Locating the Unique Hues

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Variations in colour perception have featured prominently in recent attempts to argue against the view that colours are objective mind-independent properties of the perceptual environment: either *physical* properties, such as types of surface reflectance profile (e.g. Byrne and Hilbert 1997, 2003, 2007 and Tye 2006), or else *sui generis* mind-independent properties (e.g. Campbell 1993). My aim in this paper is to defend the view that colours are mind-independent properties in response to worries arising from one type of empirically documented case of perceptual variation: variation in the perception of the «unique hues». §1 sets out the challenge raised by variation in the perception of the unique hues. I argue in §2 that the empirical findings are less dramatic than they might initially appear, and in §3 that accounting for the inter-personal differences is consistent with the view that colours are mind-independent properties that normal subjects veridically perceive, at least roughly speaking.

1. The Location Problem

Unique hues are «pure» instances of the hues red, green, yellow and blue: instances that do not appear to be a «perceptual mixture» or «phenomenally composed» of any other hues. Unique hues contrast in this respect with *binary hues*, every instance of which appears to be a perceptual mixture of two other hues: orange, for instance, appears to be phenomenally composed of red and yellow, purple appears to be phenomenally composed of red and blue, turquoise appears to be phenomenally composed of blue and green, and chartreuse appears to be phenomenally composed of green and yellow.[1]

Reflection on the phenomenology of colour perception is usually taken to favour the view that colours, like shapes and sizes, are mind-independent properties: properties whose essential nature is constitutively independent of the experiences of perceiving subjects. Indeed, this is normally conceded even by those who think that colours are not in fact mind-independent properties.[2] Correlatively, reflection on the phenomenology of colour perception seems to favour the view that *being unique* and *being binary* are themselves higher-order mind-independent properties of mind-independent properties: that some colours appear to be phenomenally unmixed precisely because they are phenomenally unmixed, whereas other colours appear to be phenomenally composed of other colours precisely because they are phenomenally composed of these colours. As Kalderon puts it, for example:

> Not only does perception present objects as colored, but perception also presents what these colors are like […] The qualitative nature of the colors is manifest to us in our perception of them. Objects are perceived to instantiate color properties and these color properties are perceived to instantiate higher-order properties that constitute their qualitative character (Kalderon 2007: 563).[3]

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[1] «Phenomenal mixture» is distinct from «physical mixture», achieved by mixing pigments or coloured lights: phenomenal mixture pertains to the appearance of colour, not its production. Although historically there has been disagreement about both the extension of the unique-binary distinction (in particular whether there are unique greens) and even its very existence (whether all colours are phenomenally unmixed), the distinction is widely accepted today, at least in part due to the success of modern opponent-process theory. I lack the space to defend the distinction here, and note only that the distinction is one that colour perceivers seem readily able to grasp, as the possibility of empirical investigation into variations in the locations of the unique hues suggests. For a more extended discussion, see e.g. Hardin 1993.

[2] A classic example is Locke. More recently, error theories about the phenomenology of colour experience have been suggested by, amongst others, Johnston 1992 and Chalmers 2007. For a defence of the claim that reflection on experience supports that view that colours are mind-independent, see Allen 2007.

[3] See also Johnston 1992. Not everyone agrees, however. Contrast e.g. Cohen 2003.

Again, colours appear to be like shape and sizes in this respect. Just as reflection on the phenomenology of shape perception appears to support the view that shapes are mind-independent properties, it suggests that there are also higher-order mind-independent properties of shapes: for instance, that some shapes appear to be symmetrical precisely because they are symmetrical, whereas other shapes appear to be asymmetrical precisely because they are asymmetrical.

Striking inter-personal variation in the perception of the unique hues, however, challenges this seemingly natural view of the unique-binary distinction. Individually, subjects are remarkably consistent in where in the visible spectrum they locate the unique hues. Some subjects can consistently identify spectral lights as unique within as small a range of 2 nanometres (nm), although the range does not generally exceed 10nm (Webster *et al*, 2000). Given that the visible region of the electromagnetic spectrum spans around 400-700nm, this represents just over 3% of the spectrum. Inter-subjectively, however, variation in the location of the unique hues can be substantial. This is especially true of unique green. A study into the spectral location of unique green by Schefrin and Werner (1990), for instance, found that otherwise normal subjects (subjects who passed standard tests for colour blindness, such as the Ishihara test) located unique green anywhere between 488nm and 536nm. This is a range of 49nm, or around 16% of the visible spectrum.

This variation in the location of the unique hues presents three closely related problems for the view that the unique-binary distinction is a mind-independent distinction between a class of mind-independently existing properties. First, if the unique-binary distinction is a distinction between mind-independent properties, then there is a general problem about misperception. Even assuming that unique green is located at the mean value (in Schefrin and Werner's study 509nm) around 90% of otherwise normal subjects misperceive its spectral location, a figure that increases as we deviate from the mean. Moreover, this misperception can be substantial. The extent of the variation is bad enough: in Schefrin and Werner's study, the difference between the mean and the lowest value is 21nm, whilst the difference between the mean and the highest value is 27nm. Worse, however, is the fact that the range of values for unique green in Schefrin and Werner's study actually overlaps with the range of values for unique blue. This means that some normal subjects perceive as unique green a spectral light that other subjects perceive to be unique blue.

As Byrne and Hilbert point out in a recent exchange with Tye, Cohen, Hardin, and McLaughlin, we cannot simply assume at the outset that there will be no variation, and hence no misperception, amongst otherwise normal perceivers. It is, they suggest, hardly surprising that normal perceivers vary in their perception of the unique hues, given that «[n]ormal humans, on any reasonable statistical interpretation of "normal", differ in numerous ways» (Byrne and Hilbert 2007: 87). Still, the sheer extent of the putative misperception at least presents a challenge for the view that colours are mind-independent properties that otherwise normal perceivers are attempting to track. To say that colours are mind-independent properties that many, if not most, otherwise normal subjects systematically misperceive, might seem like a hollow victory. At the very least, some explanation of why colour perception differs from shape and size perception might seem necessary, given that there does not appear to be a correspondingly significant variation in the perception of these visible qualities. If the inter-personal variation really is that extreme, the best explanation of this might seem to be that statistically normal colour perceivers are not, in fact, tracking mind-independent properties.

The second problem that variation in the perception of the unique hues poses is epistemic. If otherwise normal subjects vary so dramatically in their perception of colour, then how can we know where in the visible spectrum the unique hues are actually located? If we can't know where in the visible spectrum the unique hues are located, then this commits us to the existence of what might seem like theoretically unattractive unknowable facts about colour (e.g. Hardin 2003). To the extent that the epistemic objection depends on a verificationist assumption, it is easy to resist (Byrne and Hilbert 2007: 88). Short of accepting some form of verificationism, there certainly seems no reason to suppose that it must be possible to know everything there is to know about the colours. Still, if rampant inter-subjective variation means that the class of putatively unknowable colour facts becomes *too* large, then a better explanation of the apparently rampant divergence might be that there are simply no mind-independent facts in vicinity to know.

Closely related to this, the third problem raised by the location problem is that there does not appear to be any non-arbitrary reason to regard any one set of perceivers as the veridical perceivers. For instance, there seems to be something *ad hoc* about simply taking the mean value to determine the location of unique green. If we want to side-step the controversial issues about conceivability and possibility that the use of actual cases of perceptual variation promises to avoid, we might not want to place too much weight at this point on the thought that what is in fact the statistical majority might change, perhaps as a result of selective breeding or material changes in the environment. Still, we might nevertheless wonder why subjects who locate unique green at the mean value should be lucky enough to veridically perceive the unique hues? What makes it the case that these subjects are the veridical perceivers? According to Cohen, for instance:

> it is hard to see that anything could (metaphysically) make it the case that one of the variants [i.e. one of different experiences] is veridical at the expense of the others: it seems that any considerations that could be brought forward in support of the veridicality of one of the variants could be matched by considerations of equal force in favour of some other variant. (2006: 310)

Of course, in a sense there is, as Byrne and Hilbert (2007: 88-9) argue, a simple response to Cohen's question: what makes it the case that a one person's experience is veridical and another's isn't, is that the first person experiences a light as unique green, and the light is unique green, whereas the second person doesn't experience what is in fact a unique green light as unique green. But again, the apparently substantial non-convergence in the experiences of otherwise normal subjects can at least be seen as presenting a challenge to the view that there are any mind-independent facts that could make it the case that some subjects veridically perceive the unique hues, whilst others don't. If variation is rife, then perhaps the best explanation of this is that the unique-binary distinction is not grounded in the mind-independent nature of the colours after all.

Variation in the location of the unique hues has been used to motivate a number of different theories about the nature of colour. For instance, eliminativists have used the location problem to argue that nothing in the mind-independent environment is really coloured at all (e.g. Hardin 1993: xxiii, 79-80). Relationalists have used the location problem to argue that colours are mind-dependent relational properties, individuated in terms of the experiences of perceiving subjects (e.g. Cohen 2005). Selectionists have used the location problem to argue that physical objects simultaneously instantiate a plurality of non-relational mind-independent colours, and that otherwise normal subjects who disagree about the location of the unique hues each perceive members of different families of mind-independent colour property (e.g. Kalderon 2007). Alternatively, the location problem can be used to motivate the view that colours are mind-independent properties that different subjects perceive under subjectively determined modes of presentation, and hence that facts about phenomenal mixture are really just facts about the «way we perceive colour», and do not reflect anything about the intrinsic nature of the colour itself (e.g. Block 1999, Thompson forthcoming).

The question that I consider in what follows is whether accounting for variation in the location the unique hues requires any of these responses. I will argue that it does not. Although there might be other reasons for rejecting the view that there is a single class of mind-independent properties that otherwise normal perceivers track, and amongst which there is a mind-independent distinction between those that are unique and those which are binary, the location problem does not of itself establish this conclusion.[4]

2. Deflating the Location Problem

The location problem is worrying because the variation in the perception of the unique hues appears to be so extreme. My aim in this section is to argue that the empirical findings are less dramatic than they might seem. One relatively superficial reason for looking at the empirical results in more detail is that they seem to imply that inter-personal perceptual variation is both rife and substantial, and yet our everyday experience does not appear to bear this out. In day-to-day life, inter-personal disagreements about colour arise only relatively infrequently; indeed, everyday experience *must* suggest that our ordinary colour judgements generally converge, otherwise the results of the empirical studies into variation in the location of the unique hues would not be initially shocking. This at least raises a question: if variation between normal perceivers is really as extensive as these reports suggest, then why doesn't this variation manifest itself on a more regular basis?

Turning to the empirical results, the first thing to notice is that if there is a problem about the perception of unique green, it cannot simply be assumed without further investigation that the problem generalizes across the colours. For instance, Webster *et al* (2000) found that individuals' unique hue settings are largely independent; perhaps more surprisingly, the same appears to be true of binary hues, too (Malkoc *et al* 2005). This means

[4] I will not say anything here about other types of perceptual variation that might be used to argue against the view that colours are mind-independent. Proponents of arguments from perceptual variation sometimes treat different cases of perceptual variation as constituting a common kind: variation between otherwise normal perceivers in the location of the unique hues is assimilated to that between normal and non-normal human perceivers (e.g. people who are colour blind), between perceivers from different species, and within the same individual to variation across the wide range of different perceptual conditions (e.g. Cohen 2004). It is far from obvious, however, that perceptual differences that result from varying very different types of factor demand a common response, any more than variation in the perception of shape and size should lead us to deny that shapes and sizes are mind-independent properties. I discuss different types of variation in colour perception in detail elsewhere (Allen 2009, 2010).

that you cannot predict where in the visible spectrum a subject will locate any particular unique hue on the basis of where they locate any of others. As such, variation in the location of one unique hue does not automatically ramify around the hue circle, displacing the other unique hues by comparable amounts.

This is reflected in the fact that amongst the unique hues, variation in the perception of unique green is atypical. In their widely discussed study, for instance, Schefrin and Werner (1990) only found an overlap between the range of values for unique green and unique blue. This is consistent with the findings of many similar studies, the results of some of which are collated by Kuehni (2004). As Kuehni's collation shows, overlaps in the spectral location of the other unique hues emerge if the data from individual studies is pooled: the combined data for studies that use spectral lights to test for variation reported by Kuehni, for instance, locates unique blue between 458-495nm, unique green between 490-555nm and unique yellow between 544-594nm, yielding an overlap between all three unique hues. But pooling data from distinct studies raises problems, as differences in experimental set-up are likely to affect the results. For instance, one factor that militates against pooling data from different studies that use spectral lights to test for variation is the striking variation of perceived colour with light intensity. As Kuehni emphasises, where in the spectrum a subject locates the unique hues depends crucially on the intensity of the light, a phenomenon presumably related to the Bezold-Brücke hue shift: the shift in apparent colour of monochromatic spectral light either towards blue (from green) or towards yellow (from yellow-green or red) as its intensity increases.

Part of the reason why it is only the range of values for unique green and unique blue that overlap is that these colours are comparatively the most similar unique hues; it therefore takes less variation for the ranges of these hues to overlap in the first place. For instance, Kuehni (2005a) investigated individual differences in the perception of unique hues using Munsell chips, between which there are approximately equal differences in perceived colour.

He found that the distance between the mean hues identified as unique green and unique blue was approximately 8.5 Munsell hue steps. This contrasts with a difference of approximately 10 hue steps between the mean values for unique yellow and unique green, approximately 13 hue steps between blue and red, and although it is approximately equal to the difference between red and yellow, Kuehni at least reports having the impression that the mean green and blue chips were more similar to each other than the mean yellow and red chips; this anecdotal evidence is consistent with the prevalence of blue-green («grue») confusion amongst other subjects.

The greater comparative similarity of green and blue is only part of the reason why the ranges for the other unique hues do not overlap, however. Part of the reason is simply that the extent of the variation in the location of unique green is uncharacteristically extreme in the first place. Inter-personal variation in the location of the other unique hues is not nearly so dramatic. Discounting unique red, which is a non-spectral colour (and so for which there is no strictly comparable data) variations in the location of unique blue and unique yellow are significantly smaller. Schefrin and Werner, for instance, found that subjects located unique blue between 465-495nm and unique yellow between just 568-589nm. In contrast to the 16% of the visible spectrum that the values for unique green cover, this represents around 10% of the visible spectrum for unique blue and around just 7% of the visible spectrum for unique yellow. To the extent that there is greater inter-subjective convergence in the perception of the other unique hues, the pressure to deny that the experiences of normal subjects are roughly speaking veridical diminishes. Two subjects who disagree over exactly where in the visible spectrum to locate unique yellow, for instance, will at least agree that the other's light is yellowish, that is, instantiates some determinate of the determinable colour property, yellow.

Not only is there a question about whether the variation in the location of unique green generalizes across the colours, but there are also questions about how to interpret the results for unique green itself. Consider first the extent of the range of values for unique green. The extent of the range of values for green is potentially deceptive. The spectral lights identified as unique green by Schefrin and Werner's subjects span 16% of the visible spectrum, with an upper limit of 535nm. This sounds extreme. However, sensitivity varies across the spectrum. The region of the visible spectrum from around 510nm to 555nm (which the range for unique green overlaps with) is a region of relatively poor hue discrimination. In this part of the visible spectrum, differences in wavelength do not translate into differences in perceived colour. A greater variation in the wavelength of a light is therefore needed for a just noticeable difference in perceived colour than elsewhere in the visible spectrum. This is reflected in the fact that subjects tend to be more sensitive to departures from unique green at shorter wavelengths than at longer wavelengths: as in Jordan and Mollon's (1995) study, for instance, where the mean value for unique green is 512nm, with a lower limit of 487nm (-25 nm) and an upper limit of 557nm (+45nm). The «green» part of the visible spectrum, 494-557nm (a difference of 63nm) corresponds to seven Munsell chips, between which there are approximately equal differences in colour. In contrast, the «yellow» part of the visible spectrum, 572-586nm (a difference of just 14nm) corresponds to five perceptually equally spaced Munsell chips (Hardin 1993: 160-1). This averages out to 9nm per Munsell chip in the «green» part of the visible spectrum, in contrast to just 2.8nm in the «yellow» part. The variation in *perceived* colour is therefore substantially less than the variation in wavelength would lead us to expect. This predication is supported by the findings of Wuerger *et al* (2005). Using a system of comparison specifically designed to take into account differences in sensitivity across different wavelength regions (by plotting values in the approximately uniform *L*a*b** colour space), Wuerger *et al* (2005) found that the average inter-subjective variation in the location of the unique hues, even unique green, is merely 1.5 times the average intra-subjective variation.

This doesn't yet address the problem of the *overlap* in the ranges for unique green and unique blue. This is because the region of poor colour discrimination occurs at the higher end of the range of values for unique green, yet it is the lower values for green that cross-over the top end of the values for unique blue. But here too, it is important to approach the results with caution. For one thing, the Schefrin and Werner study in which unique green was found to range from 486-535nm was designed to investigate the effects of ageing on the location of the unique hues, and their study therefore included data from subjects aged between 13-74 years. One of their main conclusions was that the loci for unique green tends to displace towards shorter wavelengths with age, due to the crystalline lens in the eye becoming more opaque. This raises the possibility of treating the problematic lower values for unique green—the values that overlap with the higher end values for unique blue—as simple cases of misperception. Although Block (1999) objects that such a move would be ageist, this response hardly seems intolerably *ad hoc*. It is a common place that many of our natural faculties deteriorate as we age, and our perceptual faculties are no exception, as anyone who wears glasses can attest to.

At the very least, it is noteworthy that none of the individual experiments on younger subjects recreate the overlap in the values for green and blue reported by Schefrin and Werner. Although there is an overlap in the values if the results of these different experiments are collated, potentially important differences in experimental set-up should make us wary of pooling data from different experiments. Only one of the other studies that Kuehni mentions, that of Ayama *et al* (1987), really comes close to finding an overlap between blue and green, with the range for unique blue ending at 489nm and the range for unique green beginning at 490nm; but as this study itself collates results from a number of previous experiments, its results are subject to the same qualification.

Besides, further problems with interpreting the empirical results about variation in the perception of the unique hues are raised by the use of using monochromatic, or near monochromatic, spectral lights to test for inter-personal variation. In the natural environment, it is incredibly unusual to perceive light of this kind. Most natural light is continuous across the entire visible spectrum. Correspondingly, most material objects reflect at least some light from every part of the visible spectrum. Consequently, most of the light that reaches the eye in normal conditions is broadband spectral light.

Generally speaking, veridical perception under normal conditions is consistent with misperception in non-standard conditions. Any account of the function of our perceptual systems should tie the veridicality of colour vision to conditions that are normal for its use (e.g. Burge 2003). Given that our colour vision evolved in, and continues to be used in, an environment predominantly populated by broadband spectrum emitters and reflectors, it does not seem *ad hoc* to suppose that it misfires when it is used in non-standard circumstances.

Jordon and Mollon (1995), for instance, suggest that the use of spectral lights might be at least partly responsible for some of the more extreme variations that are reported in the perception of the unique hues. According to Jordan and Mollon, some of the more substantial variations might be the result of subjects' visual systems habitually compensating for inter-personal physiological differences in the amount of pigmentation in the fundus of the eye. Eyes with heavier pigmentation in their iris tend to absorb more short wavelength light, changing the spectral composition of the light striking the retinal receptors. When subjects with differently pigmented eyes perceive a real world object as unique green, there will be a difference in the ratios of the signals emitted by their retinal receptors (the initial input to the perceptual process), consequent upon the difference in the light striking these receptors. If these subjects' visual systems are differently calibrated to compensate for these physiological differences, then their experiences will diverge when they perceive non-standard monochromatic spectral light. Although there will be no difference in their receptor's output ratios when they perceive a monochromatic green light (as the heavier pigmentation only affects the shorter wavelength light that enters the eye), their differently calibrated visual systems will react differently to these identical signals. Differences in the location of unique green under laboratory conditions would therefore be a consequence of the fact that the visual system is calibrated to veridically perceive the colours of more common broadband stimuli.

The evidence for whether this kind of normalization actually occurs in the case of unique green is equivocal. For instance, Webster *et al* (2000) tested Jordan and Mollon's hypothesis using Munsell chips, and failed to confirm the prediction that inter-subjective variation would be less dramatic when material objects (in contrast to spectral lights) are used. This result is supported by experiments, also using Munsell chips, by Kuehni, who found that the dominant wavelength of chips identified as unique green still spanned 488-555nm, which is around 22% of the visible spectrum, and around 25% of the Munsell hue circle (reported in Kuehni 2004).

But it should be noted that even though Kuehni did not find a significant reduction in the range of values for unique green, nor did he find any overlap in the chips identified as unique green and unique blue. This is because he *did* find a very significant reduction in the range of values for unique blue: whilst Schefrin and Werner found that subjects identified spectral lights of between 465-495nm (roughly 10% of the visible spectrum) as unique blue, Kuehni found that the dominant wavelengths of Munsell chips identified as unique blue spanned just 475-481nm, representing merely 2% of the visible spectrum, or around 5% of the Munsell hue circle. Kuehni offers no explanation of this finding, although it is possible that the factors suggested by Jordon and Mollon are operative, given that differences in pigmentation in the iris would directly affect the amount of short wavelength «blue» light striking the retinal receptors.

3. Veridical Perception, Roughly Speaking

Experiences that are not veridical in one respect can still be veridical in another. When we perceive an object to instantiate a unique hue, we arguably do not *just* perceive it to instantiate a unique hue. In addition to seeing it as instantiating a unique hue, we also perceive it to instantiate a number of more general, determinable, colour properties; in information processing terms, information about both the determinate and determinable colour properties an object instantiates is simultaneously encoded in the experience (Matthen 2005: 75). For instance, things that look unique red, like things that look scarlet or crimson, also look to instantiate the coarse-grained determinable property, red.

Experiences that diverge at the level of the fine-grained colour properties they represent can still converge at this more general level. If the experiences of otherwise normal subjects do converge at this more general level, then the problems posed by inter-personal variation do not arise: if otherwise normal subjects do not disagree about the coarse-grained determinable colours they perceive objects to instantiate, then at least at this level there is no general problem of misperception, no epistemic problem, and no problem of arbitrariness. What I want to suggest in the final section is that there is sufficient inter-personal agreement at this level to support the conclusion that the colours are mind-independent properties that otherwise normal subjects veridically perceive, at least roughly speaking.

Even setting aside disagreements over borderline cases that arise as a result of the inherent vagueness of our colour concepts, and not any variation in colour perception, the claim that colour perception is at least veridical at the level of coarse-grained determinable colours might seem problematic. In response to a similar suggestion by Tye (2006, 2007), for instance, Cohen *et al* (2007) argue that there is rampant variation even in the perception of determinable colours. They cite findings by Malkoc *et al* (2005) that focal instances («best examples») of the eight unique and binary colour categories often overlap with those of neighbouring categories. For instance, the best example of orange identified by one subject can be identified as the best example of yellow by another, whilst another's best example of orange can be identified as the best example of red by someone else. Similarly, even if one subject does not see as unique green something that another sees as unique blue, the subject's unique green will at least overlap with the other's binary hue category, blue-green. Do these experiments therefore show that we do not veridically perceive the colours of objects at least at the level of determinable colours?

The conclusion can, I think, be resisted. First, the inter-subjective *agreement* that Malkoc *et al* found is at least as remarkable as the inter-subjective *disagreement*. Whilst there was overlap in the ranges of instances named as best examples of the unique and binary hues, this overlap was often generated only by a limited number of responses; the majority of responses tended to cluster away from the other hue categories (Malkoc *et al* 2005: Figures 1a, b). As Malkoc *et al*, note the centroids of stimuli labelled by basic colour terms across a wide variety of human languages cluster around similar points in colour space (see also Kay *et al* 1997). Indeed, Malkoc *et al themselves* take this cross-linguistic convergence in colour categorization to suggest «that the special and shared status of basic colour terms may reflect special and shared properties of the human visual system or of the visual environment» (2005: 2154); that is, Malkoc *et al* suggest that there is some empirical support for the view that colours are mind-independent properties of the visual environment, the view that Cohen *et al* use their results to undermine. Insofar as what variation there is occurs against the background of widespread agreement, this might seem sufficient to discount some of the more anomalous responses, even of otherwise (statistically) normal perceivers, as cases of misperception.

There are also questions about the extent of the disagreement reported by Malkoc *et al*. As Byrne and Hilbert (2007: 90, fn. 5) note, the reported disagreements seem to be due as much as anything to the colour-naming technique that Malkoc *et al* use. The worry about variation in the location of the unique hues is made vivid by the apparent contrast between intra-personal consistency and inter-personal variation, yet in Malkoc *et al*'s findings, intra-personal variation was almost as great as inter-personal variation.

But even setting these qualms to one side, the relatively few anomalous responses in the study were not entirely anomalous. There is still a general level at which even these responses agree with those of the other participants. For instance, a subject who sees as orange (a binary mixture of yellow and red) a sample that another subject sees as red, at least agrees that it is a determinate of the more general determinable reddish. Likewise, a subject who sees as orange a sample that another subject sees as yellow at least agrees that the sample is a determinate of the more general determinable, yellowish.

Cohen *et al* (2007) point out that as well as *veridically* perceiving the sample to be yellowish, the subject who sees the yellow sample as orange also *misperceives* it, insofar as they also see it as being reddish. Hence, some disagreement re-emerges at the level of coarse-grained determinables. But at this point it is important to be clear about exactly what the problem posed by inter-personal variation is. In response to Byrne and Hilbert's attempts to suggest that there is in fact «no puzzle of true blue» (2007: 89), I argued in §1 that insofar as the challenge has suasive force it depends essentially on the frequency and extent of the inter-personal variation; a single case of apparently blameless misperception is not sufficient. Specifically, *widespread* disagreement holds out the promise of rampant misperception, seemingly arbitrarily apportioned amongst the otherwise statistically normal population, leaving a host of essentially unknowable facts about the colours of objects. If the scale of the problem is too large, then a better explanation of the differences might simply be that there is no single set of mind-independent properties that otherwise normal colour perceivers are tracking.

The disagreements that re-emerge at the determinable level, however, are not nearly so troubling. First, to the extent that normal subjects *agree* in many of their perceptual judgements about coarse-grained colours, veridical perception amongst the statistically normal population is high; and even if these subjects' judgements are perhaps not «as true» as they might be, the respect in which they are veridical helps to off-set the respect in which are false. Second, although there might still be some uncertainty about precisely what colours some objects are, broad agreement means that there will be a substantial range of facts about the determinable colours of objects that can be known. Finally, given the widespread convergence in at least some respects at the level of coarse-grained determinable colours, it no longer seems intolerably *ad hoc* to privilege the experiences of some subjects at the expense of others. There is, of course, some respects in which certain subjects will get things wrong; but as there are other respects in which the same subjects will simultaneously get things right, their responses are not being dismissed out of hand. Insofar as the challenge depends essentially on the extent of the arbitrariness, then the challenge dissipates.[5]

This applies just as much to unique green, given that real world objects (as opposed to spectral lights) perceived to be unique blue and unique green do not overlap. If someone sees as unique green a Munsell chip that another subject perceives as bluish-green, or even greenish-blue, then they at least agree that the chip is some determinate of the general determinable, greenish (cf. Byrne and Hilbert 1997: 274). Even if their experiences differ to the extent that the latter represents the chip as *also* falling under the determinable bluish, there is as yet no reason to suppose that these subjects' experiences are not veridical at least in respect of representing the chip as greenish.

Indeed, there might even be limited inter-personal agreement in the perception of spectral lights in this respect. When subjects perceive as unique blue monochromatic lights that other subjects perceive as unique green, these subjects at least agree, and so there is not yet any reason to deny that they veridically perceive, that the light is a determinate of the determinable colour, *cool*. Cool colours are colours from the blue-green area of colour space; they contrast with warm colours from the red-yellow region of colour space. Although in

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[5] In part, Cohen *et al*'s (2007) objections to Tye depend upon his telelogical account of the representational content of experience, according to which the representational content of experience is determined by what «Mother Nature» intended it to detect. Even assuming that the function of Normal (in the teleological sense) colour vision is to detect the coarse-grained colours of objects, they argue that disagreement at the level of determinable colours shows that the majority of normal (in the statistical sense) colour perceivers are not reliable colour detectors, and hence not Normal. But the commitment to Tye's «psychosemantics» is an optional commitment, and not necessary to defend the general view that colours are mind-independent properties of the environment (cf. Byrne and Hilbert 2007: fn. 6).

English we have distinct colour words for properties from different regions of the area of colour space that «cool» covers, the more coarse-grained term appears to be sufficient for the purposes of many language users. Out of 110 languages considered by the World Colour Survey, around 40 appear to be «grue languages», having colour words that are best understood as applying to green and blue (Kuehni 2005b), and it has even been suggested that composite categories persist in at least the thought of speakers of more evolved languages (Hardin and Maffi 1997: 369).[6]

So, despite the role that empirical findings about inter-personal variation in the perception of the unique hues have played in recent attempts to argue against the view that colours are objective mind-independent properties, the problem of locating the unique hues does not require us give up this common sense intuition. It is consistent with what variation there is that colours are mind-independent properties that normal perceiving subjects veridically perceive, at least roughly speaking.[7]

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[6] This response assumes a «universalist» theory of colour categorization, according to which inter-subjective convergence in colour categorization mirrors genuine discontinuities in the mind-independent environment. This is not uncontroversial. «Relativists» dispute the extent of the putative convergence in human colour categorization, regarding colour categories as determined primarily by cultural, environmental and/or linguistic factors (e.g. Saunders and van Brakel 1997). On the other hand, some universalists think that convergence in categorization can be explained simply by appealing to the innate structure of the visual processing mechanisms, without supposing that there are any corresponding discontinuities in the mind-independent environment, (e.g. Hardin 1993). But the view that our colour categories reflect genuine differences in the mind-independent environment at least seems to be a reasonable working hypothesis. On the one hand, there is good evidence that the universalist view of categorization is at least generally correct, even if cultural, environmental and linguistic factors can sometimes affect our classificatory practices (see, e.g. the essays collected in Hardin and Maffi 1997). At the same time, the view that these universal categories carve a class of independently existing properties at the joints, like the view that the unique-binary distinction is a mind-independent distinction between a mind-independent class of properties, appears to fit our pretheoretical intuitions.

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