feature maps, that is, pairing features with their positional coordinates in the image.

(4) Structural descriptions. On these theories, shape representation contains explicit information about parts of the object or scene, and relations between the parts. Combinations of shape primitives are structural descriptions whose special attraction is that they represent the global shapes of the components of complex objects.

(5) Structural information theory. This theory is an exact formulation of two principles in Gestalt psychology: figural goodness and the principle of Prägnanz. Figural goodness refers to the simplicity, order, and regularity of objects, whereas the latter principle asserts that from different perceptual interpretations of a scene the one with the highest figural goodness will be chosen.

Palmer concludes that more complex models, especially those that encode shape in terms of hierarchically organized structural descriptions based on some set of shape primitives, have more power to explain phenomena of three-dimensional shape perception (406-7).

With respect to color perception, the key question is whether singular color percepts should be taken as having constituent structure or not. On one view, seeing something orange is seeing something that is simultaneously reddish and yellowish, that is, a perceptual mixture of two other colors (Boynton, 1997; Tye, 2000, 162-5). At some places Hardin can be understood as taking the same line (e.g., 1997, 290-1), even though at other places he argues more explicitly against the idea that binary hues have constituent structure (Hardin, 1988, 43; see also Thompson, 2000, 171). The first point to note is that even if singular color experiences can have constituent structure, it is only a minimal one. Moreover, even accepting this minimal compositionality within singular color percepts, these percepts are still representationally atomic because their minimal constituent structure does not reliably track any corresponding physical structure in the environmental color stimuli. This claim needs argument which will be provided below. To sum up, with respect to perceptual states the opposite of representational atomism is *structural encoding*: a perceptual state P structurally encodes its stimulus S_P if (i) P has constituent structure, and (ii) its constituent structure does reliably track, or map, some corresponding physical structure within S_P.[13]

In this section I have argued that visual representations of particular shapes are compositional and often quite complex states, whereas visual representations of particular colors are much simpler states that are either not at all compositional, or only minimally so. For this reason, shape perception conveys much more information about particular shapes than does color perception about particular colors. Moreover, this information about shapes and spatial layouts is readily accessible to the

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13 Here is a brief summary of arguments for and against the compositionality of binary hue experiences.

1. Pros. At the beginning of this section I mentioned two criteria for perceptual compositionality. Binary hues satisfy these criteria. In addition, the observation that orange does not appear both red and yellow, does not threaten the idea that the experience of red and that of yellow are constituents of the experience of orange (see Byrne and Hilbert, 1997, 280; Thompson, 2000, 169-73). As I have noted elsewhere (Jakab, 2000, 339), vodka is neither water, nor alcohol, yet it has two key constituents: water and alcohol. Similarly, at the level of perceptual experience, orange is *red 'diluted' by yellow*, or *yellow 'contaminated' by red*. Looking *only* yellowish colorwise is the same as looking yellow. Unique hue experiences have no constituents (other than themselves). The compositionality in the experience of orange should be understood as a combination of certain perceptual states (i.e., positive output *both* in the red-green channel and the blue-yellow channel, in terms of the opponent processing theory).

2. Cons. Hardin (1988, 43) argues that particular colors are represented by vectors in a three-dimensional vector space, and that such vectorial representations of colors have *vector components*, and vector components are not parts of vectors. Hence, on this analysis, no color experience has any constituent structure in the sense I just presented.

conceptual faculty. I offer this as an explanation of why conceptual revelation is true of shape perception but false of color perception.

V Two versions of physicalism about color

Physicalism about color is the thesis that object colors are physical properties of surfaces, and they are the canonical causes of our experiences of color. On physicalism, object colors are observer-independent. This means that (1) they can exist (i.e., be physically realized) in the absence of perceiving organisms, and (2) they are specifiable without making reference to observers' perceptual responses. Current versions of color physicalism propose to identify colors with types of surface reflectance (Hilbert, 1987; Byrne and Hilbert, 1997b, 2003; Matthen, 1988, 24-5; Tye, 1995, 147-8; 2000, ch. 7; Dretske, 1995, 88-93).

There exist, however, two rather different brands of physicalism about color. According to Hilbert, Byrne, Tye, and Dretske, the property of being a color (say, red), does not in any way include a relation to perceivers. Indeed, being red is one and the same property in every possible world: color names are rigid designators (Tye, 2000, n. 4 on 167). On the alternative account (Jackson and Pargetter, 1997; McLaughlin, 2003a,b), colors are identified with the bases of the dispositions to elicit experiences of color. Something is red only if it *fills the redness-role*, that is, it disposes its bearers to look red. To this view McLaughlin adds that some surface property R is redness only if it is common to all surfaces that are disposed to look red (to perceivers of type P, in circumstances C). McLaughlin explicitly rejects the idea that color names are rigid designators. For instance, the surface property R that disposes its bearers to look red to trichromat humans in average daylight, might not have done so — it might not have played the redness role. Had it not done so, it would not have been redness.

Note some subtleties about this second brand of color physicalism. It is still true on this view that colors can be physically realized in the absence of perceivers, since even if there were, say, no trichromat humans, the bases of the dispositions to look red (say, to trichromatic humans in daylight) could still be present. Such properties can also be characterized without making reference to reactions of perceivers. Redness can be characterized in terms of surface reflectance, composition of radiant light, and so on. However, notice that redness can be characterized in perceiver-independent terms only if we refer to some of its contingent features that happen to obtain in the actual world, but remain silent about its essential attributes. For playing the redness-role is essential for a property to be redness, but the redness-role consists in eliciting experiences of red (in suitable perceivers, in suitable circumstances).

Therefore, characterizing the colors by this essential attribute of them inevitably makes reference to reactions of perceivers.

Perhaps the most dramatic difference between the two approaches to color physicalism just presented is that on the rigid-designator account colors are absolute, whereas on the non-rigid version they are relative to perceivers and circumstances. In fact, both Jackson and Pargetter (1997) and McLaughlin (2003a,b) are color relativists. This means that color-roles like the redness-role necessarily include the specification of circumstances and that of perceivers. According to the notion of relativized color, there is no such property as *red, full stop*. What there is is *red, for subject S in circumstance C*. Relativization seems to be a very useful move since dependence of color perception on the circumstances and on perceivers is obvious. What looks bluish green to me in average daylight looks black to me in red light. It might easily happen that, on purchasing a shirt, it looks to me one shade in the store, and a noticeably different one in the street. Similarly, if the shirt looks to me green with a tinge of blue in daylight, it might still look green with a tinge of blue to someone else in the very same circumstance.[14] It is widely believed that there are even greater differences between the color perception of different species (Thompson et al., 1992; Matthen, 1999).

To the contrary, the rigid-designator version of color physicalism is absolutist about color. According to Dretske, Tye, Byrne, and Hilbert, a given type of surface reflectance R is one and the same color Q for everyone; therefore, it looks Q to trichromat humans in 'normal,' or 'optimal' circumstances of perception. It may not look Q to dichromats, but that's because dichromats do not have 'normal' color vision. Similarly, if a surface exhibiting R looks some color other than Q to a trichromat human, then either the circumstances fail to be normal or some kind of *normal misperception* obtains (Matthen, 1988; Dretske, 1995, 88-93; Tye, 2000, 151-62; Haugeland, 1981, 18; Matthen and Levy, 1984).

VI Problems with color absolutism

There are two main problems with color absolutism. First, 'normal' or 'optimal' conditions of perception are pretty variable. Second, independently of the relevant circumstances, normal trichromat humans vary substantially in their color perception. Regarding the circum-

14 And both of us can have perfectly normal color vision. This means that both of us pass the standard tests for color discrimination, since currently that is the only measure of the normality of one's color perception.

stances, there are a number of crucial factors influencing color perception: illumination, surround effects (simultaneous contrast), state of adaptation of the eye, and so on. Individual differences in color vision are, to a large extent, due to differences in the spectral sensitivity profiles of the three wavelength-selective retinal photoreceptor classes (Lutze et al., 1990; Neitz and Neitz, 1998; Hardin, 1988, 76-82). The changes in perceived color that these factors produce are, most often, only slight: they are changes in the perceived narrow shade of surfaces, but not in their broader perceptual color category. Ripe tomatoes look red to every trichromat, but the exact shade of red that a particular tomato looks to different trichromats in the same illumination, or to the same observer under two different illuminants seems to vary to a measurable extent.

For instance, take sunlight as the best norm of illumination. Natural lighting by the sun differs widely in different parts of the day, and in different weather conditions (see Shepard, 1997). Despite approximate color constancy (Fairchild, 1998, 156-7; Wandell, 1995, 314-15), perceived narrow shades change with illumination to some extent. In everyday situations we tend not to notice such changes, but they can be demonstrated in the laboratory (Brainard and Wandell, 1992).[15] Simultaneous contrast effects on color perception are also ubiquitous. The perceived narrow shade of a particular surface changes slightly with changes in the color of its surround (Wandell, 1995, chs. 4, 9; Fairchild, 1998, 135-9; Chichilnisky and Wandell, 1995; Shepherd, 1999). Finally, due to individual differences in color perception, one and the same surface in the same circumstance often looks different in color to different color-normal subjects (Kuehni, 2001). Not extremely rarely, such variation shows up in everyday verbal communication. Think of a debate between husband and wife whether a particular fabric is predominantly green, or predominantly blue (Byrne and Hilbert, 1997, 272).

For these reasons, color science introduced standards. Standard illuminants are lights with precisely specified relative energy distribution. Standard color contexts for viewing color samples often consist of achromatic grays, blacks, or otherwise attempt to minimize chromatic induction (Fairchild, 1998, 135). To eliminate variation in color perception

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15 When illuminant changes are temporal (like when the sunlight gradually changes in the afternoon, or we enter from the street into a store illuminated with fluorescent tubes), we tend not to notice the resulting slight change in our color perceptions, because we cannot memorize exact shades (Raffman, 1995, 294-5; Tye, 2000, 11-13). In cases of spatial variation of illumination within one scene, color constancy obtains if the visual system can discern the illuminant change and estimate its magnitude (Maloney, 1999, 2003).

due to differences in adaptation of the eye, experimental subjects can all be adapted to the same illumination (e.g., dark-adapted before viewing color stimuli on a computer monitor). Any particular standard circumstance for perception can minimize within-subject changes in color perception. However, there exist many different standards in color science, each having a different effect on subjects' color perception. Switching between standards does cause changes in the perception of particular color samples by particular subjects.

This problem of standard variation (McLaughlin, 2003b, sections 10-11) raises a question for color absolutists. A given sample looks different in color in different standard circumstances to the same observer; but which of these circumstances reveals *the true color* of the sample? Remember, for color absolutists a given sample X has one and the same color for everyone, regardless of changes in circumstances of perception.[16] But the color X looks to any perceiver differs in different standard circumstances. So, even if we admit, with Matthen (1988), Dretske (1995, 88-93), and Tye (2000) the possibility of normal misperception, we first have to pick and choose which of color science's standard conditions to take as revelatory with respect to the true shades of objects. There seems to be no non-arbitrary ground for such a choice. Furthermore, if we do make this choice, the unavoidable consequence will be that in our everyday life we are virtually never in the circumstance that reveals the true shades of objects, so with very rare exceptions we always misperceive the colors. Individual differences cause a similar problem: whose color perception reveals the true colors (narrow shades) of objects, given that color-normals often explicitly disagree in their color perception and judgment of one and the same sample in the same circumstance? Pick any one subject and it follows that anyone who disagrees with her about the exact shades of objects (at least 90 per cent of color-normals, on closer scrutiny) will be in error. This is an utterly absurd consequence, and what generated it is the assumption of color absolutism. Hence the motivation for relativism about color (McLaughlin, 2003a,b).

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16 By 'color' here I mean *narrow shade*. The main problem for color absolutism is to secure specifically the narrow shades against the threat of relativization. I agree with McLaughlin (2003a,b) and Hardin (1988) that this cannot be done in any remotely plausible way. It is no good as an argument to switch to broad color categories and note that ripe lemons look yellow to virtually everyone (Stroud, 2000, 173-4) since the maximum we can achieve by such a move is color absolutism about a small number of broader color categories or determinables, and the leftover relativism about the thousands of narrow shades that we actually perceive on particular occasions. Buy it if you like it.

VII Some replies to the challenge

Naturally, color absolutists have tried to counter the challenge just presented. Tye (2000, 89-93) argues that individual differences in color perception are properly understood as differences in one's capacity to discriminate colors. When two subjects A and B look at the same color sample S in the same circumstances, and S looks pure green to A whereas it looks slightly bluish green to B, what is going on, according to Tye, is that B has better color-discrimination than A. B is capable of discerning the tinge of blueness in the sample that A does not notice. The difference is like that between two gauges, one more finely calibrated than the other. A blunt ruler may say of a steel rod that it is roughly 19 inches long; a better ruler may say of the same rod that it is 19.35 inches long — neither ruler is mistaken. The same moral applies to individual differences in color vision, Tye contends. Thus the existing individual differences between trichromat subjects do not support the conclusion that some, perhaps many, color-normals misperceive the narrow shades of objects. Tye also thinks that the phenomenon of color constancy is robust enough so that changes in normal illumination cause at most ignorable changes in perceived shades (Tye, 2000, 147, 150), and that simultaneous contrast effects occur only occasionally, therefore they can be safely regarded as cases of normal misperception, on a par with shape illusions.

Regarding the latter two claims, they are simply false (see Fairchild, 1998, 156-7; Wandell, 1995, 314-15). Tye's suggestion about color constancy (2000, 147, 150) is made to sound plausible by effectively confusing broad color categories and narrow shades under the term 'color.'[17] Moreover, simultaneous contrast effects are ubiquitous, not occasional. Any particular reflecting surface under constant illumination can look a whole variety of different shades (even very different ones) to the same subject, depending on its surround. So the question which of the surrounds reveals the true shade of the sample continues to bother the absolutist. Perhaps some neutral mid-gray background reveals the true shades of objects? Again, any such choice seems entirely arbitrary (McLaughlin, 2003b), and it implies that in everyday life we very rarely see the true shades of objects — perhaps we do so only in the color scientist's laboratory.

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17 For instance, he says: 'Grass in the early morning looks to have the same color as it does at midday or late in the afternoon, even though the light is very different' (147). This claim is true if, by 'color,' we mean *broad color category* like green, but false if 'color' means *narrow shade*.

Tye's proposal about individual differences, despite being ingenious, does not work either. Variation in trichromatic color perception can take forms that cannot be accounted for by Tye's calibration approach. If a green sample looks slightly yellowish green to subject A, and slightly bluish green to B, this cannot be a mere difference in their ability to discriminate colors. A discerns a tinge of yellowishness, whereas B discerns a tinge of bluishness; now the question, which one of them is right, arises in a nastier way for the color absolutist. The sample is either yellowish or bluish; there is strong reason to assume, within the absolutist approach, that it cannot simultaneously be both.[18] Moreover, if, by assumption, the sample is objectively bluish green, whereas it looks to subject A yellowish green, then it seems very hard for Tye to avoid the conclusion that A, a perfectly normal color perceiver, misperceives the sample. There exist some data suggesting that this sort of individual variation might actually exist (Jakab, 2001, ch. 6).

Byrne and Hilbert (1997b, 2003) propose two other ways to accommodate variation in trichromatic color perception in the absolutist approach. Their first proposal (Byrne and Hilbert, 1997b, 272-4) is that narrow shades or certain specific color categories like unique green or slightly bluish green are not contraries: if a surface is unique green, it does not follow that it is therefore not slightly bluish green. Some bluish greens are certainly not unique greens, but others may be. Byrne and Hilbert offer an analogy: there are shapes that are both squares and diamonds, namely, any square standing on one of its corners. Yet it might mistakenly appear to someone that no diamonds are ever squares — perhaps the idea that no bluish greens are ever unique greens is the same way mistaken, suggest Byrne and Hilbert. Of course, there are many diamonds that aren't squares, but there are also bluish greens that are not unique greens, so this analogy between shape and color seems to obtain.

If it is accepted that unique green and bluish green *are* contraries, then it still remains true that seeing a unique green surface as green with a tinge of blue is only a marginal error and such a color perception is for

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18 Blue and yellow are perceptually incompatible (no surface ever looks simultaneously bluish and yellowish all over); therefore, if color perception veridically represents some physical properties that are the colors, then it should follow that blue and yellow as object colors (i.e., being simultaneously bluish and yellowish all over) are objectively incompatible. This incompatibility is also inherent in Byrne and Hilbert's characterization of colors in terms of surface reflectances (1997, 265-6; see also Tye, 2000, 159-65; Bradley and Tye, 2001).

the most part veridical (i.e., that the surface is predominantly green is correctly perceived).

In response, it is worth noting that even if being bluish green is compatible with being unique green in the way Byrne and Hilbert assume (something I do not believe), being slightly yellowish green and being slightly bluish green are certainly incompatible properties simply because being bluish and being yellowish are incompatible (see above). So if a sample looks slightly yellowish green to A and slightly bluish green to B, then at least one of them must be in error. A *marginal* error only, Byrne and Hilbert would add; a marginal error *with respect to broad color categories*, I would add. But what is a marginal error with respect to broad color categories is a total error with respect to narrow shades. If, by assumption, a particular surface is slightly bluish green, but it looks to me slightly yellowish green, then I completely misidentify the narrow shade (the *determinate*, in Byrne and Hilbert's terms: 1997b, 266-7, 276-8, 280-1) in question.[19] I might still be correct about which broad color category (determinable) the perceived surface belongs in, but regarding the narrow shade, I am simply off the mark. Thus variation in normal color perception prevents absolutists from specifying the narrow shades in terms of surface reflectance (i.e., as metameric sets), and it forces them to admit that the overwhelming majority of color-normal people, in most circumstances, misperceive the narrow shades of objects in normal circumstances of perception.

In their most recent article, Byrne and Hilbert (2003) choose the latter way. They argue that a slight but ubiquitous error with respect to the visual perception of shapes occurs fairly frequently in humans.[20] So it should come as no surprise if such errors obtain in 'normal' color vision as well. Byrne and Hilbert would ask that since the existence of this kind of error does not make relativism about shape the least bit plausible, why should it make color relativism any more plausible? Byrne and Hilbert note that there is a relevant difference between color perception and shape perception, namely that in the latter case there are 'independent tests' for the exact veridicality of shape perception, whereas there is no

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19 Using Sternheim and Boynton's terms (Sternheim and Boynton, 1966; Byrne and Hilbert, 2003), if a particular surface looks to me 90 per cent greenish and 10 per cent yellowish, whereas it is, *objectively*, 100 per cent greenish (i.e., unique green), then I simply misidentified the narrow shade in question. I took it to be *the one* that is 90 percent greenish and 10 per cent yellowish (lightness and saturation specified) whereas it is, objectively, the one that is 100 per cent greenish or unique green.

20 The opthalmological condition that brings about this sort of perceptual error is called *aniseikonia* (Byrne and Hilbert, 2003, section 3.4.).

comparable test for color perception (Byrne and Hilbert, 2003, section 3.4.). But, they suggest, this difference does not support color-relativism — it only leads to a strange form of agnosticism about narrow shades (Byrne and Hilbert, 2003, n. 50). Since to different trichromatic subjects different metameric sets (narrow shades) will look unique green, and since there is no independent test for the correctness of the perception of narrow shades, it is in principle impossible to decide who is right about perceiving unique green, and so it is in principle impossible to establish which metameric set *is* unique green — objectively, or in absolute terms. Mutatis mutandis for all other narrow shades, we should add. We can probably learn the reflectance basis of the eight broad chromatic categories (red, green, yellow, blue, orange, purple, yellowish green and bluish green) plus that of black, mid-gray and white. Perhaps we can do a little better, characterizing narrower color categories like scarlet or navy blue in terms of reflectance. But just go to a paint shop, look at the thousands of available narrow shades each one of which is affected by the problem of agnosticism. The sample called Patio Pink very likely appears slightly different in color to different normal color perceivers, even in the same circumstances. In the other direction, the color that *is* 70 per cent reddish and 30 per cent bluish, cannot be characterized in terms of reflectance. This is because to different normal color perceivers different and often non-overlapping narrow ranges of reflectance (metameric sets) will appear 70 per cent reddish and 30 per cent bluish. Thus on Byrne and Hilbert's view, the reflectance basis of all narrow shades is in principle unknowable. However, according to them, there still exist the narrow shades that are objectively unique green, or objectively 70 per cent bluish and 30 per cent reddish, and so on. This is Byrne and Hilbert's absolutist reply to the problem of individual differences.

My two summary points are these: (1) on closer scrutiny, color absolutists turn out to have absolutely no idea how to specify narrow shades in terms of surface reflectance. Existing proposals, when taken literally, are plain wrong (Tye, 2000, 161-5; Bradley and Tye, 2001, 482; Byrne and Hilbert, 2003; Jakab, 2001; Jakab and McLaughlin, 2003). In addition, these proposals are vastly oversimplifying: they ignore illuminant dependence, simultaneous contrast, individual differences, effects of adaptation: that is, almost all key phenomena of color perception; hence, they do not seem capable of offering a more plausible solution (see Jakab, 2005). (2) The even more serious problem is that nothing specifiable or otherwise fixable could count as a particular narrow shade for the absolutist. One could take into account the complications just mentioned, and come up with extraordinarily complicated definitions of narrow shades in terms of surface reflectance. This looks like an enormous task. However, any such specification would necessarily make reference to particular illumination standards, surrounds, and standard perceivers, thereby inevitably raising the problem of arbitrary choice: why *those* standards, and not others? The only way out for the absolutist is agnosticism about *all* narrow shades — in Byrne and Hilbert's spirit. Remember, this is the bottom line for absolutists, after they set out *to specify the narrow shades* (in perceiver-independent terms). To avoid this pitfall, the road is open to abandoning absolutism about color.

VIII Why relativizing colors is plausible whereas relativizing shapes would be absurd

Here is a difference between color perception and shape perception that follows from Byrne and Hilbert's view. Individual differences in shape perception together with the (very plausible) view of type physicalism and absolutism about shape do not lead us to agnosticism about shape. However, individual differences in normal color perception together with type physicalism and absolutism about color do lead us to agnosticism about color, as Byrne and Hilbert admit (2003, n. 50).

The reason for this difference, according to Byrne and Hilbert, is that there is an independent test for *correctness* of shape perception, whereas no such test exists for color perception. But why isn't there an independent test for the correctness of color vision? Byrne and Hilbert's answer is that (1) colors are perceived by only one modality (unlike shapes); moreover, (2) colors, contrary to shapes, do not play any interesting causal role, hence they do not figure significantly in the data and theories of other sciences.[21]

I think this latter reply is wrong. In my opinion, we have an independent test for the correctness of shape perception because shape perception conceptually reveals the shapes, therefore there exists a normative connection between shapes and the corresponding types of visual shape experience. For instance, the visual experience of something being circular is supposed to be such that it makes available to intellectual reflection the essence of being circular. Here is the story in more detail.

As we saw above, shape percepts are compositional. Perceptual states representing particular shapes on particular occasions have constituent structure, and by it they encode information about the spatial structure of the physical conditions that are their canonical causes, namely par-

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21 According to Byrne and Hilbert (2003, section 3.4.) another reason for the lack of an independent test is that we have no acceptable naturalistic theory of the content of color experience. Byrne & Hilbert (2003) propose an account of color content to solve this problem.

ticular shapes. Color percepts, on the other hand, are representationally atomic — they do not encode structural information about their causes (surface reflectances, wavelength compositions, etc.).

Due to the structural information encoding just mentioned, there are two ways in which shape percepts carry information about shapes:

(1) Lawlike covariation or tracking. Optimally, percepts as of squares track squares; percepts as of spheres track spheres, and so on.

(2) Structural information encoding. Relevant geometric information can be teased out of visual shape percepts by the processors that operate on them, and this information can become available to conceptual representation.

Now, shape perception is mistaken when there is a discrepancy between (1) and (2): for instance, when a shape percept P_s covaries with certain ovals (or egg-shapes) in the environment, yet it delivers to the processes that operate on it the information that each point on the indicated shape's perimeter (or 3D surface) is at equal distance from its center. That is, the structural-information-encoding part conveys information about something round or spherical, when in fact an oval or egg-shape appears in the scene.[22]

Due to the lack of structural information encoding, there is only one way color percepts carry information about the colors, and that is tracking. Since there is no structural encoding in color percepts, there is no possible discrepancy between the two sources of information.

Next, the required synchrony or harmony between the two sources of information (1) and (2) is the source of the normative link between shapes and shape percepts. This is why, on finding individual differences in shape perception, we can establish who is right and how shape perception *should* work. And the lack of (2) in the case of color perception is the reason why the normative link is missing between colors and color percepts.

This difference in normativity between shape perception and color perception explains why it is reasonable to relativize colors, but not shapes. No matter whether a subject locates unique green on one Munsell chip or rather another (see Kuehni, 2001), as long as she performs well in color discrimination, her color vison is normal *and veridical* — there is no non-question-begging reason to suppose otherwise. There is no theoretical reason whatsoever to anchor unique green to this, rather that that, narrow reflectance range. That's why 'unique green full stop'

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22 Of course any such discrepancy can be brought to light only via another complex mode of representation that can check the information delivered by structural encoding. For instance, one can measure the dimensions of the viewed stimulus with a ruler to see whether it is indeed the way it looks.

is indeterminate in its reference. However, 'unique green for subject S, in circumstances C,' is not the same way indeterminate.

Moreover, recognizing the difference in normativity between shape perception and color perception helps to come to terms with the independent test problem raised by Byrne and Hilbert. What Byrne and Hilbert call an independent test for shape perception is checking for the harmony between the two sources of information in shape perception: tracking and structural encoding. For instance, does a subject find circular objects circular? Do her visual percepts that track circular shapes induce the behavioral output in her that is a report of a circular shape? Note that this is done simply by showing circles to the subject (the tacit assumption is that doing so will elicit the type of visual percept in her that tracks circles), and asking her what shape they look. If she reports an ellipse, she might have astigmatism, aniseikonia, or some other opthalmological (or neurological) condition.

This normative element in shape perception is quite important. Shape perception is supposed to reveal the properties that are the *particular* shapes in rich (and correct) detail. In Dretske's evolutionary terminology (Dretske, 1988, 1995, ch. 1) shape perception was selected for this achievement, and so if function is understood in terms of evolutionary history, then shape perception has the function of providing rich detail about particular shapes to humans and various animals. Providing such detail served skills like locomotion, navigation and manipulation — that's how it added to the organism's fitness. Note also that the mere need for effective discrimination and recognition of shapes does not necessitate structural encoding, but complex behavioral interaction with shapes, like navigation or manipulation, do. If all an organism needed to do was to discriminate and recognize shapes, then its visual system could in principle succeed by encoding them in a low-dimensional similarity space where particular shapes would be represented as single points, quite similarly to the representation of colors in color space.

Although color experience does not structurally encode particular object colors, this simpler form of representation already helps the organism to discriminate surfaces based on their narrow shade, and recognize them based on broad color categories.[23] And that's all animals and most humans need color for. Actions and movements directed at an object need to take into account the object's shape but not its color.

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23 Notice that discrimination and recognition can also go wrong, and this shows that color perception is also normative — of course. All I am suggesting is that there is a special ingredient of normativity that is present in shape perception, and is missing from color perception.

Probably for these reasons, color vision does not provide any detailed information to the rest of the cognitive system about the rather complex states of affairs that are the particular colors. These states of affairs include surface reflectances of target objects, their interaction with reflectances of surrounding surfaces and the illuminant, and a number of other factors. Color perception does handle such information (see Maloney, 1999, 2003), but it does not make it available to the rest of the cognitive system.[24]

To wrap up this section, here is the skeleton of my main argument. Color absolutism fails on independent grounds. This entails two things. First, that color is relative to circumstances and subjects. Second, that the rather minimal compositionality (if any) within singular color percepts cannot be taken as a form of structural encoding of color stimuli. Given the relativity of color, there remains no room for a universal or normatively supported correspondence between the unique-binary structure of color percepts, and the physical structure of color stimuli. Finally, since there is no structural encoding in singular color percepts, color perception lacks an aspect of normativity that is inherent in shape perception.

IX Summary

1. What the idea is, and what it is not

There exists an important difference between our visual representation of shape and that of color: representations of particular shapes are highly complex and compositional, and the role of this complexity is to capture the structure of object shapes and spatial layouts. In contrast, perceptual representations of particular colors are rather simple, with very little, if any, compositional organization. One consequence of this is that visual representation of space makes a lot of information available to the conceptual faculty about particular shapes, whereas color perception conveys only very limited information about particular colors. Another

24 Assume that Maloney's account of how color-vision represents information about surface reflectance or illuminant energy distribution is correct (Maloney, 1986, 1999, 2003; Maloney and Wandell, 1986). That is, color vision represents surface color properties by means of linear-models basis functions and differents sets of weights corresponding to particular narrow shades or color categories. However, even if this is so, it is certain that such representations are not available to conscious reflection, or propositional knowledge. There is no way such information can be teased out of our experience of color.

consequence is that a universal link is established between perceived shapes and object shapes, whereas the link between perceived colors and object colors is perceiver-relative. This in turn explains why shape perception is normative in a way color perception is not. Finally, two remarks follow to clarify my view.

First, in some modalities, perceptual information plus intellectual reflection on it may yield only partial knowledge of the nature of stimulus properties — knowledge short of conceptual revelation. For instance, auditory experience plus intellectual reflection were sufficient for the development of music theory, but to understand the nature of sound as mechanical vibration, and especially the precise frequency relations and composition of particular complex sounds, we did need experimental methods (e.g., Mollon, 2003, xxii; Young, 1804).

Second, notice that the reason why shape perception is conceptually revelatory whereas color perception is not has nothing to do with the mere fact that we have perceptual access to shape and space in more than one perceptual modality, whereas we access color in only one modality. Perception of shape by touch is a largely sequential process. For instance, in finding out the shape of an object in a pitch dark room, we move our hands around it, touching it in many different positions along the way. Taking this sequentiality into account, tactile percepts of particular shapes are quite complex — they are far from being representational atoms. This is probably one of the reasons why congenitally blind people can develop a full-blown concept of space, contrary to some age-old views according to which they cannot (Senden, 1960; see Evans, 2002 for discussion). But again, this is due to the complexity of perceptual representations, and not at all to multimodal access. The creation of music theory was not aided at all by our capacity to feel sound as vibration by touch. When I put my palm on a loudspeaker and feel the vibration that I can simultaneously hear as a complex sound, the tactile sensation is not complex in the way the auditory one is — it does not have components that can be deciphered and separately undergone (see Section IV). For another example, imagine that some people's heat sensations are recalibrated for feeling electromagnetic radiation between 400 and 700 nm. Whenever such a subject sees a ripe tomato as red, she can touch it and feel it as hot. Ripe oranges feel quite warm to her, ripe lemons less warm, limes kind of tepid, and blueberries ice-cold.[25] Now she has access to

25 Note that what matters in this thought experiment is that in the second, hypothetical, modality in which color is perceived, it is perceived via representationally atomic perceptual states. Whether undergoing these states is like feeling temperature, or it is like something else, is irrelevant.

color in two modalities, but in both of them the access is mediated by representationally atomic percepts. This still does not reveal to her the nature of particular object colors. If ancient Greeks had had such recalibrated heat sensation, then, I think, they still would not have come up with an exact science of color, based merely on their (now bi-modal) perception of color stimuli, plus intellectual reflection. On the other hand, if some of us had retinas with 15 different types of cones with adjacent narrow ranges of sensitivity, representing, and making available to conceptual representation, spectral power distribution data of lights arriving at the eye, then there would be more of a chance of those persons developing an intricate system of concepts describing the perceived 'visual chords.' Moreover, in this case color would be absolute in the sense that the constituent structure of individual color percepts would impose constraints on which type of percept can (correctly) track which stimulus. For instance, a light with even spectral power distribution could not be correctly represented by a color percept that conveys to the conceptual faculty the (mis)information that there is a deep energy minimum in the middle of the spectrum flanked by two peaks at the ends.

2. *A word about anti-realism*

Here is a brief outline of a view of color consciousness on which Brian McLaughlin and I largely agree. What it is like to see the colors cannot be accounted for in representational externalist (or 'phenomenal externalist') terms. Phenomenal externalism about color experience (Dretske, 1995; Tye, 1995, 2000; Byrne and Hilbert, 1997b, 2003; Hilbert and Kalderon, 2000) fails because it crucially assumes the truth of color absolutism (McLaughlin, 2003b). This means, phenomenal characters of color experiences are determined by the internal constitution of our brains (McLaughlin, 2003b; Jakab, 2001, 2005; Jakab and McLaughlin, 2003). Thus we get phenomenal internalism and color relativism. If, however, not even relativized colors turn out to be natural properties of some sort, that would constitute a genuine threat to color-realism (McLaughlin, 2003b, 122, 124-8).

Even in this latter case, however, a version of narrow intentionalism about color experience would remain in play. It is the idea that phenomenal character is an aspect of content (or aboutness) that is nevertheless internally supervenient. When we perceive colors, we are directly or primarily aware of surfaces and their properties (even though some of those properties are systematically illusory). It is the external surfaces themselves that look to us in ways determined by the phenomenal character of color experience. (See Jakab, 2003.)

What distinguishes color perception from shape perception is the presence vs. absence of structural encoding, and not that our experience of shape is representational whereas color experience isn't. In general, representationally atomic states may or may not veridically represent stimulus properties. On the other hand, mental states *ipso facto* veridically represent what they (successfully) structurally encode of their stimuli.

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