The Metaphysical Significance of Colour Categorization: Mind, World, and their Complicated Relation

1. Introduction: Are Colours *Real*?

As is well known, colour categorization has been a test case for the Whorfian thesis that the conceptual landscape of our native language radically shapes our experiences of the world. In this chapter I put discussion of colour categorization to an alternative use. I will be describing how current understanding of categorization bears on the ancient metaphysical debate over the reality, or otherwise, of colour. This debate concerns the fundamental nature of colour, for example whether colour is a physical property, like wavelength of light, or a mere projection of the mind onto external objects. Physical science describes the world in terms of particles and forces that do not bear qualitative properties like colour, taste and smell, so it is open to question whether or not colour has a place in the ordinary physical world. Thus we can formulate a series of metaphysical questions concerning colour: *Are colours mind-independent, physical properties? Can we say that objects are actually coloured? Are our colour experiences a visual representation of certain physical properties?*

As Democritus wrote in the fifth century BC, "by convention sweet and by convention bitter, by convention hot, by convention cold, by convention color; but in reality atoms and void" (DK 68B9, trans. Taylor

1999). Interpretative controversies aside, I take Democritus to be articulating the metaphysical theory of colour which I will call *anti-realism*. In other words, mind-independent reality, made up of "atoms and the void", has no colour (or taste, or temperature sensation), and such qualities are artefacts of "conventions" generated by the human mind. Contemporary anti-realists posit that colours are purely fictional or illusory properties, and that strictly speaking colours do not exist. On that view it is false to say that grass is green, for no object is actually coloured (Hardin 1993).

Yet it should be clear that this extreme view can be avoided if one examines more closely the mind-world relation that perceptual systems exploit. The *relationist* says that colours are real and not illusory properties, but that they are in some sense perceiver-dependent.[i] John Locke famously said that colours are "nothing in the objects themselves but powers to produce various sensations in us" (Locke 1690/1993:71). That is to treat colours in a relational way, as fundamentally defined by their effect on perceivers. More recently, Hatfield (2003) has argued that colour is a "psychobiological property". He invokes an analogy with "nutritious". No substance is intrinsically nutritious – it is only so because of its life-sustaining effects on particular animals. Likewise, no object is intrinsically coloured, and can only be thought to have a colour because of its interactions with seeing animals. Yet it is still true to say that grass *is* nutritious (for cows), and that grass *is* green (for humans).

In this chapter I will argue that an understanding of perceptual categorization gives us a strong motivation for rejecting any simple dichotomy between real/physical properties and unreal/psychological attributes. This undermines the extreme anti-realist view and leads to a novel argument in favour of a relationist theory of colour. I will begin by discussing what I mean by categorization.

2. Defining Colour Categorization….. Loosely

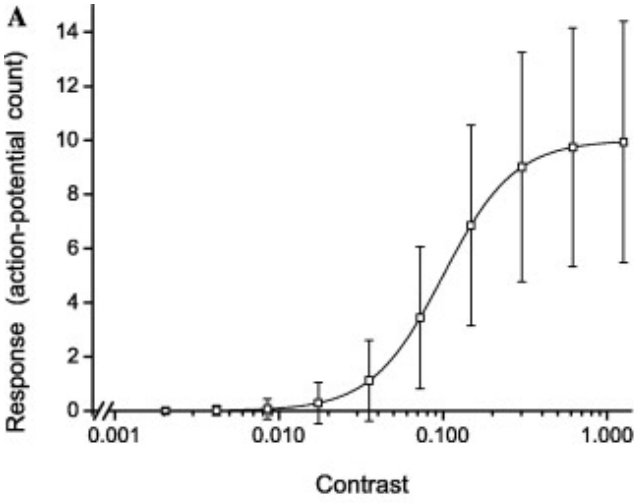
Roughly speaking, the *Whorfian* view on colour categorization is that the phenomenon is language-mediated, and therefore cognitive in origin (Davidoff 2001), whereas the *universalists* take colour categories to reflect features of our basic perceptual physiology (Berlin and Kay 1999). In this chapter I intend to sit happily on the fence between Whorfians and universalists, holding a pluralist position like the one advocated by Dedrick (2006). If universalism is starkly associated with the view that "physiology determines named colour categories", and Whorfianism with the thesis that, "physiology plays no interesting role in the development of named colour categories", then both positions seem implausible (Dedrick 2006:9). The substantive debate is over the extent to which physiology or language dominates colour category formation. I will be non-committal about this, only asserting that physiology must have *some* role, as do language and cognition.

Thus a claim can be made for the existence of both low-level, (physiological) and high-level (linguistic and cognitive) categorization mechanisms. The former are associated with well understood physiological mechanisms in the sensory periphery, while the latter are associated with the linguistic and cognitive functions of the cortex.[ii] I intend "categorization mechanism" to mean, loosely, any sorting system that treats diverse physical stimuli in roughly identical ways.[iii] I agree with theorists such as Bruner (1957) and Matthen (2005) that classification or categorization is central to the operation of sensory systems, and that it is appropriate to seek adaptive explanations for the existence of categorization schemes.

For example, simple non-linearities in sensory responses can serve as categorization mechanisms. If a sensory neuron has a strongly accelerating response function, it can be thought of as classifying stimuli into two categories, e.g. low or high intensity. Moreover, the exact specification of the mechanism can also serve to make salient certain physical differences while eliding others. A sigmoidal response function will exaggerate the difference between a stimulus just below the acceleration threshold, and one just above it, while treating two stimuli both above or below the threshold as relatively similar or indistinguishable, and those in the middle, accelerating range, are more distinguishable (see Figure 1).

Figure 1

Naka-Rushton model of the nonlinear (sigmoidal) contrast response function of a V1 neuron. See Chirimuuta and Tolhurst (2005) for detail.



In sum, categorization defined broadly can be thought of as the *warping of perceptual space* (Kuhl et al., 2008). An "unwarped" perceptual space treats all stimuli as equally salient and discriminable. A warped space results in clusters of similar appearing stimuli, which in turn have salient dissimilarities from other clusters. Thus categorization is also associated with the existence of a similarity space of quality clusters, like the familiar colour space.

The early stages of human colour perception can be understood in this way. The first signal for colour vision is the differential response of the three retinal cone types. Our photoreceptors cannot finely resolve the

wavelengths of incoming light to perform a detailed spectral analysis. Instead, countless different stimulus spectra produce the same signal, while opponent coding at the post-receptoral level exaggerates the difference between the physically quite similar stimuli that maximally excite the M and L cones.

Note that I have been careful to avoid the claim that these opponent mechanisms explain our conscious experience of colour categories. This was the universalist line advocated by Hardin (1993), but it faces criticisms not only from Whorfians but also from visual neuroscience (Valberg 2001, Mollon 2003). My claim is that some form of categorization takes place at the low level, and that it constrains, but does not determine the high-level categorizations of which we are consciously aware. Nor do I want to invoke rigid demarcation between perception and cognition, and deny that perception is culturally influenced and informed by cognition. I have focused here on categorization mechanisms in the sensory periphery where it is safe to assume that neurons are encapsulated from cognitive processing. For example, the retina receives no top-down connections from the brain. But that is not to say that perception, in general, is like this.

Interestingly, the operational definition of high-level colour categories is still a matter of dispute. Davidoff (2001) takes categorical perception (CP) effects to be the criterion for a colour category boundary. Yet Hanley and Roberson (2011) have shown that these can occur within a colour

category. Thus Jraissati *et al*. (2012) argue for *psychological saliency*, operationalized with consistency and consensus measures, as the criterion for colour categories. I will put this issue to one side and say that a high-level colour category is simply one that is marked by an individual's language, and is associated with a conscious experience of perceptual similarity amongst co-classified objects.

High-level classification schemes are also a feature of other modalities.[iv] The canonical examples of categorical perception are from research on perception of phonemes, a clear case of categorizations that are language-relative.[v] However, unlike the classifications of smell, taste, or of speech perception, colour categories cannot always be said to mark out biologically or socially important kinds. Not all red things are dangerous or poisonous, nor do they have one socially-governed significance. Instead, to understand the function of colour categorization it will be necessary also to consider the relationship between colour and non-chromatic vision (Kingdom 2011, Shevell 2012).

3. Anti-Realism

We will return now to the metaphysical questions: *Are colours mind-independent, physical properties? Can we say that objects are actually coloured? Are our colour experiences a visual representation of certain physical properties?* The anti-realist gives a negative response to each of

these questions. In this section I will discuss the rationale for this position, outlining the three main points in the anti-realist argument: (1) disunity of physical causes of co-classified colours; (2) no physical explanations of colour space and colour categorizations; (3) availability of physiological explanations for these.[vi]

Firstly, it is a well known fact that colour vision co-classifies a disparate variety of physical properties and processes in objects (Nassau 2001). What is redness? Is it the ligand field effects inside a ruby, the physical optics of a sunset, or the nanostructure of butterfly wings....? Of course, one thing that unites all these different objects is that they predominantly reflect visible light in the long wavelength range. But still, if one takes a group of objects that all look to have a particular shade of red, their spectral surface reflectance (SSR) profiles may vary quite dramatically (i.e. they are *metamers*). Thus regardless of whether we consider the chemical, structural, or optical properties of objects, or whether we consider broad hue categorizations or fine classifications of shade, we find that there is disunity of physical causes of co-classified colours.[vii] This is one score against the idea that colour experience simply represents a physical property of objects. At most, one could claim that my experience of, for example, ruby red represents a set of metameric SSR's.

The second score against the simple representation idea comes with the consideration of colour spaces and categories. Hardin (1993: *xx*) writes that,

> When somebody tells me that she has a theory about colors, I expect it to be a theory of yellow and green and the like, and if I get a story about spectral luminance or reflectance profiles, or whatever, I want to know how all of that relates to those qualities that I know and love.

The point is that our primary experience of colour is of certain hues which are marked by lexical categories, and appear to bear obvious relationships of similarity and difference to each other. Such relationships are commonly represented in colour spaces, and it seems obvious to us that green is more similar to blue than it is to red, and so forth. These are defining characteristics of colour, and we therefore expect a philosophical theory of colour to account for them. Yet if we define colours as physical properties, we get no purchase on such phenomena. The spectrum of visible light is a physical continuum, and yet we perceive it as banded by a small number of distinct hue classes.

The third point raised by the anti-realist is that if we look to our internal neurophysiology then we *do* get an understanding of these defining phenomena. According to Hardin (1993:*xxi*), the outline of an explanation of colour spaces and categorizations has already been given to us by opponent-process theory in psychophysics and physiology:

> Given what is known about the processes of color perception… it is quite plain that the basic structure of opponent color space is founded on the biology of the visual system. One would be able to answer questions about the relations that colors bear to each other by appealing to the color-relevant features of physical objects only if the structure of color space had its analog in those features. That condition is not satisfied.

Given there are many reasons for scepticism about the sufficiency of low-level physiological explanations for high-level colour categorizations, it is worth highlighting the fact that all the anti-realist needs to show is that an explanation that refers to internal mechanisms – at any stage in the perceptual-cognitive hierarchy – is more likely to yield an understanding of colour spaces and categorizations than an explanation put exclusively in terms of external physical stimuli. As Pautz (2013) has recently put this in a discussion of non-visual modalities:

> in *some* cases structural *relations among* [perceptual] experiences (similarity and difference, equal intervals, proportion) are well matched by structural *relations among* their neural correlates. … In these cases the basis of certain structural facts about phenomenal character are to be found *only in the brain*. (Emphasis original.)

Pautz presents examples along these lines for smell, taste, audition and pain, and in all such instances we would be wrong to think of sensory experiences

as simply representing or tracking physical stimuli. But what are we to conclude about the fundamental nature of sensory experiences of colour, taste and smell? For both Pautz and Hardin, it is false to say that colours are ordinary physical properties, or that external objects are coloured. Furthermore, it is metaphysically problematic to say instead that the brain, or some psychological state, is the bearer of colour. So they are forced to conclude that there is simply no such thing as colour: a correct account of the world is one which says that no items, either mental or physical, are actually coloured. Ordinary human perceivers are victim of a lifelong and systematic illusion.

4. Realism

This is a radical conclusion, and good sense would seem to counsel against it. Needless to say, alternatives have been sought. The polar opposite view from anti-realism is (surprise!) *realism*. This is the theory that colours are, rightly speaking, physical properties of external objects, and the sky is blue independently of the mind.[viii] I will argue that this strategy is ineffective, and in the following section present a promising relationist alternative.

I will focus on an influential recent version of realism called *reflectance realism,* because this is the view most relevant to the debate over categorization. Hilbert (1987) argued that colour can be identified with SSR,

such that every individual light reflecting surface has a specific colour that is defined by its SSR. It follows that there are many more colours than the human eye can resolve, and that colour categorizations are arbitrary, anthropocentric groupings of the actual physical colours.

Byrne and Hilbert (2003) modified the view to include a definition of colours for light sources, transparencies and volumes, and took a different approach to the issue of categorization. On the revised theory, both higher-level colour categories ("determinable colours") and specific metameric shades ("determinate colours") are identified with *sets* of SSR functions. Byrne and Hilbert (2003:11) insist that colour categories are not unreal or subjective:

> Surfaces with grossly different reflectances can perceptually match even under fairly normal illuminants So the reflectance-types that we identify with the colors will be quite uninteresting from the point of view of physics or any other branch of science unconcerned with the reactions of human perceivers. This fact does not, however, imply that these categories are unreal or somehow subjective.

The assertion that colour categories are not subjective amounts to saying that they can be characterised in terms of physical properties. The category 'red' is a heterogeneous set of SSR's, but can be given an (incomplete) physical description in terms of all the SSR's known to belong to the set.

The problem with this position is that it trades a better definition of colour categories, one that defines red things in terms of how they look to perceivers, for a worse one which only lists SSR's of antecedently identified red items, or states (somewhat vacuously) that an item is a member of the red category if and only if it is red. Such definitions cannot be used to predict category membership for new items, and are uninformative if the property of 'being red' is left undefined.

However, the realist's problems are compounded when one moves from considering just the existence of colour classes to reckoning with similarity judgments about those categories. It is a commonplace observation that broad colour categories can be arranged in a colour space, and some classes are nearer neighbours than others: green is closer – more similar – to blue, than it is to red. Likewise, we readily make similarity judgements about specific shades: peacock blue is more similar to navy blue than it is to saffron yellow. Now one argument that has been raised against colour realism, the thesis that colours simply are SSR's (or sets of SSR's), is that this implies that perceptual similarity judgements are open to empirical disconfirmation (Johnston 1992). If colours are these physical properties, it could well turn out that physicists will discover that saffron yellow should be classified as a shade of blue, or that green is more similar to red than it is to blue, whatever the psychophysical data.

Byrne (2003) offers a complex response to this argument. Firstly, he argues that even though colour experiences represent objective colour (i.e. SSR), *propositions* concerning similarities between different colours are not represented in visual experience. Secondly, Byrne explains our tendency to make similarity judgements as being a result of our representing each shade as having proportions of primary-like colours called "hue magnitudes". Not coincidentally, the hue magnitudes **R**, **G**, **B** and **Y** are naturally associated with the unique hues of opponent coding theory (Byrne and Hilbert 2003: 14). While this interpretation of the hue magnitudes is not obligatory, if it is *not* employed the hue magnitudes are left hanging as unexplained primitives in the theory.[ix]

One final point is that nothing in Byrne and Hilbert's account suggests how reflectance realism can be applied to the colour categorisation phenomena studied by linguists and psychologists. Colour name categories should not be identified with their determinable or determinate categories, nor can category boundary effects be explained in those terms. Indeed, Byrne (personal correspondence) agrees that such categorisation phenomena *are* perceiver dependent. So at the end of the day, the colour realist cannot explain many central colour phenomena – categorical perception, naming, colour spaces, and similarity judgments – without making reference to the human mind and visual system. This result should come as no surprise to the vision scientist, psychologist or anthropologist. For we learn from those

disciplines that colour is one of the many ways that our minds, categorize, contemplate, and make sense of the world.

5. Relationism

My view is that relationism is the one philosophical theory of colour that can make sense of this last insight. The basic tenet of relationism is that in order to understand colour, one must consider both the perceiver and the external stimulus, and treat colour as somehow arising from the interaction between these two. Returning to our metaphysical questions – *are colours mind-independent physical properties? can we say that objects are actually coloured? are our colour experiences a visual representation of certain physical properties?* – the relationist answers "no" to the first, "yes" to the second, and "no" to the third. For if colours are defined as perceiver dependent properties – e.g. dispositions to affect perceivers in certain ways (Harvey 2000), psychobiological properties (Hatfield 2003), or ecological properties like affordances (Thompson 1995) – then even if colours are not mind-independent physical properties we can still say that external objects *are* coloured.

The attraction of relationism is that it allows one to balance the fact that colours are fundamentally shaped – dare I say, constructed – by the mind/brain, with the fact that colours would be nothing without the external

stimulus. The anti-realist concluded that colour experiences are illusory, even though they are the outcome of normal, functional, sensory operations, and are actually informative about the external world. The realist, on the other hand, tried to avoid admitting that colours are in any way perceiver dependent, and has trouble accommodating basic psychological facts about colour. Relationism is a promising middle way between these extremes.

Naturally relationism faces difficulties of its own. One famous objection is that perceptual experience does not present colours as perceiver-dependent properties.[x] In my own account of relationism, I emphasise the fact that colour vision is integrated with non-chromatic visual processing (Shevell and Kingdom 2008, Shevell 2012). This means that colour perception is part and parcel of the mechanism for recovering numerous different properties of objects – shape, distance, lightness, and material composition. As Akins and Hahn (in press) have put it, colour vision is not for mere colouring. Thus a natural way to think about colour is as a means by which we see these other, perceiver independent, properties of objects.[xi]

For example, Kingdom (2011) describes how colour vision serves to disambiguate the form of some purple flowers from the shadows cast on them. So one's perception of their colour is a way of seeing their shape. Likewise, Kingdom discusses the close connection between perception of colour differences and perception of changes in material substance. Changes

in colour are readily interpreted as alterations in a material surface, rather than mere optical effects. This makes adaptive sense, given that in our environment colour differences are usually the result of a material change, whereas changes in achromatic luminance, unaccompanied by colour shifts, are normally due to shadows or shading. My perception of colour is a way of seeing material change and constancy.

Consideration of the many uses of colour vision helps us see how visual experiences involving subjective perceptual categorisations need not be illusory. The category itself may not map on to any objective physical property, but it may still contribute to the discrimination and re-identification of objects. I will conclude with an example which illustrates the idea that subjective categorization is a means to perceiving objective physical properties.

5.1 Categorization and Colour Constancy

Colour realists have argued that colour constancy is evidence for their thesis that colour experience represents SSR. For SSR is a illumination-invariant property of objects, and colour constancy ensures that our perception of the colours of objects is relatively stable across illumination changes (Tye 2000). The problem with this proposal – as is obvious to anyone with colour vision – is that colour constancy is not *that* good. Since we can generally notice some shift in hue or brightness when the lighting changes, it is not

true to say that our experiences of colour are invariant with respect to illumination.

Cohen (2008) takes the opposite position from the colour realist and argues that there is no *apparent* colour constancy. When I turn on a tungsten bulb and the pages of my book turn from pure-white to yellow-white, Cohen argues that while the page's colour appearance is fundamentally different, my visual system still recovers the (counterfactual) fact that if the lighting were the same in these two instances, the paper would have the same colour. In my opinion, this account is not true to our experience of constancy. What we are actually presented with, visually, is a complex impression of both change and stability. For example, if I turn on the light bulb there will be a striking change in the colours of things – they will tend to look more yellow – but at the same time there is something invariant about their appearance.

My conjecture is that high-level colour categorization helps us ignore the instability of experience with changing illumination. For in nearly all cases of shifts in illumination one would still, without hesitation, categorize each object in the same way as before. Oranges still look orange, grapes still look green, though a different shade. Indeed, stability of categorization only breaks down in conditions under which colour constancy is limited (Hansen, Walter and Gegenfurtner, 2007). If the categorizations were not available to us (cognitively or perceptually), would it not be so much more difficult to

disregard the shift from cool-green to yellow-green, and judge the grapes as having the same surface properties as before?

Given complex perceptual experiences, where stability and instability of colour seem to coincide, my proposal is that the invariant "component" of experience reflects the sameness of colour categorization across different lighting conditions. Moreover, the sameness of categorization tracks the objective fact that the material properties of the objects have not changed. We have good reason to think that colour categories are useful for recovering the actual stability of material objects, even if nothing in the physical world mirrors their structure (Olkkonen, Witzel, Hansen and Gegenfurtner, 2010). This breaks with the realist idea that constant colour vision aims to represent objective physical properties (SSR), but does not deny that colour constancy allows us to track the objective sameness of things in the world.

It is not simply that colours can be equated with our hue categories, and are therefore subjective; or that categorization is merely a distraction from the essential business of perception, which is to recover objective physical properties. For categorization – the warping of perceptual space – does help us keep track of what is there in external reality. Given that perceptual systems belong to evolved creatures with specific informational needs and finite neural capacities, perceived reality will be distorted and

simplified if it helps the animal recover essential information about the external world.

5.2 Closing Remarks

It is useful to think of perceptual categorisation as just one instance of a general rule about perceptual systems, which is that all discrimination functions come with peaks and troughs. Human observers are best at discriminating achromatic contrast at levels around the absolute detection threshold, and most sensitive to changes in wavelength in the 500 nm range. Many other animals perceive changes in UV reflectance and polarisation of light, to which we are completely oblivious. The point is that no animal needs to see all stimuli equally well. Categorization is just one kind of mechanism for highlighting the stimulus differences that are important to the animal, and eliding others.

This brings us to an important point which was not addressed earlier. Above I emphasised that although colour may be perceiver-dependent, and colour categorisations subjective, these still provide information about non-spectral properties of perceiver-independent reality – shapes of objects, changes in their material composition, etc. – aiding a creature in its negotiation of a complex environment. Now I do not claim that *all* instances of colour vision have this feature. For example, my experience of the

spectral bands of a rainbow does not yield any obviously practical information. (Though it does reveal the celestial magnificence of the world.)

More subtly, many of the external properties that are selectively highlighted by perceptual mechanisms for discrimination and categorisation have their special status because of the particular interests and needs of the animal. It is not as if colour vision is a means to an unbiased picture of objective stimulus properties. For instance, if Mollon's (1989) hypothesis that primate trichromacy evolved to aid foraging turns out to be true, then we see ripe red fruit as saliently different from a background of leaves not because the fruit is, objectively speaking, so very different but because in our evolutionary history it was advantageous to treat the colours of fruit and leaves as categorically distinct.

Finally, the order which arises with perceptual categorisation is extremely advantageous to limited beings like ourselves. Compare the phenomenology of colour with that of pitch. For those not endowed with perfect pitch, one note does not have any categorical quality which makes it saliently different from other notes. For this reason, most of us cannot recognise or classify a note, when heard, as C, D#, E etc.. Thus absolute pitch is hard to remember. With colour, on the other hand, it is easy to classify a shade, and remarkably easy to recall what that colour was from one view to the next. On seeing a persimmon for the first time, a viewer will probably notice and remember that it is an orange fruit. This knowledge will

make it easy to recognise a persimmon the next time around. In order to learn to identify a persimmon, no-one need register the exact shade of the skin, whether it is closer to the colour of an orange or a mango. Indeed, that there are only a handful of colour categories makes them more useful in such situations – it is easier to remember what colour category an object belongs to if there are only 10 options, not ten thousand.

It should now be obvious why the anti-realist's equation of perceiver-dependence with illusion and error is wrong. If all perceiver dependent contributions to sensory experience are considered erroneous, then it follows that for a perceiver not to be subject to error he or she must resolve all physical stimuli equally well, with no response nonlinearities or subjective categorizations anywhere in the sensory system. This is a completely non-ecological way of thinking about perception! As venerable as it is, our philosophical tradition needs to give up on the idea that perception aims at an objective, God's eye view on the world. That is the assumption at the core of both the realist and anti-realist theories of colour. I hope that by now the inadequacies of those views have been demonstrated.[xii]

6. Summary

This chapter has explored the "Janus-faced" nature of colour. As Mausfeld Niederée and Dieter (1992:47) write, "the concept of human color vision involves both a subjective component, as it refers to a perceptual

phenomenon and an objective one... We take this subtle tension to be *the* essential ingredient of research on color perception…" I have argued that relationism is the only ecologically acceptable way to incorporate the study of categorization phenomena into a metaphysical theory of colour. The anti-realist is forced to conclude that colour categories – like all colour phenomena – are illusions. The realists, on the other hand, had to exclude psychological categorisation phenomena from their theory of colour. Relationism shows how it can be that the existence of colour and its categories depends on perceivers, but that these are not mere illusions. Colour, we might say, is the subjective interpretation of objective physical stimuli.

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[i] See Cohen (2009) for an extended defence of relationism.

[ii] This is an illustrative over-simplification. There is also a contested area of perceptual/cognitive categorization associated with higher sensory processing.

[iii] cf. Holt and Lotto (2010) "*Categorization, …. ,* reflects a decision about an object's type or kind requiring generalization across the perceptually discriminable physical variability of a class of objects". Note that under my loose definition of categorization I also include instances of generalization across *potentially but not actually* discriminated physical stimuli.

[iv] E.g. for discussion of smell and language see Plumacher and Holz (2007).

[v] See Holt and Lotto (2010) for review.

[vi] See Hardin (1993, 2003) and Pautz (2006) for further detail.

[vii] Philosophers normally refer to this as the *disjunctiveness* of physical causes.

[viii] More accurately, this is a specific version of realism known as *reductive realism* or *physicalism*. It can be contrasted with *non-reductive* or *primitivist* versions, which do not claim that colours are identifiable with other physical properties such as SSR (Campbell 1993, Watkins 2002).

[ix] Thanks to Christopher Hill for discussion on this point.

[x] See Chirimuuta (2011) for a response.

[xi] More formally, I define colour in the following way: *Colours are properties of perceptual interactions involving a conscious perceiver (P) endowed with a wavelength discriminating visual system (V) and a stimulus (S) with spectral contrast of the sort that can be exploited by V*. Colour turns out to be a property of a perceptual *process*, rather than a property of a perceived *object*. I call this an "adverbial" account of colour. It is a kind of relationism, because both perceiver and stimulus appear in the definition of colour (Chirimuuta, under contract).

[xii] I would like to thank Don Dedrick, Cristoph Witzel and two anonymous reviewers for comments on an earlier version of this chapter. I am also grateful to Alex Byrne and David R. Hilbert for discussion of their theory.