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Colour Vision, Philosophical Issues About

Colour#Vision

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The primary issues concern whether objects have colours, and what sorts of properties the colours are. Some philosophers hold that nothing is coloured, others that colour are powers to affect perceivers, and others that colours are physical properties.

1. Introduction

According to our everyday experience, many things are coloured. Roses are red and violets are blue. On the other hand, according to physical science, roses and violets are composed of colourless particles (or at any rate, if not particles, something equally colourless). These two pictures of the world do not seem to be obviously compatible, and indeed many have found them to be plainly incompatible. Galileo, for example, thought that physical science had shown that objects are not really coloured, but instead are "in the mind". Philosophical theories of colour since the scientific revolution have attempted either to reconcile the two pictures, or else to explain why one of them should be rejected.

Until recently, philosophers drew most of their data about colour and colour perception from their own experience of colour. Although personal experience is a valuable source, in fact a good deal of information relevant to abstract philosophical questions about colour and the world as revealed by science is to be found in the work of colour scientists. Many contemporary philosophers take the physical, biological,

and behavioural sciences to place serious constraints on philosophical theories of colour.

2. Central philosophical issues about colour

2.1. The problem of colour realism

If someone with normal colour vision looks at a lemon in good light, the lemon will appear to have a distinctive property—a property that bananas and grapefruit also appear to have, and which we call "yellow" in English. As we all know, however, it does not follow from the fact that an object *visually appears* to have a certain property that the object *has* that property. To use an example dating back to the ancient Greeks, a straight oar half-immersed in water *appears* bent, but of course it does not *have* the property of being bent. Ordinarily we take for granted that lemons and so forth are as they appear, but in a philosophical mood one naturally wonders whether we are right to do so.

Such reflections give rise to the central philosophical problem concerning colour, the problem of *colour realism*. It is posed by the following two related questions. First, do objects like lemons, bananas and grapefruit really have the distinctive property that they appear to have? That is, are any objects yellow? Second, what is this property? A physical property of some sort, perhaps (for example, a certain way of reflecting light)? Or maybe some kind of property specified partly psychologically (for example, a power to produce certain sorts of sensations)? (Of course, there are parallel questions for the other colour properties that objects appear to have.)

These questions can be made to seem especially pressing by emphasising the physically diverse nature of objects that look coloured, and the way in which the visual system processes colour information. As noted above, colour is not a property attributed to objects in fundamental physics. In addition, the perception of colour is a complex process and the relation between the physical properties of an object and the colour it appears to have is far from straightforward. In particular, it is not true that yellow-looking objects, for example, are those that reflect "yellow light": there is no simple relationship between the light reaching the eye from an object and the colour that object is perceived to have.

The problem of colour realism is fundamentally a problem about *perception*—vision, in particular. The questions concern the nature of certain properties that objects visually appear to have, and whether reality is in these respects as it appears to be. The problem is not in the first instance one about how we talk and think, although of course facts about colour language and colour concepts may be relevant. It is plausible to assume that the way we use colour language is closely connected to the character of human colour vision, but the problem of colour realism itself concerns perception and not language. These points have to be stressed because many non-philosophers find it almost irresistible to think that philosophical questions are basically questions about how words should be defined, and so are of little relevance to science. The problem of colour realism is no more about the definitions of words than is the problem of why the dinosaurs went extinct.

2.2. The representational content of visual experience

It is helpful to put the problem of colour realism in terms of what visual experience *represents*, or its *representational content*. When someone has a visual experience, the scene before her eyes visually appears a certain way: for example, it might visually appear to someone that there is a yellow ovoid object in the bowl, or that two lines are the same length. In the jargon, her experience *represents* that there is a yellow ovoid object in the bowl, or that two lines are of the same length. Her experience represents the world *correctly* if there is a yellow ovoid object in the bowl, or if the two lines are of the same length; otherwise, her experience represents the world *incorrectly*. In the former case the subject's experience will be *veridical*, and in the latter case *illusory*. For example, if the subject is looking at lines of the same length with appropriately oriented arrowheads on the ends (the Müller-Lyer illusion) the subject's experience will represent the lines to be of different lengths (even if she believes that they are of the same length). Her experience represents the world incorrectly and is therefore an illusion.

In this terminology, the problem of colour realism concerns certain properties (the colours) represented by visual experience and whether such experiences represent the world correctly. There is a large philosophical (and, of course, psychological) literature on mental representation, and sometimes philosophical discussions of colour draw heavily on it (see, for example, Boghossian & Velleman 1991).

2.3. Why colour matters to philosophy

Although colour is of interest in its own right, in philosophy it mainly serves as a tractable example that can be used to investigate problems of more general scope. One reason why colour is particularly suitable for these purposes is that a great deal is known about the relevant physical properties of objects, and the way in which colour information is extracted and processed.

One of these more general problems concerns the relation between appearance and reality—whether, or to what extent, the world is as it appears. This problem may be investigated in a reasonably manageable way by just restricting attention to a specific instance of it, namely the problem of colour realism.

There are a number of other philosophical problems that can be usefully addressed by focussing (not necessarily exclusively) on colour. Examples include many central issues in the philosophy of perception: how to distinguish the various sensory modalities; the relationship between perception, thought, and action; and whether we see objects like lemons "directly", as opposed to seeing them via our awareness of mental intermediaries. And the famous "inverted spectrum" thought experiment, which supposes (waiving some qualifications) that objects that look green to me look red to you, and vice versa, has been used to illuminate a variety of philosophical topics from the nature of consciousness (Block 1990) to our knowledge of others' minds (Palmer 1999).

3. Philosophical views and theories of colour

3.1. Eliminativism

Eliminativism is the view that nothing is coloured—at least, not ordinary physical objects like lemons. The eliminativist therefore convicts ordinary experience of widespread error. Historically, eliminativism is the dominant philosophical view, and has its roots in the ancient Greek atomists.

Some eliminativists are *projectivists*: they hold that we "project" colours that are "in us" onto objects in our environment. According to the projectivist, *some* things are coloured (for example, neural events, or mental entities like sensations or visual experiences), which we then mistakenly take for properties of objects like lemons. Projectivism is often found in psychology textbooks: Stephen Palmer, for instance, writes that "colour is a *psychological* property of our visual experiences when we look at objects and lights, not a *physical* property of those objects and lights" (1999, p. 95).

An obvious problem with projectivism is that the "inner" things the projectivist says are coloured don't have the right colours, if indeed they have any colour at all. Nothing inside the brain becomes yellow when one is looking at a lemon, and it is obscure how a visual experience could be coloured.

But an eliminativist need not be a projectivist. The most defensible kind of eliminativism is simply the view that *nothing* is coloured, not even sensations or visual experiences.

The main line of argument for eliminativism proceeds by claiming that science has straightforwardly shown that objects like lemons do not in fact have colours. The surface of a lemon has a reflectance, various microphysical properties, and is disposed to affect perceivers in certain ways. No *other* properties are required to explain causally our perceptions of colour. But the colour properties, whatever else they are, *do* causally explain our perceptions of colour. So there is no reason to suppose that the lemon is yellow.

This argument does issue a powerful challenge to those who think that lemons *are* yellow, but that this property is not to be identified with a reflectance (the percentage of light reflected by a surface), a microphysical property, or a disposition to affect perceivers (see the discussion of *primitivism* in section 3.5 below). But it begs the question against someone who *identifies* the property yellow with (say) a reflectance.

The case for eliminativism therefore depends on showing that colours can't be identified with properties that do causally explain our perceptions of colour.

3.2. Dispositionalism

Dispositionalism is the view that colours are dispositions (powers, tendencies) to cause certain visual experiences in certain perceivers in certain conditions; that is, colours are *psychological* dispositions. (Strictly speaking we should add that, according to dispositionalism, at least sometimes our perceptions of colour are

veridical. This qualification should also be added to the three other views discussed below.)

Dispositionalism is often associated with the seventeenth century English philosopher John Locke who, incidentally, also invented the "inverted spectrum" thought experiment (see section 2.3). In Locke's terminology, dispositionalism is the view that colours are *secondary qualities*. A simple version of dispositionalism is this: the property yellow = the disposition to look yellow to typical human beings in daylight (for other versions see the introduction to Byrne & Hilbert 1997).

Poisonousness is a straightforward example of a dispostional property. To be poisonous is to be disposed to cause bodily harm if ingested or otherwise taken into the body. According to dispositionalism, yellowness is like poisoness: to be yellow is to be disposed to cause certain visual experiences if placed in certain viewing conditions. The comparison with poisonousness brings out the *relational* nature of dispositionalism. Just as a substance may be poisonous for certain organisms and harmless to others, many dispositionalists hold that lemons are only yellow "for us", and might even be blue relative to some other class of perceivers.

One objection to dispositionalism is that "certain perceivers" and "certain conditions" cannot be specified in a principled way. Perhaps a more fundamental problem is that it is not obviously well-motivated. It is certainly plausible that yellow objects are disposed to look yellow (at least once various qualifications are made). However, it is equally plausible that square objects are disposed to look square. It is not very tempting to conclude from this that squareness *is* a disposition to look square, and indeed shape properties were traditionally supposed to be paradigmatic examples of properties that are *not* secondary qualities. It is not at all clear why colour should be treated any differently. The dispositionalist needs to explain why perceivers should be mentioned in the story about the nature of colour, but not in the story about shape.

3.3. The ecological view

Thompson *et al.* (1992) have recently developed an "ecological view" of colour, inspired by J. J. Gibson. The ecological view rejects the orthodox account of vision as "inverse optics"—the process of extracting information about the scene before the eyes from retinal stimulation together with built-in assumptions about the environment. On the positive side, the ecological view stresses the connection between perception and action, and insists that the "animal and environment" should not be treated as "fundamentally separate systems" (Thompson *et al.* 1992, p. 21); environmental properties are supposed to be partly "constituted" by visual perception. Colours, in particular, "are not already labelled properties in the world which the perceiving animal must simply recover…Rather, colours are properties of the world that result from animal-environment codetermination" (p. 21).

The ecological view is perhaps best seen as a version of dispositionalism, identifying the colours with "ecological-level dispositions" to affect perceivers (Thompson 1995, p. 751). However, it must be emphasised that the ecological view's proponents see the comparison to traditional dispositionalism as somewhat superficial.

One obvious criticism of the ecological view is that it relies on controversial claims about perception. But there is a more basic difficulty, namely that crucial components of the theory are hard to understand. In particular, the claim that colours are "codetermined" by the perceiver and its environment is unclear.

3.4. Physicalism

Physicalism is the view that colours are physical properties of some kind, for example microphysical properties, or reflectances.

Physicalism has been disputed on a number of grounds. First, it is argued that physicalism cannot account for the apparent similarities and differences between colours. In other words, the physicalist cannot explain the structure of *phenomenal* colour space (Boghossian & Velleman 1991).

Second, and relatedly, it is argued that physicalism cannot account for important observations about the way colours appear to us. For example, it is argued that physicalism cannot explain why orange is a *binary* hue (every shade of orange is seen as reddish and yellowish), while yellow is a *unique* hue (there is a shade of yellow that is neither reddish nor greenish) (Hardin 1993).

Third, it is argued that studies of colour vision in animals show that there is no single kind of physical property (e.g. a reflectance) detected by colour vision. So, since colours are whatever is detected by colour vision, it is concluded that colours aren't physical properties (Thompson 1995).

3.5. Primitivism

According to primitivism, objects *are* coloured, but the colours are *not* dispositions to affect perceivers, or physical properties (Yablo 1995). In fact, the primitivist claims that there is *no* especially informative account of the nature of the colours. If primitivism is correct the colours are analogous to fundamental physical properties, like the property of being electrically charged. Given the reductive cast of mind in cognitive science, it is not surprising that primitivism is generally the preserve of philosophers.

Like eliminativism, primitivism is unmotivated if there are *already* perfectly good candidates to be the colours, for instance physical properties of some sort, or psychological dispositions. The basic argument for primitivism, then, is similar to the argument for eliminativism: the alternatives must be dispatched first.

As is evident from this brief survey, there is little consensus on the best approach to the problem of colour realism; this is largely because the considerations for and against particular theories are rarely conclusive. But it would be wrong to think that no progress has been made. Philosophy is often advanced by showing that apparently unrelated theses are after all closely connected, so forcing a proponent of, say, dispositionalism to take on a complicated burden of commitments. Much of the recent work in the philosophy of colour can be seen in this light.

4. Impact of cognitive science on issues about colour

One notable feature of recent philosophical work on colour is the attempt to integrate philosophical concerns with what is known empirically about colour and colour vision. Below we discuss a few areas in which this interaction either has been, or has the potential to be, especially significant.

4.1. Colour spaces and opponent processes

The colours stand to each other in a complex web of similarity relations. To take the simplest possible case, purple is more similar to blue than to green. And shades of red, for instance, can be more or less similar to each other. Relations of colour similarity also have an *opponent* structure. Red is opposed to green in the sense that no reddish shade is greenish, and vice versa; similarly for yellow and blue. Further, there is a shade of red ("unique red") that is neither yellowish nor bluish, and similarly for the three other *unique hues*—yellow, green, and blue. Thus, in experiments summarized by Hurvich (1981), a normal observer looking at a stimulus produced by two monochromators (light sources that emit in a narrow band of wavelengths) is able to adjust one of them until he reports seeing a yellow stimulus that is not at all reddish or greenish. In contrast, every shade of purple is both reddish and bluish, and similarly for the other three *binary hues* (orange, olive, and turquoise). The binary hues are sometimes said to be "perceptual mixtures" of the unique hues. These sorts of observations, supplemented with physiological data, form the basis of the opponent-process theory of colour vision. The main idea of this theory is that colour perceptions are the result of two opponent processes (red-green and yellow-blue) and one non-opponent process (light-dark).

As mentioned in section 3.4, two objections to physicalism start from these facts. We can now elaborate slightly on the second of these. If physicalism is true, the objection runs, then the difference between the unique and binary hues must be explained in terms of "unique" and "binary" physical properties of objects like lemons and oranges. However, the correct explanation is in terms of neural opponent processes, and does not involve the physical properties of objects at all. This objection is controversial, but at least the opponent-process theory has lead philosophers to a renewed interest in understanding relations of similarity and difference among the colours.

4.2. Animal colour vision

One very active area of current empirical research is comparative colour vision—the study of colour vision in non-human animals. Colour vision is very widely distributed among animals. Some degree of colour vision appears to be the default condition for all the major groups of vertebrates and is also common among invertebrates. Among animals with colour vision there is enormous variation in the precise type of colour vision and the purposes for which it is used. Traditionally, philosophers have restricted their attention to human colour vision, although fortunately this seems to be changing. As mentioned in section 3.4, the kinds of variation in colour vision found in animals has been used against physicalism, and also to support the ecological view.

4.3. Variation in perceived colour

The perceived colour of an object depends in complicated ways on both the illumination and the other objects in the scene before the eyes. As many people have

discovered, even lightness relationships can be reversed by sodium lighting of the sort often found in parking lots. And interior decorators know that the perceived colour of an object can change depending on the colour of its surroundings.

The perceived colour also depends on the perceiver: colour vision in human beings is surprisingly variable for a basic perceptual ability. Approximately 10% of men suffer from a substantial deficit of red-green colour vision and complete red-green colour blindness is not rare. There is also substantial variation among people classified as having "normal" colour vision with, for example, the spectral location of unique green ranging over 30 nanometers, nearly 10% of the visible spectrum. In addition to variation between subjects there is variation within subjects. For example, the optical media of the eye, in particular the macula and lens, tend to yellow with age, producing shifts in perceived hues.

These facts have implications for philosophical theories of colour. For example, dispositionalism appeals to "certain perceivers". Given the degree of normal variation, slightly different specifications of the privileged class of perceivers will make a big difference to the resulting dispositionalist theory. The dispositionalist needs to give a principled reason for selecting one group rather than another to be the "certain perceivers"; similar remarks apply to the dispositionalist's "certain viewing conditions".

4.4. Colour constancy

As just mentioned, perceived colour depends on the illumination. What is less well known is that in many circumstances perceived colour is relatively insensitive to changes in illumination. This feature of human (and animal) colour vision is known as approximate colour constancy. It implies that in many circumstances the perceived colour of an object is more closely tied to its (illumination-independent) surface properties than to the spectral character of the light reaching the eye. Some cognitive scientists have attempted to explain colour constancy by treating colour vision as a system that extracts information about the surface properties of objects, in particular their reflectances, from the light reaching the eye. This provides one of the inspirations for physicalist theories of colour (Hilbert 1987).

4.5. The inverted spectrum

It is often supposed that there is no reason to believe that people are "spectrally inverted" with respect to each other (see section 2.3). And in fact, due to the influence of the logical positivists of the early twentieth century, it used to be a common philosophical opinion that spectrum inversion makes no sense at all, because it is not "verifiable". However, with improved understanding of the genetic and physiological basis of colour blindness, beginning in the 1970's, some colour scientists have speculated that there might be actual cases of spectrum inversion in the human population. Red-green colour blindness is caused by genetic defects that result in two of the three types of cones containing pigments that are very similar in their spectral sensitivity (their readiness to absorb light of different wavelengths). There are two types of red-green colour-blindness, depending on whether the spectral sensitivities of the two relevant cone-types match that of the normal middle wavelength-sensitive pigment or that of the long wavelength-sensitive pigment. A person who has inherited the genes for both forms of red-green colour blindness would have the two pigments

switched from the normal condition. If the development of the neural circuitry for colour vision depends only on the cell-type and not the pigment it contains, then this pigment-switching scenario should result in spectrum inversion. Perhaps unfortunately, there does not seem to be the required independence between circuitry and pigment. Still, the mere fact that spectrum inversion is treated as a testable empirical hypothesis shows that it can't be dismissed as a philosopher's fiction.

4.6. Metamers

Lights with quite different spectra and surfaces with quite different reflecting characteristics can appear to be identical in colour. This phenomenon, known as *metamerism*, is a consequence of the fact that all the information available for perception of colour derives from just three cone-types with broad spectral sensitivity. If the light reaching the eye from two objects produces the same response in each of these three cone-types then they will appear to have exactly the same colour no matter how their spectra or reflectances differ. This fact about (human) colour vision has been a driving force in philosophical discussions of colour over the last three decades. The central issue is whether metamerism is incompatible with taking colours to be physical properties, because the phenomenon seems to show that there is no single spectrum (or reflectance) that all objects with a particular colour share. For a variant of this argument see Hardin 1993, pp. 63-4; for a response see Jackson 1996.

Glossary

Disposition A power or tendency. Sugar cubes have the disposition to dissolve in in water, and wine glasses have the disposition to break when dropped. Something can have a disposition without actually doing the thing it is disposed to do: a forever dry sugar cube is disposed to dissolve, and a safely stored wine glass is disposed to break.

Phenomenal color space A color space is a system for representing relations of similarity among colors using spatial relations. The familiar color solids are examples of color spaces. A *phenomenal* color space takes the relevant similarities to be provided by the way colors appear to us.

Physical property A property that figures in true physical theories or one that is reducible to such properties. Mass and charge are uncontroversial examples of physical properties. It is controversial whether mental properties (e.g. pain), or aesthetic properties (e.g. beauty) are physical properties.

Reflectance The way in which an object reflects light. Many objects reflect a fairly constant percentage of the light incident on them at each wavelength in the visible spectrum. This set of percentages, often represented by a curve, is the (spectral) reflectance of that object.

Secondary quality A disposition to cause experiences in a perceiver. Secondary qualities are traditionally opposed to *primary* qualities. According to the seventeenth century philosopher John Locke, primary qualities (unlike secondary qualities) are properties that all physical objects possess and that "resemble" our ideas of them. His examples included size, shape, and motion. Sounds, tastes, smells, and colors are often regarded as secondary qualities, although this is controversial.

Spectral or spectrum The (visible) spectrum is the range of wavelengths of visible light, from approximately 400 nanometers to approximately 700 nanometers. The adjective "spectral" is used to characterize the distribution of a property or measurement across the spectrum. Thus the spectral reflectance (of an object) is its reflectance at each wavelength and the spectral sensitivity (of a cone-type) is its sensitivity at each wavelength.

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