Is the Image of Colour Science Used by Cognitive Scientists and Philosophers Pathological?

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According to a consensus of psycho-physiological, neurophysiological and philosophical doctrines, colour sensations (or qualia) are generated in a cerebral 'space' fed from photon-photoreceptor interactions (producing 'metamers') in the retina of the eye. The resulting 'space' has three dimensions: hue (or chroma), saturation (or 'purity'), and brightness (lightness, value or intensity) and (in some versions) is further structured by primitive or landmark 'colours' – usually four, or six (when white and black are added to red, yellow, green and blue). It has also been proposed that there are eleven semantic universals – labeling the previous six plus the 'intermediaries' of orange, pink, brown, purple, and grey. Versions of this consensus provide ontological, epistemological and semantic blueprints for the supposedly brute fact of the reality of colour ordained by Nature. Colour, like gold, is presumed to be a 'natural kind', picked out by 'advanced' information processing languages like our own (Berlin and Kay 1969/1991; Kay et al 1997).

In contrast I regard 'seeing colour' not as a matter of light waves impacting on eyes, producing sensations to be categorised and labeled in the 'colour space' of the brain, but as an instrument for achieving human intentions and activities, forming an interlocking network whose internal coherence relies on systematically engendering certain ways of viewing the world. This can be understood if we keep in mind contrasts between non-modern and modern societies: localised influences and resources in non-modern societies are drained away into the impersonalised relations of abstract systems, so that the very tissue of experience alters, conjoining proximity and distance in unprecedented ways, and in the case of colour enabling or constraining us to see in terms of hue, saturation and brightness. Re-characterised, these dimensions become transcendent tokens of time-space distanciations (like writing, vital to the memory controls of modern states). They become universalised commodifications regulating everyday life in time-space routinisations, and a sedimentation of the impersonal, public or 'official' language of *seeing colour* in terms of black, white, red, yellow, green, blue, brown, purple, pink, orange and gray. This is what becomes a new grammar of reality. If we insist on talking about 'colour concepts' then we must understand a particular concept as the location of activities, norms and institutions of established practice. And as with any practice of any importance, colour concepts have a history within which they come to be, are sustained and transformed, and sometimes perish as parts of the histories of those particular practices and societies. In this sense, colour concepts are more like moral or value concepts than those of the natural sciences. To abstract them from the contexts which they inform and which inform them is to risk a damaging misunderstanding. That is exactly what colour science does.

Here is an alternative conception and an all too brief overview of some incoherencies, which make otiose the relativist claim that only the practitioners of colour science are qualified to judge it. While electrochemical events are a *precondition* for seeing colour, I regard the reception of sensations in 'the colour space' as semantically labeled natural categories, kinds, or information, as a 'just so' story: it is Wittgenstein's beetle in a box. I consider the authority of this consensus is better regarded not as the result of truth-tracking of Nature, but as the socio-historical and political outcome of various philosophical presuppositions, scientific theories, experimental practices, technological apparatus, and their recursive feedback into the lifeworld. My approach is informed by, but not the same as that of Gibson, in that I want to pursue the notion of 'social affordances' which, in relation to colour I call 'a historically inflected exosomatic organ' which takes up, uses, the affordances. This suggests that colour has become a naturalisation through science-based technologies, and through its praxes and materialisations, has become a perceptual and cultural entity that structures experience and understanding in the lifeworld. (Saunders 1992; Saunders and van Brakel 1997). Consequently I explore the historical ontology of 'colour' without assuming an underlying biological constant. In this regard I consider colour science has created a new 'reality' – most suited to performing such tasks as quality control on an assembly line, or identifying military targets. To bring this out clearly would require a counter-historiography of mainstream colour science (MCS). Instead I try to provide a moment of distanciation, a more synoptic overview, as one positive condition of understanding. In this brief paper I hope to show how the non-trivial behaviour maxims that govern colour science, are not only loaded with internal incoherencies, adhoccery and the concealment of the workings which blind it to its own constraints and conditions of possibility but that despite these inadequacies, colour science enjoys an extraordinary pragmatic success, for which I suggest an explanation.

In support of the image of truth-tracking natural kinds, MCS takes a number of theses for granted.[1] 1. Colour is a perceptuolinguistic and behavioural universal, with a physical, quantifiable substratum. 2. It is exhaustively described by three independent attributes: hue, saturation, brightness. 3. There are four phenomenal unique hues: red, green, blue, yellow. 4. The unique hues are underpinned by two opponent psychophysical and/or neuronal channels: red/green, blue/yellow.[2]

The story runs that there are three types of photon-responding cones in the retina, each with a different photopigment, and different spectral sensitivity. The three cone types are maximally responsive to short (S), middle (M) and long (L) wavelengths of light. However individual cones are 'colour blind', preserving no details of wavelength. Only by comparing their outputs can 'information' be extracted about the activating wavelength and passed on to the next step of processing, called 'opponency'.

While the properties of the three types of cones are generally accepted, the evidence for opponency is more tendentious. The generally accepted story is of one achromatic and two chromatic channels. The first so-called brightness channel processes overall luminance. The second, red/green channel compares the outputs of the M and L cones. The third, yellow/blue channel, is claimed to compare the output of the S cones with some combination

[1] Full references can be found in Saunders and van Brakel (1997).
[2] Nearly all CSsts subscribe to 1, but successively fewer to 2,3,4.

of the outputs of the L and M cones. But this psychophysical model is at odds with many experimental results.[3]

In psychophysics many types of experiment yield evidence for something like the three channels just described. One could say that almost any quantitative colour vision experiment that depends on processes after the receptors can be interpreted in terms of the three channels, and quite often the pragmatic interpretation makes the results easier to understand. That's why most colour scientists believe in them now. Some cases seem 'quite strong evidence', some not. You have to look hard at each individual case to evaluate this. Important, of course, is to realise how much of an opponent scheme was imposed by the scientist rather than by the results. That's the first main class of problems: the individual cases are often not so convincing when you look closely. (Even the cancellation experiment, so dear to the modern advocates of opponency can be interpreted largely in terms of the cone pigments.) The second main class of problems is that there is no generally accepted quantitative formulation. The consensus is just for 'something like the three channels'. Everybody can 'model' his or her own data, often quite precisely, but no general model works. Even elementary things, like whether the LM channel takes the difference or the ratio of the L and M cone outputs, or some other function, are still undecided. This is bizarre in a field where the methods allow (are designed to produce) quantitatively very precise data. There is too a third class of problems, namely that many findings don't even fit into the general scheme.

In the physiology of monkeys cells, in the optic nerve, these cells fall roughly into the three groups as far as their colour responses go, but once you get into the brain that breaks down. There are many problems with this, from anaesthetic, via variability of data with supposedly irrelevant stimulus conditions, to the so-called 'codings' particularly of spatial properties by the same cells. Add to that the fact now generally accepted that the opponent colours revealed by physiology (magenta-teal, chartreuse-violet) are nowhere near the supposed primary or unique hues, the image is very much at a loss. This is not a difference between psychophysics and physiology, because many quite persuasive opponent colour interpretations of psychophysical experiments are in terms of the physiological opponent scheme. The MacLeod-Boynton colour space for example, which is widely used, is essentially a photopigment based space, used to represent and analyse both psychophysics and physiology. So there seems to be a major conflict between the advocates of colour-names and unique-hue psychophysics versus the rest.

What cognitive science textbooks have taken up, when they regard colour science as a paradigm of information processing and modularity, is really a set of widely shared presumptions or working hypotheses rather than achievements. This is melded into the long tradition of empiricist thought on colour. I think the situation is that cognitive science wants a paradigm that appears to work, and have grossly overemphasized the extent of colour science's achievements. This is of course *ekphrasis*. Colour Science is actually very much an 'empirical' science, which has developed some 'reliable' methods but where consensus and understanding are restricted to modest sub-domains. It is surely its methods and practices, which allow it to create an exosomatic organ. Colour science is poor at theory but adequate to discrimination applications. The bad colour science is at the level of general theory and understanding.

What experimental support is there for the assumption that colour in daily life consists of three psychologically salient components: hue, brightness and saturation? There are problems about a three dimensional spatial metrics as the proper psychological dimension of colour vision. The physical attributes of colour do not independently affect the psychological dimensions. Some say the psychological colour space has seven dimensions not three. None of the existing systems of colour classification achieves the goal of uniform perceptual intervals between any two adjacent colours. Therefore hue, brightness and saturation notwithstanding their usefulness for particular industrial-military purposes, can only claim to describe scientific colour spaces. This is what I mean by a 'floating model'.

The a priori suppositions are supported by such nostrums as 'Color vision is the ability to discriminate among different wavelengths of light ...' (Gordon and Abramov 2001, 93). Or 'the basic linguistic categories themselves have been induced by perceptual saliences common to the human race ... biology determines phenomenology and, in consequence, a piece of semantic structure" (Hardin 1988, pp. 168, 156). This account relies on photons per unit of time, unit of area and unit of solid angle, the cones in the retina, metamers, opponent processes, colour spaces and basic words which data are made to fit. But one colour scientist (D'Zamura 2003) has insightfully pinpointed a constructive possibility – there are different organisations of colour sensitive mechanisms that appear to underlie behaviour concerning colour appearance and behaviour in detection tasks. In other words 'seeing colour' and 'detecting' should not be conflated, as the entire image of colour studies has hitherto done. There are without doubt colour scientists who have founded their whole careers on not conflating them, but the image of colour science taken over by cognitive science, philosophy and related disciplines has not grasped this distinction. Here lies one of the instances that Wittgenstein diagnosed as conceptual confusion in psychology. It is this that leads to the sterile debates about mind and body and 'gaps' and whether seeing colour is the discrimination of wavelengths. A failure to address these issues is masked by collusion over ignoring them. Rather, the colour detection that colour scientists deal with has established its own norms of correctness and epistemological claims in adjacent discipline, by light of which the incoherencies have become unobtrusive, and adhoccery, normal. This is what I am gesturing towards when I speak about 'pathology'. It is the totally relativistic claim that only colour scientists can properly speak about the 'truth' of colour science. It might be regarded as an example of Habermas's 'systematically distorted communication.'

[3]Though it could be said that there are as many psychophysical models as there are colour scientists, the account I present tends to be the one presented in textbooks and taken over by such adjacent disciplines as cognitive science, philosophy, linguistics, and anthropology.

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