# In Defence of Natural Daylight

Keith Allen
University of York
ka519@york.ac.uk

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ABSTRACT: Objects appear different as the illumination under which they are perceived varies. This fact is sometimes thought to pose a problem for the view that colours are mind-independent properties: if a coloured object appears different under different illuminations, then under which illumination does the object appear the colour it really is? I argue that given the nature of natural daylight, and certain plausible assumptions about the nature of the colours it illuminates, there is a non-arbitrary reason to suppose that it is under natural daylight that we are able to perceive the real colours of objects.

## 1. Illumination and Perceptual Variation

Objects appear different as the illumination under which they are perceived varies. Consider the effect of shining a blue light on a white wall, or viewing an object in the red-orange glow of candlelight. Or varying the colour of the illumination less noticeably, consider the effect of turning on a incandescent desk lamp in a room that is already lit by natural daylight, or the colour an item of clothing appears under the fluorescent strip lighting of a shop changing room. What does this type of illumination-dependent perceptual variation tell us about the nature of colour?

Accounting for illumination-dependent perceptual variation is sometimes claimed to pose a problem for the view that colours are *mind-independent* properties of material objects: properties whose essential nature is constitutively independent of the experiences of perceiving subjects. If an object's colour is constitutively independent of the experiences of perceiving subjects, then an object's colour does not vary as experiences of the object vary across changes in the illumination. But then which experiences, in which conditions, present the object's *real* colour? In the absence of any non-arbitrary reason to privilege any particular experience over any of the others, it might seem gratuitous to suppose that there is any fact of the matter as to which colour the object *really* is.

For example, one of the many considerations that Berkeley adduces to argue that colours are not 'real properties or affections inherent in external bodies', but rather properties of mind-dependent ideas, is that 'the same bodies appear differently coloured by candle-light, from what they do in the open day'.[1] Russell appeals to similar considerations in the course of arguing that the colour his table appears is 'not something which is inherent in the table, but something depending upon the table and spectator and the way the light falls on the table'. According to Russell, this is because:

> the parts that reflect the light look much brighter than the other parts...if I move, the parts that reflect the light will be different because of reflected light, so that the apparent distribution of colours on the table will change...[and] even from a given point of view the colour will seem different by artificial light.

Russell concludes that because all the colours that objects appear under different illuminations have an equal claim to reality, then 'to avoid favouritism, we are compelled to deny that, in itself, the table has any one particular colour'.[2] Indeed, Russell ultimately concludes not just that there is no one particular colour that the table has, but in fact that 'it is quite gratuitous to suppose that physical objects have colours' at all; instead, colours are really mind-dependent properties of sense-data.[3]

Although Russell eliminates colours from the mind-independent material world, and Berkeley eliminates the mind-independent material world altogether, others appeal to illumination-dependent perceptual variation to motivate one of a number of more or less robustly realist theories of colour. One option is to deny that colours are mind-independent properties of material objects, and claim instead that colours are either mind-dependent dispositions of objects to look coloured to normal perceivers in normal conditions, or more generally relations between subjects, objects and illuminants.[4] If colours are mind-dependent properties, then there is no metaphysically deep reason to privilege to any particular experiences in any particular conditions. What we decide to call 'the' colour of objects may be determined by the experiences of 'normal' perceivers in 'normal' conditions, but there is no non-arbitrary reason for preferring precisely these experiences. By hypothesis, there is no colour the object 'really' is independent of the experiences of perceiving subjects, so in this sense all the colours the object appears are equally real.

An alternative approach is to combine the claim that colours are mind-independent properties with some form of pluralism. For instance, Jackson and Pargetter attempt to reconcile the existence of perceptual variation with a physicalist—or what they call 'objectivist'—theory of colour, by identifying colours, not with dispositions to appear coloured, but instead with the categorical grounds of dispositions to appear coloured, suggesting that these categorical grounds themselves change as the illumination varies:

> The blue light may actually change the relevant physical properties of the wall's surface, in which case the right thing to say is that the wall under blue light *is* blue. The light actually *turns* the wall from white to blue.[5]

A variation on the general approach is the 'selectionist' response to illumination-dependent variation, which involves simultaneously ascribing objects a plurality of persisting mind-independent colours that variations in the illumination merely serve to uncover.[6] Again, neither view accords any metaphysically deep, non-arbitrary privilege to any particular experiences in any particular conditions. By hypothesis, the colours presented by experiences under different conditions are all mind-independent, and so in this sense all the colours the object appears are equally real.

Whatever their other differences, eliminativist, mind-dependent, and pluralist theories of colour are all motivated by the thought that there is no non-arbitrary reason to suppose that any particular colour experiences, in any particular conditions, present the real colours of objects. I will argue against this claim. A non-pluralistic mind-independent realism about colours needs to vindicate as far as possible our ordinary colour ascriptions; to argue that there are mind-independent properties that deserve to be called 'colours', but that correspond only very imperfectly to the colours we perceive would be a hollow victory at best.[7] Consistent with this requirement, I will argue that there is a non-arbitrary reason to prefer colour experiences in natural daylight, given the nature of natural daylight, and certain plausible assumptions about the nature of the colours it illuminates. After setting aside attempts to account for illumination-dependent variation that appeal to colour constancy in §2 and rigidified descriptions of normal conditions in §3, I offer a defence of natural daylight in §4, and note some limitations of this defence in §5.

One limitation of the argument should be noted at the outset: I am concerned only with illumination-dependent perceptual variation. Perceptual variation is unique neither to variations in the illumination as far as colour perception is concerned, nor to colour perception in general. On the one hand, the colour an object appears depends not just on the illumination under which it is perceived, but on the background against which it is perceived, and facts about the perceiving subject. At the same, just as there is some sense (more on this in §2) in which colour experience varies as the illumination changes, there is some sense in which shape and size experience also varies depending on an object's distance from the eye and it spatial orientation. It is sometimes suggested that different kinds of perceptual variation form a common kind, and therefore demand a common response.[8] But just as there are many different reasons why a car won't start that do not all demand a common response, there might be many different reasons why perceptual experience varies. If nothing else, to suppose that different forms of perceptual variation form a common kind threatens to prove too much: as Berkeley and Russell's entirely general use of the argument from perceptual variation illustrates, if different instances of perceptual variation form a common kind, then some explanation is required of why variation in the colour perception differs from variation in the perception of shape and size.[9] A complete defence of a piecemeal account of different types of perceptual variation would need to consider each case on its own merits, and lies beyond the scope of this paper. My aim in this paper is the more modest one of arguing that at least illumination-dependent perceptual variation does not undermine the claim that colours are mind-independent.[10]

## 2. Colour Constancy and Perceptual Variation

There is a sense in which illumination-dependent variation in colour perception presents less of a problem than it might initially appear. Colours, like shapes and sizes, exhibit perceptual constancy. Although it is controversial exactly what perceptual constancy amounts to, it is generally assumed to involve the ability to perceive an object's colour to remain constant across a wide variety of perceptual conditions, and on the basis of experience to be able to identify the object's colour as conditions vary. Given this understanding of perceptual constancy, in whatever sense it is true that objects *appear different* as the perceptual conditions vary, there is another more important sense in which objects *appear the same* as the perceptual conditions vary.

For instance, although there is some sense in which white walls illuminated by blue light 'appear' blue (after all, if we were to depict the parts of the white walls illuminated by blue light on a canvass, then we would use blue paint), we do not normally perceive white walls illuminated by blue light *to be* blue. At least when the normal contextual cues are available, white walls illuminated by blue light *appear to be* white walls illuminated by blue light. In this respect, there is there something phenomenologically suspect about Russell's claim, central to his version of the argument from perceptual variation, that 'there is no colour which pre-eminently appears to be *the* colour of the table or even of any particular part of the table—it *appears to be* of different colours from different points of view'.[11]

This is not only true of a wide variety of colours, seen under a wide variety of illuminants, but colour is similar to shape and size in this respect. For instance, although there is also some sense in which a large tree in the distance 'appears' the same size as a smaller person in the foreground, we do not normally perceive the tree in the background *to be* the same size as the man in the foreground. Because of size constancy, we perceive it *to be* larger, but further away.[12]

The fact that colour exhibits perceptual constancy suggests a quick response to the worry about illumination-dependent perceptual variation. If we perceive objects' colours to remain constant across variations in the illumination, then it is consistent with the mind-independence of colour that there are a whole range of very different perceptual conditions in which objects appear to be the colours they really are. As such, there is no need to privilege just one type of experience in one set of perceptual conditions; experiences in different perceptual conditions will often all present the object's colour just as well.

Nevertheless, the quick response to the problem of illumination-dependent variation is too quick. Colour constancy is an incredibly important feature of our colour experience, facilitating the identification and reidentification of material objects across the varied array of normal circumstances under which we perceive them; indeed, the fact that colours exhibit perceptual constancy is often taken to be one of the main sources of motivation for the view that colours are mind-independent properties in the first place.[13] But simply appealing to colour constancy does not of itself dispel the problems posed by illumination-dependent perceptual variation.

First, this description of the phenomenology of perceptual constancy is controversial. According to some, perceptual constancy can be explained purely in terms of post-perceptual judgements, grounded in experiences that do not actually present a constant property as perceptual conditions vary. Russell, for instance, suggests although we are in the 'habit of judging' that tables remain constant in colour (shape, size, etc.) as the perceptual conditions vary, the 'real' properties of objects are 'not what we see'; instead our judgements about them are merely 'inferred from what we see'.[14] Clearly, if we do not perceive the shapes, sizes and colours of objects to remain constant as the perceptual conditions vary, then the challenge to identify those conditions in which experience presents the real colours of objects would remain.

But even granting this description of perceptual constancy, illumination-dependent perceptual variation still poses problems. Although there are a range of conditions across which colours exhibit perceptual constancy, colour constancy is not perfect; as such, some further account of differences as the conditions vary is required.

On the one hand, there are some conditions in which constancy breaks down altogether; in these conditions, we cannot, even roughly speaking, determine what colour an object is. In general, constancy tends to break down when the illumination under which an object is seen does not occur naturally.[15] Chromatically coloured lights, for instance, often make it difficult to identify an object's colour: imagine perceiving a red wall under blue light, or a green wall under red light. Even if we are able to tell that the colour an object appears under chromatic illumination is not the colour it really is, and hence that the appearance is a mere appearance, we might nevertheless be unable to identify which colour the object really is in these conditions. So, there is at least an asymmetry between those conditions under which objects look the way they really are given that constancy mechanisms are in play, and those situations in which constancy mechanisms break down. We therefore need a non-arbitrary reason for preferring one of these ranges of conditions over the other.

But even in conditions under which objects exhibit constancy, the degree of constancy achieved varies. For instance, we might be able to correctly identify a car as broadly-speaking green (i.e. some determinate of the determinable green) under the orange street-light of a car park, and thereby distinguish it from cars that are broadly-speaking red, blue or silver; but even so, we might be unable to tell exactly what shade of green the car is in these conditions, or distinguish it from other cars that are slightly different shades of green. Even under less noticeably different conditions, the range of very specific colour discriminations that we are able to make can be affected by the nature of the illumination. For instance, although we generally get a good idea of what colour an object in shadow is, we typically get a much better sense of what colour it is when we move it into direct light. So even amongst the varied set of conditions throughout which colours exhibit perceptual constancy, we still need to determine whether there is any reason to suppose that some illuminants are better than others.

## 3. Normal Conditions and Rigidification

As a matter of descriptive fact, we tend to prefer experiences of colour under natural daylight. For instance, if we like the colour of a piece of clothing under the fluorescent light of a shop changing room but not in broad daylight, we tend to think that the garment does not appear the rather unpleasant colour it really is under the artificial illumination in the shop; we are less likely to think that the way the garment appears in natural daylight is a mere appearance. But is this seemingly instinctive preference for natural daylight well grounded?

A shallow explanation of our preference for natural daylight would be that natural daylight simply happens to be the statistically normal illuminant for colour perception. The fact that we are more likely to see objects illuminated by natural daylight certainly affords pragmatic reasons to identify an object's colour with the colour it appears under this illumination. But the explanation is shallow, because there is no reason to suppose that there is anything about this illumination *as such* that makes it particularly appropriate for determining the colours of objects. The problem with this explanation of our preference for natural daylight is that it seems to depend too heavily on the contingencies of our actual situation. There is at least some intuitive resistance to the idea that if sodium street lighting (for example) became the statistically normal illuminant under which to perceive colours, then sodium street lighting would thereby become the optimal illuminant under which to determine the real colours of objects, and the colours of objects would change accordingly.[16]

One response to this problem is to rigidify the description of viewing conditions to statistically normal viewing conditions as they *actually* are. Combining this response with a dispositionalist theory of colour, for example, means that an object's colour will be identified with its disposition to look red to *actual* normal perceivers in *actual* standard daylight conditions.[17] But this response does not fully address the underlying problem. Rigidification is supposed to help respect the intuition that the colours of objects would not 'really' change if the prevailing conditions changed, and thereby capture some of the intuitive pull of the claim that colours are mind-independent properties. The problem with this strategy is that the 'really' carries no metaphysical force unless there is some further reason to privilege actual normal conditions over and above the fact that they are the statistically normal conditions hereabouts; otherwise, 'really' is just an honorific that marks the existence of a convention to arbitrarily prefer one set of conditions over any other.

By way of illustration, imagine a world exactly alike ours, inhabited by people exactly alike ourselves, but where the statistically normal illumination is sodium street lighting. Considering the possibility that the prevailing illumination might have been different, the philosophers in this world might assure themselves that if natural daylight had been the statistically normal illumination in this world, things would not 'really' have been differently coloured, because objects 'really' are the colours they appear under what is *actually* the statistically normal illuminant—in the imagined world, sodium street lighting. If the simple rigidification strategy is valid for us, then there is no reason why it should not be valid for our counterparts at this counterfactual world. But the result is that there will still be as many real colours as there are conditions that can be used to fix the extension of the term 'real colour'.

The problem gets a grip because proponents of dispositionalist theories of colour standardly specify 'normal conditions' in statistical terms; specifying 'normal conditions' as those which are *conducive* to determining the colour of objects, in contrast, at least suggests that experiences in normal conditions are somehow appropriate for *detecting* what are in fact mind-independent properties.[18] It might be that dispositionalists could appeal to a more substantial specification of 'normal conditions' of the kind that I suggest in the following section. The worry, however, will be that in so doing they will undermine the motivation for the dispositionalism in the first place, at least insofar as dispositionalism is supposed to represents a response to the problem of illumination-dependent variation.

## 4. Illuminating 'Real Colour'

A deeper justification of the intuitive preference that we appear to have for natural daylight will therefore have appeal to something about normal conditions hereabouts that makes them particularly conducive to determining the real colours of objects. In this section I will argue that given the nature of natural daylight, and certain plausible assumptions about the nature of the colours it illuminates, there is indeed a non-arbitrary reason to suppose that experiences of colour in natural daylight present the real colours of objects.

It is generally agreed that there is a close relationship between colours and the way objects reflect light. Material objects reflect different amounts of light from every part of the visible spectrum, the region of the electromagnetic spectrum between 400 and 700 nanometres (nm). The relative proportion of the incident light that an object reflects at each spectral wavelength is described by its *surface reflectance profile* (figure 1).

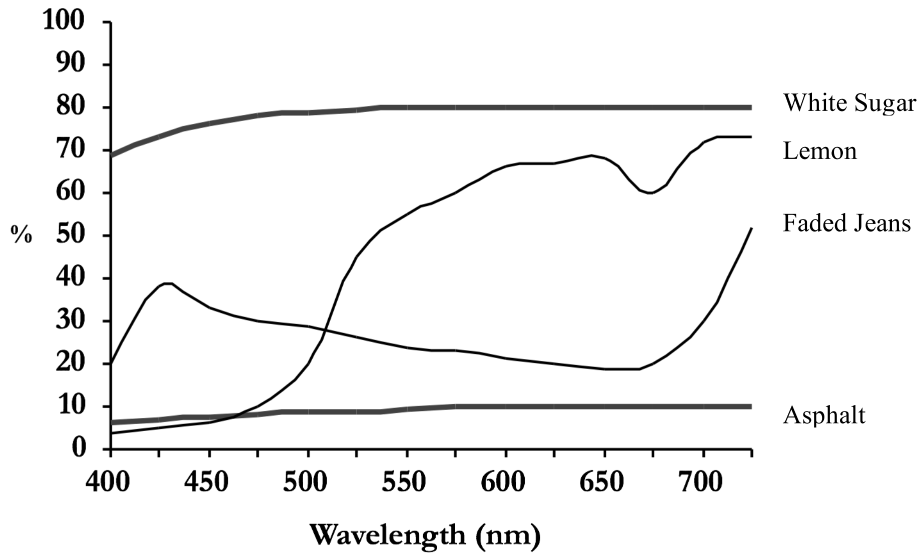


**Figure 1: Sample Surface Reflectance Profiles.**[19]

The exact nature of the relationship between colours and surface reflectance properties is complicated by the fact that reflectances cut much finer than we ordinarily suppose colours do: objects that differ in their reflectance profile often appear identical in colour (at least in specific circumstances), a phenomenon known as *metamerism*. Unless there are more colours that we ordinarily suppose, metamerism blocks the straightforward identification of colours with individual reflectances. The common response is to assume that colours at least *supervene* on reflectances: that there can be no difference in colour without a difference in reflectance. This might be because colours are identical with *types* of reflectance profile, specified with reference to facts about perceiving subjects—typically (but not necessarily) the way in which the visual system processes the light that it receives from material objects.[20] Or it might be because colours are *sui generis* mind-independent properties, as 'naïve realists' (or 'primitivists') argue.[21] Either way, assuming that colours supervene on reflectances, the close relationship between colours and the way in which objects reflect light suggests a solution to the problem of illumination-dependent variation.[22]

Just as material objects reflect different proportions of light at different spectral wavelengths, light sources emit different proportions of light at different spectral wavelengths. The different proportions of light that a light source emits at each wavelength can be represented (in an arbitrary unit) by the light source's *spectral power distribution*, as illustrated in Figure 2, which represents the spectral power distributions of four standard C.I.E. (International Commission on Illumination) illuminants.

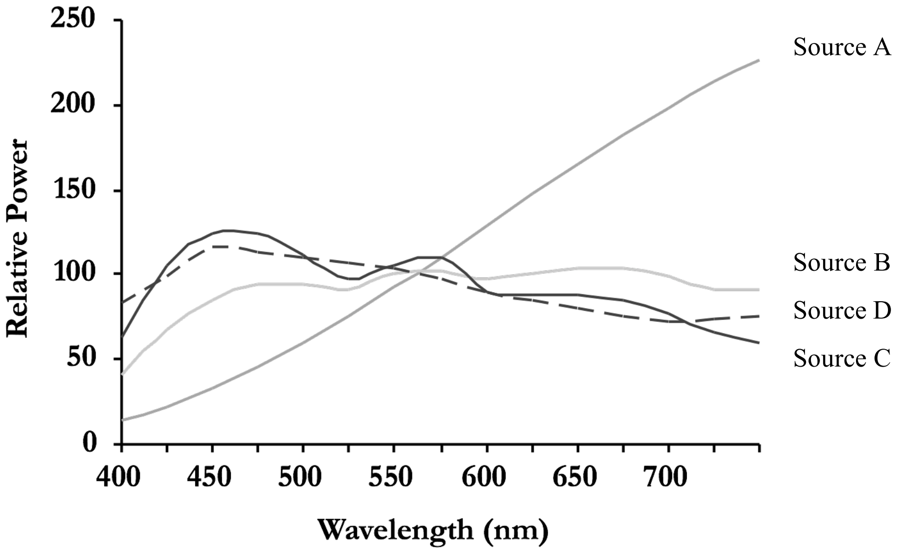


**Figure 2: Spectral Power Distributions of C.I.E. Standard Illuminants**
Source A represents the spectral power distribution of an incandescent tungsten lamp; Source B direct sunlight at noon on a clear day; Source C skylight on an overcast day; Source D daylight on a clear day.[23]

The light that reaches the eye (the retinal signal) is a function of the object's surface reflectance profile and the composition of the light that strikes an object (the incident light). In effect, this means that the light that reaches the eye from material objects encodes information about how objects modify the incident light at different spectral wavelengths (i.e. their surface reflectance profile), that can be extracted from the retinal signal given information about the composition of the incident light. Assuming that colours supervene on reflectances, there will be a non-arbitrary reason to prefer illuminants under which the spectral power distribution of the light that reaches the eye *mirrors* (more or less) exactly the surface reflectance profile of the material object. This is because those conditions in which the spectral power distribution of the retinal signal mirrors the surface reflectance profile of the object will be conditions in which differences in the relative proportion of the composition of the retinal signal at each wavelength correspond to differences in the relative proportion of the light that the object reflects at each wavelength, and it is these differences in the relative proportion of the light that the object reflects at each wavelength that determine its colour.

One way of putting the point is in terms of the computational task that the visual system performs in creating a representation of colours in the subject's environment. This is often described as the task of 'discounting the illuminant'. This need not be taken to imply that differences in colour appearance due to variations in the illumination are unavailable to conscious attention, and hence need not be taken to imply that there is no sense in which coloured objects appear different as the conditions vary.[24] The point is rather that the visual system appears to be trying to 'disentangle' the contribution that the incident illumination makes to the composition of the retinal signal, and thereby to the way the object is experienced. The case in which the composition of the retinal signal mirrors differences in the object's surface reflectance profile is the limiting case in which the object's surface reflectance profile can simply be 'read off' the retinal signal; it is a case in which the incident light makes no contribution to differences in the relative composition of the light that reaches the eye, and so its contribution does not need to be 'disentangled'.

Illuminants need to satisfy two conditions in order to present the colours objects really are. First, they need to emit light continuously across the entire visible spectrum. Second, they need to at least approximate to equal energy light: light with a flat spectral power distribution.

The first condition requires that the light reaching the eye carry information about the object's reflective behaviour at every visible spectral wavelength. To see the rationale for this, consider the contrast between natural daylight and monochromatic light: light composed of a single spectral wavelength, or else a strictly limited range of spectral wavelengths, up to no more than about 10nm. Monochromatic light is not a good illuminant under which to determine an object's real colour because the light striking the object is composed of light from a limited range of spectral wavelengths, and so can only encode information about the reflective behaviour of the object at those wavelengths. Because an object's reflective behaviour—that which determines its colour—is much more extensive than this, the information that the light carries about the object's reflective behaviour—and hence its colour—is only partial. In particular, the light that reaches the eye carries no information about how the object reflects light in any other part of the visible spectrum. As such, it radically under-determines the nature of the object's surface reflectance profile, and the colour it determines: even when you know what the composition of the light reaching the eye is, this is consistent with the object instantiating one of a wide variety of different colours.

By way of illustration, consider two objects which reflect light very differently across most of the visible spectrum, and therefore differ significantly in colour, but which reflect the same proportion of the incident light at 510nm, like the yellow lemon and blue jeans whose spectral reflectance profiles are illustrated in Figure 1. When they are illuminated by a 510nm monochromatic green light, the information available in the reflected light reaching the eye isn't sufficient to distinguish between these objects: solely on the basis of the information available, it is impossible to tell whether the object's reflective behaviour across the rest of the visible spectrum is more like that of the yellow object or more like that of the blue object. Yet there is a significance difference in the way these objects reflect light across the visible spectrum, and dependent upon this a significant difference in the these objects' colours.

Natural daylight differs from monochromatic light insofar as it is a *continuous* illuminant: it is composed of light of a broadband spectral wavelength, and not just light of a specific (or limited range of) wavelength(s). Indeed, the broadband wavelength light of which natural daylight is composed is not just continuous, but *entire spectrum light*: it spans the entire visible spectrum. Not all continuous illuminants are entire spectrum lights. Part of the reason why an object's colour appears different in candle-light—one of the facts to which Berkeley draws attention—is that although candles emit light continuously, they do so only in the higher end of the visible spectrum: candlelight is composed exclusively of light with a wavelength of no less than (roughly) 550nm, light that is phenomenally red-orange. Hence, white things, which reflect light in equal proportion across the visible spectrum (see Figure 1), assume a reddish glow in candlelight, because they reflect almost entirely the phenomenally red-orange light that strikes them. The colours of red and yellow things, which tend to reflect more long wavelength light than short wavelength light, appear more vivid. Conversely, the colours of blue and green things, which tend to reflect more light in the lower regions of the visible spectrum, appear duller.

Entire spectrum light is preferable to any kind of light that is not composed of light from every part of the visible spectrum. If the light striking the object is not composed of light at any particular visible spectral wavelength, then it can convey no information about the reflective behaviour of the object at that wavelength. As such, it is able to provide only partial information about the object's reflective behaviour, and so it does not carry full information either about the object's reflectance, or the colour that this reflectance determines. In contrast, entire spectrum light does not under-determine the nature of the object's reflectance. Given the composition of the incident light, it is therefore possible to determine the objects' spectral reflectance profile.

Natural daylight is not unique in being composed of light of each and every spectral wavelength; in fact, many light sources emit light at each part of the visible spectrum (see Figure 2). Even amongst illuminants that emit light in every part of the visible spectrum, however, natural daylight is still the gold standard because it satisfies the second condition of being (roughly) speaking *equal energy light*: its spectral power distribution is (roughly) flat across the visible spectrum. (I return to the qualification in §5.) For an illuminant to reveal an object's real colour, differences in the composition of the reflected light that reaches the eye should mirror (more or less exactly) differences in the way the object reflects light at different parts of the visible spectrum. Any differences in the spectral composition of the light that reaches the eye should be due to the fact that an object reflects light in different proportions across the spectrum; differences in the composition of the reflected light should not be a function of differences in the composition of the light incident upon the object in the first place. In these conditions, the surface reflectance profile can simply be 'read off' the retinal signal.

For instance, consider the difference between natural daylight and fluorescent illumination. Fluorescent lights emit most of their energy in the visible part of the electromagnetic spectrum, but are not ideal as far as perceiving the real colours of objects is concerned, because like other electrical discharge lamps the emission spectra for fluorescent lights contain a limited number of (usually three) sharp peaks and troughs.[25] In the case of fluorescent lights, these peaks are fairly evenly spread across the spectrum, thereby giving a reasonably representative sample of an object's reflective behaviour in different parts of the visible spectrum. Still, the fact that there are these disparities in the spectral power distribution of fluorescent lamps means that the information that reflected fluorescent light carries about an object's entire reflectance is distorted.

Fluorescent light sources often emit most light in the yellow, green and blue regions of the spectrum, from 400-650nm, but very little in the high end of the red part of the visible spectrum, between 650-700nm. The information that the light encodes about an object's reflective behaviour in this part of the spectrum is therefore comparatively limited. This explains, for example, why people often look pale under fluorescent illumination. Pale skin reflects a higher proportion of the incident light in the long wavelength region of the spectrum than in the lower region. Because the fluorescent lamp emits comparatively little light in this part of the spectrum in the first place, the spectral power distribution of the light that reaches the eye is skewed in favour of those wavelengths where the illuminant's emission is greater to start with. The result is that the fluorescent light does not carry accurate information about how the skin reflects light in the top end of the visible spectrum, between 650-700nm.[26] Consequently under this illumination, the skin appears less red than it really is. Under natural daylight, in contrast, differences across the spectrum in the power distribution of the light reaching the eye mirror more closely differences in the way the skin reflects light in different parts of the visible spectrum: the skin's reflectance profile and the spectral power distribution profile of the reflected light are roughly isomorphic.

## 5. The Limits of Natural Daylight

I have argued that, assuming colours supervene on reflectances, there is a non-arbitrary reason to privilege colour experiences in entire spectrum equal-energy light. As such, there is a non-arbitrary reason to privilege natural daylight, because natural daylight is roughly speaking equal energy light that is continuous across the entire visible spectrum. I want to conclude by noting three qualifications about the limits of natural daylight.

The *first* qualification is that the spectral power distribution of C.I.E. illuminant D or $D_{65}$ (Figure 2) only represents one of the phases of natural daylight. Because the nature of the light that reaches objects on the ground varies constantly, there is not any single spectral power distribution profile that describes natural daylight as such. Consider, for example, the differences between daylight on a heavily overcast day, and daylight on a lightly overcast day; when the sun goes behind a cloud in an otherwise blue sky, and when there is not a cloud in sight; and the direct illumination of the sun at noon, and the red light of the sun at dusk.

The spectral power distribution of direct sunlight is shifted slightly towards higher visible spectral wavelengths, and so appears slightly yellowish. As the sun moves closer to the horizon, the balance of the spectral power distribution of sunlight shifts further towards the long wavelength, phenomenally red, region of the visible spectrum. In contrast, the light on an lightly overcast sky ('north daylight') contains a greater proportion of short wavelength, phenomenally blue, light. And skylight—light from the sky, with no direct sunlight—is predominantly blue light. These variations in natural light are caused by atmospheric interference, the most prevalent of which is Rayleigh scattering, whereby small particles in the atmosphere (such as air molecules, dust and water particles, volcanic ash, and pollution) more efficiently scatter shorter wavelength blue light from the sun's beam than longer wavelength red light: the balance of the spectral power distribution of direct sunlight is shifted towards the higher end of the visible spectrum because the short wavelength light that the sun's radiation contains is more effectively scattered from the sun's beam by small particles in the atmosphere.[27]

Of the phases of direct sunlight, the midday sun is the best phase under which to determine the real colours of objects, because at midday the sun's light most closely approximates to equal energy light. Still, direct sunlight is not the ideal illuminant under which to perceive an object's real colour. Because proportionally more of the short wavelength blue light has already been scattered by the particles in the atmosphere, the sun's light is slightly too yellow. If a scene is illuminated only by direct midday sunlight, the balance of the spectral power distribution of the light is shifted towards the higher end of the spectrum, affecting the colours that objects in the scene appear accordingly. Eliminating direct sunlight from the scene has the converse effect: if the direct sunlight on an otherwise clear day is blocked, the objects in the perceptual scene are illuminated instead by skylight, and because of the effects of atmospheric scattering, colours illuminated by skylight appear bluer than they really are.[28]

The light on a lightly overcast day, when there is neither direct sunlight nor skylight, comes closer to the ideal of being equal energy light. This is no doubt part of the reason why the instructions with *The Munsell Book of Color* (the most widely used 'colour atlas') specify that its coloured chips should be viewed in either north daylight or its artificial equivalent, 'scientific daylight'.[29] However, when it comes to determining the real colours of objects, north daylight is still not perfect. The north daylight represented by the C.I.E.'s standard illuminant C, for instance, has a peak in its spectral power distribution in the short wavelength end of the visible spectrum, between about 440-490nm, the region that looks blue to blue-green. Again, the reason for this is atmospheric scattering. Clouds are predominantly composed of larger water particles than those that cause the generally blue appearance of the sky. Unlike smaller particles, larger particles scatter all light equally: this is the reason why clouds generally look white. Light cloud cover therefore dramatically reduces the Rayleigh scattering that occurs on clear days. But it does not eliminate it entirely; it is still slightly too blue.

Natural daylight which is a *combination* of direct sunlight and skylight—represented by the spectral power distribution of the C.I.E.'s fourth standard illuminant, $D_{65}$—is much better in this respect (Figure 2). Generally speaking, the effect of the slightly yellow sunlight cancels out the effect of the bluer skylight, the net result being that this phase of daylight is, to all intents and purposes, equal energy light.

The final two qualifications to the defence of natural daylight concern important limitations of natural daylight. The *second* qualification is that natural daylight is only to be preferred when perceiving the colours of reflective, and more generally light-modifying, objects. In response to the suggestion that an object's 'real' colour is the colour that it looks to be to a normal observer in conditions of normal illumination, for instance, Austin objects that there are a number of coloured things that this does not apply to. What is the real colour of a bioluminescent fish that appears vividly multi-coloured at a depth of a thousand feet? Or what is the real colour of the sky, the sun or the moon? 'We say that the sun in the evening sometimes looks red—well, what colour is it *really*? What are the "conditions of standard illumination" for the sun?'.[30] With reference to this discussion, Hardin adds to this list stars and neon tubes, asking, 'Do some objects have their own special 'standard conditions' for viewing?'[31]

However, these examples do not show that no sense can be made of the idea that objects instantiate mind-independent colours. First, the class of light-modifying bodies is large enough, and of sufficient importance to us, for it to be significant that there is a non-arbitrary justification of our preference for natural daylight. From an ecological perspective, it is, after all, with naturally illuminated light-modifying material objects—food, drink, conspecifics, predators, natural landmarks—that we are often concerned.

Nor do other kinds of object form as wildly a heterogeneous class as the remarks of Austin and Hardin might suggest. Broadly speaking, objects can be divided into two classes, depending upon whether they *modify* (reflect, refract, diffuse etc.) light that strikes them, or themselves *emit* this light. The group of light-modifying objects contains what Austin called 'medium sized dry goods', including the bioluminescent fish on the deck of the ship, the moon, the sky and clouds, along with transparent volumes. The group of light-emitting objects includes the stars, the sun, neon tubes and the bioluminescent fish in the sea at a depth of one thousand feet.[32]

Light-modifying objects need light to modify if they are to exhibit their light-modifying behaviour. The ideal conditions under which to perceive this behaviour will be those in which the light that they modify is equal energy white light, or light that approximates as closely as possible to this ideal. Of course, we also want to say that light-emitting objects can be coloured; but it is not clear that this requires us to introduce as many different 'standard conditions' as there are objects that emit light. An object's propensity to emit light is best determined when the light that reaches the eye is the same as the light that the object emits. A light-emitting object's real colour is therefore that which it appears to have when the light that reaches the eye has not been distorted: when there is nothing in between the light source and the eye to modify the light, and no other competing light sources whose illumination can overpower, or otherwise interfere with, the light emitted by the object. So, for instance, the sun is not really red when it is close to the horizon, because the light that it emits is modified by the intervening particles in the atmosphere. For the same reason, it is not really quite as yellow as it generally appears, either, as this is also the result of atmospheric scattering. The same holds for other light emitters. Night time is the best time at which to determine a star's colour, for example, because during the day the light from a star is too weak to compete with the much more intense light from the sun. Similarly for neon tubes, and all other light emitters, including the bioluminescent fish.

The bioluminescent fish brings out the further point that the categories of light-modifier and light-emitter are not mutually exclusive: something can both modify light and emit it. But the fact that objects can both emit and modify light does not show that the project of trying to specify standard conditions of perception for objects that do not modify light is fruitless. It just shows that there is more than one way in which objects can be coloured: as a light-modifier the fish is really a muddy sort of greyish white, as a light-emitter it is really vividly multicoloured.

The *third* and final qualification of the defence of natural daylight is that even midday sun on a clear day is not the ideal illumination under which to perceive colour. The spectral power distribution of natural daylight is neither perfectly smooth nor entirely flat. We therefore have to allow that there could be still better lighting conditions under which to determine an object's real colour than natural daylight. But this is not a *reductio* of the view that colours are illumination-independent. The differences in colour appearance under natural daylight and actual equal energy white light will be so negligible as to be practically irrelevant. So even if there was a slightly better illumination than natural daylight under which to determine an object's real colour, this at least does not undermine the truth of our ordinary colour judgments.[33]

## NOTES

[1] Berkeley, G., *Three Dialogues Between Hylas and Philonous*, in M. Ayers ed. *Philosophical Works* (London: Everyman, 1975, originally published 1713/1734), pp. 185-6.

[2] Russell, B., *The Problems of Philosophy* (Oxford: Oxford University Press, 1912/1967), pp. 2-3.

[3] Russell 1912, p. 18.

[4] For dispositionalism, see e.g. McGinn, C., *The Subjective View* (Oxford: Clarendon Press, 1983), and Peacocke, C., *Sense and Content* (Oxford: Clarendon Press, 1983). For more general relationalist theories, see e.g. Thompson, E., *Colour Vision* (London: Routledge, 1995), and Cohen, J., "Color Properties and Color Ascriptions: A Relationalist Manifesto", *Philosophical Review* 113 (2004), pp. 451-506.

[5] Jackson, F. and Pargetter, R., "An Objectivist's Guide to Subjectivism About Colour", in Byrne, A. and Hilbert, D. eds. *Readings on Color* (Cambridge, Mass.: MIT Press, 1997), p. 73. See also Campbell, K., "Colours", in R. Brown and C. Rollins eds. *Contemporary Philosophy in Australia* (London: George Allen and Unwin, 1969), and McLaughlin, B., "Colour, Consciousness and Colour Consciousness", in Q. Smith and A. Jokic eds. *Consciousness: New Philosophical Perspectives* (Oxford: Oxford University Press, 2003), pp. 100-9.

[6] Nunn, T. Percy., "Are Secondary Qualities Independent of Perception?", *Proceedings of the Aristotelian Society* 10 (1909-10): 191-218, and Mizrahi, V., "Color Objectivism and Color Pluralism", *dialectica* 60 (2006), pp. 283-306. For selectionist responses to inter-subjective perceptual variation see Kalderon, M., "Color Pluralism", *Philosophical Review* 116 (2007), pp. 563-601, and Allen, K., "Inter-Species Variation in Colour Perception", *Philosophical Studies* 142 (2009): 197-220. These responses to inter-subjective perceptual variation do not entail selectionist responses to intra-personal (e.g. illumination-dependent) perceptual variation, and there are reasons for resisting generalizing the selectionist strategy this way, in light of facts about colour constancy discussed in §2 below.

[7] This requirement underlies Thompson's 'argument from external reducibility' (1995, pp. 122-132), directed against reductive physicalist theories of colour (thanks to an anonymous referee for drawing this to my attention). I lack the space to consider Thompson's argument here, but note that even if the argument is successful against reductive physicalism, it is consistent with (and indeed helps to

motivate) the naïve realist view that colours are *sui generis* mind-independent properties considered in §4. A similar requirement underlies Berkeley's (1713/4, p. 184) argument against the mind-independence of colour based on the observation that objects appear different colours when seen under a microscope, than when seen with the naked eye. Berkeley himself suggests that there is a non-arbitrary reason to prefer those experiences that employ a microscope, because an object's real colour will be that which is 'discovered by the most near and exact survey'. Berkeley's argument only undermines the existence of a sharp appearance-reality distinction if we treat it as an implicit *reductio ad absurdum* of this distinction.

[8] In the case of variations in colour experience, see e.g. Cohen 2004, pp. 454-69. As a general claim about all kinds of perceptual variation, see e.g. Berkeley 1713/4 and Russell 1912.

[9] For responses to the generalization worry, see e.g. McGinn 1983, p. 11, Jackson and Pargetter 1997, p. 71, and Cohen 2004, pp. 460-1, and pp. 496-7 fn. 19, who argue that the argument from perceptual variation does not generalize from colours to shapes and sizes, because we have criteria for what it is to be a shape that are independent of the way shapes look.

[10] For a slightly more detailed defence of this approach, and a response to the problem posed by inter-species variation in colour perception, see Allen 2009. See also Byrne, A. and Hilbert, D., "Color Realism and Color Science", *Behavioural and Brain Sciences* 26 (2003), pp. 3-21, and Kalderon 2007 for related discussion.

[11] Russell 1912, p. 2, second emphasis added. For related discussion, see also Hilbert, D., "Color Constancy and the Complexity of Color", *Philosophical Topics* 33 (2005): 141-158, Kalderon, M. "Metamerism, Constancy, and Knowing Which", *Mind* 177 (2008), pp. 549-585, and Allen K. "Being Coloured and Looking Coloured", *Canadian Journal of Philosophy* (forthcoming).

[12] Compare Austin's remarks about a stick in water: "it does *not* look *exactly* like a bent stick, a bent stick out of water—at most it may be said to look rather like a bent stick partly immersed *in* water", *Sense and Sensibila* (Oxford: Clarendon Press, 1962), p. 29.

[13] I argue this in Allen, K., "The Mind-Independence of Colour", *European Journal of Philosophy* 15 (2007), pp. 137-158. See also Byrne and Hilbert 2003, Hilbert 2005, and Kalderon 2008.

[14] Russell 1912, p. 3.

[15] This is because in creating a representation of the subject's environment on the basis of the information available in the retinal signal, the mechanisms subserving perceptual constancy exploit the fact that there are a limited number of types of naturally occurring illuminant and surface reflectance profile. See e.g. Palmer, S., *Vision Science* (Cambridge, Mass.: MIT Press, 1999) pp. 133-4.

[16] Not everyone shares this intuition, however; for instance, Jackson and Pargetter 1987, p. 78 and McLaughlin 2003, pp. 107-9 suggest that our intuitions about what colours objects would be in worlds where the prevailing illumination differed are not sufficiently determinate.

[17] See, e.g. Wright 1992, pp. 113-4. The basic rigidification strategy is consistent with relationalist and pluralist theories of colour more generally.

[18] For instance, Wright 1992, pp. 108-139.

[19] After Byrne and Hilbert 2003.

[20] See e.g. Tye, M., *Consciousness, Color, and Content* (Cambridge, Mass.: MIT Press, 2000), and Byrne and Hilbert 2003.

[21] See e.g. Campbell, J., "A Simple View of Colour", reprinted in Byrne, A. and Hilbert, D. eds. *Readings on Color* (Cambridge, Mass.: MIT Press, 1997).

[22] The supervenience of colours on reflectance properties is independently motivated by the need to secure a causal role for colours in the production of colour experiences. See, e.g. Tye 2000 for relevant discussion.

[23] After Wyszecki, G. and Stiles, W., *Color Science* (New York: John Wiley and Sons, 1967), p. 144.

[24] See Hilbert 2005, and §2 above.

[25] Wyszecki and Stiles 1967, p. 153.

[26] For illustrations, see e.g. Williamson, S.J. and Cummins, H.Z., *Light and Color in Nature and Art* (New York: John Wiley and Sons, 1983), and Brainard, D. H., Wandell, B. A., Chichilnisky, E.-J., "Color constancy: From Physics to Appearance", *Current Directions in Psychological Science* 2 (1993), pp. 165-170.

[27] Lynch, D and Livingston, W., *Color and Light in Nature* (Cambridge: Cambridge University Press, 2001).

[28] Shepard, R., "The Perceptual Organisation of Colours", reprinted in Byrne, A. and Hilbert, D. eds. *Readings on Color* (Cambridge, Mass.: MIT Press, 1997).

[29] Certain practical considerations also favour this choice of illuminant. North daylight tends to be the preferred illuminant of painters, for instance, because on overcast days objects do not cast strong shadows that can change considerably during the time it takes it complete a painting. Good artificial approximations to north daylight are also widely available, whereas there have been difficulties producing illuminants that approximations to $D_{65}$, the C.I.E.'s fourth standard illuminant representative of daylight on a clear day. See Henderson, S., *Daylight and its Spectrum* (Bristol: Adam Hilger, 1970), pp. 279, 289-90.

[30] Austin 1962, p. 66.

[31] Hardin, C.L., *Color For Philosophers* (Indianapolis: Hackett, 1988), pp. 68-9.

[32] I do not mean to imply that there are therefore two different types of colour. For instance, both could fall under the general account of colours in terms of 'productances' suggested by Byrne and Hilbert (2003, §3.1.2)

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