The Language of Colour: Neurology and the Ineffable

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It is often claimed, following Joseph Levine, that there is an 'explanatory gap' between ordinary physical facts and the way we perceive things, so that it is impossible to explain, among other things, why colours actually look the way they do. C.L. Hardin, by contrast, argues that there are sufficient asymmetries between colours to traverse this gap. This paper argues that the terms we use to characterize colours, such as 'warm' and 'cool', are not well understood, and that we need to understand the neurological basis for such associations if we are even to understand what is fully meant by saying, for example, that red is a warm colour. This paper also speculates on how Hardin's strategy can be generalized.

Keywords: C.L. Hardin; colour; colour vocabulary; explanatory gap; perception; *qualia*

1. Introduction

A major part of the mind–body problem is to explain why mental states have the phenomenal qualities that they do. It is often held, for example, by Joseph Levine (1983, 1991), that there is an 'explanatory gap' here. The simplest such states are perceptual *qualia*, and the examples most commonly chosen are colour *qualia*. Even if we knew everything about the physics of colour, and even if we knew everything about the eye and the brain, this would not explain why colours actually *look* the way they do, why green stimuli give rise to green *qualia*, for example, as opposed to red ones. This is perhaps because colours are essentially ineffable — simple impressions, in Hume's (1955) sense, which cannot be characterized in any useful way.

However, some (such as C.L. Hardin 1987, 1988, 1997) take a more optimistic line, and argue that there are enough asymmetries within the colour circle to ensure that it is possible to explain why colours look the way they do. In particular, any possible inverted spectrum (seeing green where others see red, for

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example) can be ruled out as detectable after all. More generally, colour vision science shows there to be many useful connections between phenomenology and physiology. For example, that red is (unlike orange) a *unique* (i.e. unmixed) hue, and unlike green, a *positive*, *advancing*, and *warm* hue, can perhaps be explained physiologically. However, attention needs to be directed to exactly how these italicized predicates — the language of colour — get their meanings. It will be argued that we need to have predicates of this kind if explanations of why colours look the way they do are to be forthcoming, and we are not to surrender to the claim of simple ineffability. It will also be argued that such terms are more than just metaphorical, and that they directly concern how the brain itself works, and thus involve a kind of embodiment of language, one which challenges more traditional pictures of how language works.

I shall argue that an ideal sort of explanation of why red should look warm is that there be some appropriate neurological connections between the visual and tactile parts of the brain (currently, the issue is undecided). This will link visual and tactile warmth in a way that is too direct to be merely metaphorical, but not so simply as to yield literal synonymy. Redness is not wholly ineffable, but not straightforwardly analysable either. However, red–green inversion is not the only inversion that needs to be ruled out. Other terms are needed, and I suggest that greens and yellows have a quality that may be described as *sharp*, *fresh* and *citrusy* whereas reds, blues and purples do not. As with *warm*, this quality does more than just reflect ordinary physical associations (I think). To explain this, we need to find direct neural links between the visual and gustatory centres of the brain. This needs to be further generalized, and I shall speculate on ways in which colour language could be further extended in an explanatorily useful way.

2. The Hering Colour Circle

Hardin draws heavily on the ideas of the 19th century physiologist and founder of modern colour vision science, Ewald Hering. Conventional wisdom says that there are only three basic colours (red, green and blue) from which all others can be obtained by mixture, and that this corresponds to the fact that there are three different kinds of colour photoreceptor in the retina (sometimes known, rather misleadingly, as the red, green, and blue cones[1]) which respond to different parts of the visible spectrum. Hering, however, insisted that there are four unique hues, that is to say, colours which actually look essentially unmixed, namely red, yellow, green, and blue. These yield four binary or essentially mixed hues, namely orange (red–yellow), purple (blue–red), turquoise (green–blue), and chartreuse (yellow–green). This notion of mixture is purely phenomenal, and does not relate to how colours may be obtained by combining lights or pigments. We now know that the phenomenon to which Hering draws our attention is post-

[1] The terms are misleading since the cones' sensitivity curves do not peak at the red, green and blue portions of the spectrum: The 'red' cone peaks at yellow-green, and it is the narrow difference in stimulation level between it and the 'green' cone that underpins the red–green perceptual channel.

receptoral, and concerns how differences in stimulation level in the cones are transmitted to the visual cortex. Specifically, there are two retinocortical channels, the red–green channel and the yellow–blue channel (together with the achromatic white–black channel), each of which yields opponent processing. Thus when the first channel is excited, the subject perceives red or a reddish hue; when it is inhibited, the subject perceives green or a greenish hue. Likewise, when the second channel is excited, the subject perceives yellow or a yellowish hue; when it is inhibited, the subject perceives blue or a bluish hue. The results may be summarized in the following diagram:

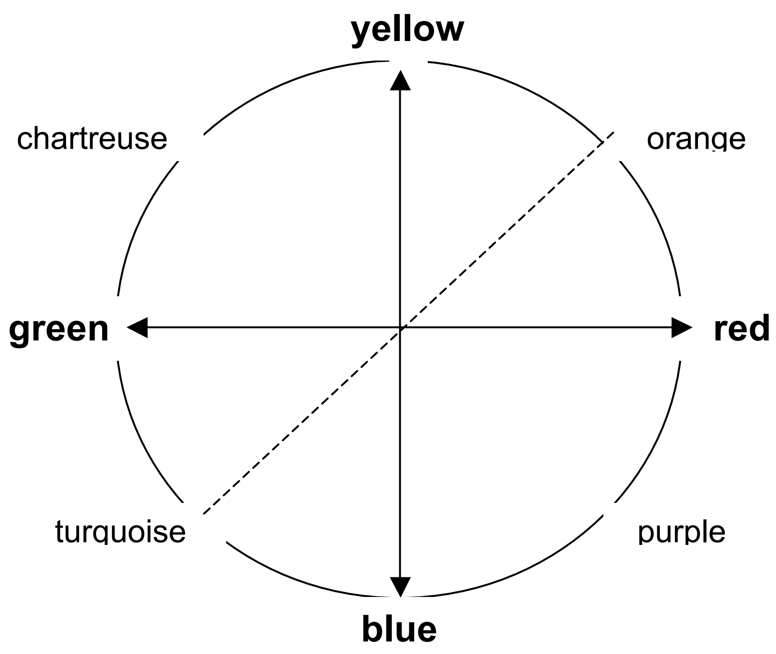

Figure 1: The Hering colour circle

Two classes of phenomenal facts are explained by this analysis. Firstly, the difference between unique and binary hues is accounted for. Colours which look essentially unique and unmixed correspond to the activation of just one retinocortical channel, whereas colours which look like mixtures of unique hues correspond to the activation of two. Secondly, we can see why some combinations of unique hues are perceptually impossible, namely red–green and yellow–blue.[2] This is because a given channel cannot simultaneously be excited and inhibited, any more than a given energy level can simultaneously increase and decrease. As Hering originally predicted, much of the phenomenology of colour perception, that is to say much of what directly presents itself to the colour-sighted percipient, is matched by the underlying physiology, and in a very straightforward sort of way.[3] The explanatory gap has not been completely traversed, to be sure, since there are many other phenomenological facts yet to be

[2] Except in extraordinary circumstances. On this, see Crane & Piantanida (1983), Billock *et al.* (2001), and Suarez & Nida-Rümelin (2009).

[3] The phenomenology is supported by quantitative results. See, for example, Hurvich (1997).

explained, but the idea that such a gap is untraversable in principle has been put into serious doubt.

Closely connected to the explanatory gap is the hypothesis of inverted *qualia*, namely that it is possible that you see colours differently from me (see the Appendix for an illustration of this phenomenon). Hardin argues against Levine that there are enough asymmetries in the colour circle depicted above to rule this out. In particular, it is highly implausible that you might see orange where I see red since what you would call 'red' (namely orange) is a binary hue and can be directly perceived as such. If there are to be any undetectable inversions, then at the very least, unique hues must be exchanged with other unique hues. The standard inversion scenario invokes an exchange of red and green, thus leading to a reflection of the colour circle in the vertical diameter. However, Hardin argues that such an inversion is also detectable since red and yellow are essentially *warm* hues, whereas green and blue are essentially *cool* hues; and this too is explicable physiologically. This is much more controversial, however, and this paper argues that this is largely because terms like 'warm' and 'cool', as used in this context, are not well understood.

3. Word/Colour Associations

What do we mean when we say that red is a warm colour? One problem is that ordinary physical associations are involved. As is often observed, reds and yellows are the colours of fire, whereas greens and blues are the colours of lakes. Obviously, red is a *fiery* colour, for example, but people with red–green inverted *qualia* will also agree: (What we call) green is indeed, for them, a colour of fire! Many will insist that this sort of thing is all that the warmth/coolness distinction amounts to, and that they cannot see anything more directly phenomenological involved. The fact that there is this sort of disagreement here is embarrassing, and weakens a lot of ordinary phenomenological evidence, for it undermines the assumption that we can all tell, without too much difficulty, how things look to us. At any rate, if it turns out that ordinary physical associations (together with some additional cultural conventions, perhaps) accounts entirely for the warm–cool distinction, then it cannot be used to explain why red looks like red as opposed to green. But we do not ordinarily suppose that a blue gas flame looks warm even though it feels it, and there is evidence that people really do perceive a genuine phenomenological distinction here. For example, Katra & Wooten, in a recent unpublished study (quoted in Hardin 1997), asked ten subjects to rate eight colour samples as 'warm' or 'cool' on a ten-point scale, with ten as 'very warm.' The mean results gave the lowest rating to the blue sample, and the highest rating to the orange sample. There was a high level of agreement among subjects:

> The remarkable correspondence between the obtained ratings of warmth and coolness and the activation levels in the opponent channels […] suggests that the attribution of thermal properties to colors may be linked to the low-level physiological processes involved in color perception. Higher ratings of warmth corresponded with levels of activation of the opponent

> channels in one direction, while cooler ratings corresponded with activation in the opposite direction. This suggests that a link to the activation level of the opponent channels, rather than the psychological quality of hue, drives the association of temperature with color, and that the association is more than simply a cognitive process.

Also, Ou *et al.* (2004) showed:

> [I]n a psychophysical experiment, 31 observers, including 14 British and 17 Chinese subjects assessed 20 colours on 10 colour-emotion scales: warm–cool, heavy–light, modern–classical, clean–dirty, active–passive, hard–soft, tense–relaxed, fresh–stale, masculine–feminine, and like–dislike. Experimental results show no significant difference between male and female data, whereas different results were found between British and Chinese observers for the tense–relaxed and like–dislike scales. […] Four colour-emotion models were developed, including warm–cool, heavy–light, active–passive, and hard–soft. […] The results show that for each colour emotion the models of the three studies agreed with each other, suggesting that the four colour emotions are culture-independent across countries.[4]

So, suppose that there really is a relevant sort of distinction here.[5] How will it help us? Levine argues, against Hardin, that although warmth is connected to redness, the connection is essentially shallow. The former could be subtracted from the latter to yield a residue, a 'cool red'. If this is right, then we do indeed have an explanatory problem since we have not managed to target what is essential to red. But Hardin rejects the intelligibility of 'cool red', and surely rightly so. What we call visual warmth does seem to be an essential part of redness. It is not all of redness, to be sure, otherwise yellow could not also be warm, so it is possible that a residue exists.[6] But this residue is only half a colour, not a purified red. Should the residue be combined with coolness to produce a new hue, what we would end up with would be something wholly alien and unimaginable, not anything that much resembles red. Appeals to warmth will not explain everything about why red looks the way it does, of course, but it surely can be used to explain something. In particular, if it can be shown that there are some direct links of an appropriate kind between the neurons which fire when we see red (and yellow) and those which fire when we feel warmth, then an explanation is well on its way.

Such neurological connections need to be found, of course, but their elusiveness is not the only obstacle to explanatory success. There remains another inverted *qualia* scenario that needs to be ruled out, which I call 'diagonal inversion', namely one which involves reflection in the dotted diagonal axis of the Hering colour circle depicted above, where red is exchanged with yellow and

4 Quoted from the Abstract.

5 A negative result here is that young children are less inclined to associate red with warmth, which suggests that the connection is cultural and learnt, not biological. See Morgan *et al.* (1975). The suggestion is not conclusive, however, since innate connections can take time to develop. It is nevertheless odd to suppose that children see colours differently from adults.

6 Though even this is unobvious. Just because being coloured is a part of being red, for example, it does not follow that there is a residue, namely a quality which remains when we subtract colouredness from redness.

green with blue. Turquoise and orange stay fixed, and purple is exchanged with its complement, chartreuse.[7] How could we extend the warmth-coolness point to handle this? Many people I have asked agree that greens and yellows have a quality that may be described as 'sharp', 'fresh', and 'citrusy' — whereas reds, blues, and purples do not. Obviously, there is the risk, once again, that we are dealing only with familiar physical associations here, since limes are green and lemons are yellow. But blackcurrants also have a sharp and citrusy taste, but do not look to me (at any rate) sharp or citrusy. On the contrary, the pale mauve of a blackcurrant yoghurt looks like the very opposite of a sharp, fresh, or citrusy colour. By contrast, lemons and limes not only taste sharp, fresh; and citrusy — they look that way as well. At least, they do to me, though I have only rather limited evidence that they do to others as well. The very fact that the matter is hard to settle indicates that the semantics of words such as 'warm', 'cool', 'sharp', 'fresh', and 'citrusy' (the language of colour) needs considerable critical attention if the explanatory gap is to be traversed successfully.

There has been plenty of research done on words apart from 'warm' and 'cool' that we might associate with different colours (though they do not illuminate the case of diagonal inversion). For example, Lars Sivik (1997: 187), when developing the Swedish Natural Colour System (NCS), discovered that:

> [t]here are many words in common use to describe the character and associative meanings of colours. Besides such attributes as yellow, blue, strong, weak, deep, and saturated, colours can also have connotations like cold, joyful, depressing, sick, healthy, dirty, feminine, masculine, etc. Such colour-relevant adjectives can add up to a rather long list. It is now possible to make a semantic map from the average judgements for each of all imaginable words, or for pairs of opposites if we choose to use bi-polar scales as in the masculine–feminine example above. In our first studies (Sivik 1970), twenty-seven such antonyms were mapped out in the NCS.

These results concern all colours, including browns and greys, not just maximally saturated hues (which are what I have been considering). Whether, and to what extent, these colour/word connections yield explanations will depend on just why they come about. Unless they relate to intrinsic phenomenological facts, rather than external associations, they will probably not be significant if only

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[7] Some rule out this possibility on the grounds that yellow is a much lighter colour then red, and also that there are more perceptual differences between red and blue than there are between yellow and green (see, e.g., Hardin 1988: 134–42, and Palmer 1999). However, these facts relate not to hue but to chroma, or saturation level, and hue and chroma are usually thought of as independent dimensions of colour, fact that is directly, visibly evident to us; so it is unclear if such asymmetries are really explanatory in any relevant way. That yellow has a very low chromatic content is easily explained by the fact that it occurs in the middle of the visible spectrum, where the light-dark sensitivity curve peaks. Green also has a lower chromatic content than red or blue. These facts might change for a 'diagonally inverted' percipient, who might be able to perceive a 'supersaturated yellow', a colour which relates to yellow as red relates to pink (and who would be unable to perceive a 'supersaturated pink', i.e. what we call 'red'). Supersaturated yellow is unimaginable to us, but does not seem paradoxical in the way in which Levine's 'cool red' is, since it merely involves stretching things a bit. We have no idea how many perceptible differences there are between green and supersaturated yellow. For more on this, see Unwin (2011).

because they will not differentiate between the experiences of normal percipients and those of colour-inverted percipients. Without such deep links, colours will remain essentially ineffable, and hence unexplainable. It is difficult to see what research could be done that would decide the matter, since it would have to rely very heavily on asking somewhat technical questions of naive subjects. However, the main focus of this paper concerns what we are *saying* when we say that red is a warm colour, and which perhaps we are not saying when we say that pink is a feminine colour, and this contrast is in itself rather hard to analyse.

So what sort of claim are we making when we say that red is a warm colour? It might be thought that the term ‘warm’ is purely metaphorical here, as in a ‘warm’ greeting. However, this does not seem to do justice to the force with which the warmth strikes us. Metaphors are things that we can usually take or leave, and although they can sometimes be very striking, they do not seem to relate to intrinsic character in a sufficiently robust sort of way. It is, after all, meant to be a primitive phenomenological fact that red looks warm, so primitive that if something fails to look warm then it necessarily fails to look red. It might be thought, on the other hand, that the term is simply literal: Red *is* just literally warm. This, however, is also unsatisfactory as it fails to do justice to the differences in the sensory modalities and associated secondary qualities. True, we describe chillies as ‘hot’ and this seems literally (i.e. not just metaphorically) right as far as appearances go, despite the fact that we are referring to flavour rather than an ordinary tactile sensation caused by a rise in temperature; but gustatory heat, or piquancy, is not strictly speaking a taste in the way in which sweetness, sourness, and so forth are tastes, since it is carried to the brain by a different set of nerves. Flavour is a complex intermodal sense, and should be distinguished from pure taste. Moreover, piquancy does relate very closely to an ordinary burning sensation on the tongue even if it is not accompanied by a rise in temperature. The reason is that similar things are happening to the tongue in each case. By contrast, warmth does not seem to relate to redness in this direct sort of way: The resemblance is not sufficiently close. What we seem to have, therefore, is something in between literal synonymy and metaphor. This in itself yields a problem, since it is unclear what that amounts to. True, we are familiar with dead metaphors, which are half way between real metaphors and literal meanings, but this again does not seem to be the sort of thing we should be looking for.

Finding generally agreed associations between colours and particular words is evidently not enough to yield interesting explanations of why colours look the way they do, if only because it needs to be shown that the meanings of the words in question attach themselves sufficiently deeply to the phenomenology. To some extent, cultural associations can be identified and used to screen the reliability of such associations. For example, we need not attach much significance to the connection between the colour pink and the word ‘feminine’, if only because the association is comparatively recent and does not extend across all cultures. But it may be hard to generalize this kind of screening technique, and Sivik’s research in developing the NCS yields a bewildering array of terms and associations. Much work has been done in configuring semantic scales and developing the topography of associations, but the issue of explanation, of just *why* certain colours (or colour combinations) should be thought of as ‘mighty’ or 'militaristic', for example, is not easy to address.

4 The Role of Neurology

A more promising locus of explanation is the brain, but here we also have difficulties. I suggested, following Hardin (1988: 129–84), that there might be significant links between those neurons which fire when we see reds and yellows on the one hand, and those which fire when we perceive tactile warmth on the other. There is currently not much evidence for this, but the crucial point is that *if* such links were to exist, then we would have something which is genuinely explanatory; and conversely, without such links, it is hard to see how any useful explanation (i.e. one which addresses the explanatory gap) can exist. This is of philosophical importance even if it is purely speculative. I suggest that it would do more than just explain why warmth is associated with reds and yellows; it would also reinforce the claim that reds and yellows really do look intrinsically warm, and would help us to answer the doubters who claim that they cannot see any such intrinsic warmth, and that we are dealing only with physical and cultural associations. This might seem paradoxical: Surely, it may be said, the *explanandum* needs to be firmly in place before we look for the *explanans*. Specifically, we must be confident that red really does look intrinsically warm (and hence know what this means) before asking why this should be so. In response, I can say that in my own case, I was disinclined to believe that red was *intrinsically* warm until the possibility of a neurologically grounded intermodal link was suggested to me: Until then, I could not see clearly what could even be *meant* by the claim. Merely saying that seeing red and feeling warmth resemble each other is not enough: Unlike the case of piquancy, the resemblance itself is not strong enough to underpin the claim.[8]

Some qualification is needed here. I am not suggesting that *all* of what is meant by saying that red is a warm colour is that there are appropriate intermodal neural links, still less that the unknown details should form part of the meaning of what we are currently saying. Since the links are required to explain the resemblance, we would otherwise run the risk that *explanans* and *explanandum* will coalesce, thus rendering the explanation trivial: That is to say, we end up saying that the existence of certain intermodal neural links explains why there are certain intermodal neural links. Rather, the neurological claim — or at the very least the weaker and physically non-specific claim that there is an important, deep link within the internal processing mechanisms involved in seeing red and feeling warmth (without the details) — should be part of what *elucidates* the particular sort of resemblance between redness and warmth that we are trying to explain. The explanation itself then consists in filling in the details. There may remain a kind of circularity here, but it is relatively harmless. It does, however, ensure that questions of meaning — i.e. questions about what we are actually

[8] However, Austen Clark (1993, 1994) has argued that such resemblances across our whole quality space, together with neural links, yields a sufficiently asymmetrical system that they yield a full physicalist reduction of all our sensory qualities. For a critique of Clark, see Unwin (2011).

saying when we say that red looks warm — remain prominent.

Nevertheless, it might still be wondered whether we really need to talk about the *language* of colour at all. After all, nonhuman animals have colour vision, and presumably there can be intermodal links there as well. Perhaps red rags present a warm sort of visual sensation to bulls which blue or green rags do not do. At any rate, it is certainly possible for certain wavelengths of incoming light to be more arousing than others, as they are in humans, and we do not need to ask about the bull's colour vocabulary or cross-modal linguistic associations in order to establish this. Furthermore, it is often said, following Thomas Nagel (1979), that we have no conception of what nonhuman *qualia* can be like, and this fact is itself often used as an argument against physicalism and in favour of there being an untraversable explanatory gap. But here, as elsewhere, the point can be exaggerated. If we suppose, for the sake of argument, that bulls are aroused more by red rags than by blue ones, then it is reasonable to infer that the hue perceived in the former case more closely resembles human red than blue. This is because red light is more arousing than blue. This conclusion can only be tentative, of course, but it would be reinforced if it could be shown that there are further physiological resemblances between bulls' brains and human ones. Yet once again, the specific issue of *language* seems to have dropped out of the picture, and the suspicion may be that it should never have been in the picture in the first place.

However, this would be a mistake. We need to consider other terms besides 'warm' and 'cool' if we are to generalize this strategy, as we need to do if we are to handle diagonal inversion, for example, and the only realistic way to tell whether people perceive certain intermodal resemblances is to ask whether certain words are associated with certain colours. This, at least, must be our first line of inquiry. We then need to filter out the external or culturally-driven associations by focusing on what may be intrinsic to the sensory processing itself. What seems to follow, then, is that the terms we use to characterize the phenomenology of colours are themselves closely connected to what goes on in the brain. Colour language is thus, in a sense, embodied, and cannot be studied independently from bodily functioning, in particular, brain activity. If we neglect the language, then we lack the means to test — or even to look for — hypotheses about intersensory connections; and if we neglect the embodiment, then we fail to distinguish the intrinsic language of colour from the much looser web of associations revealed by, for example, Sivik's (1997) studies.

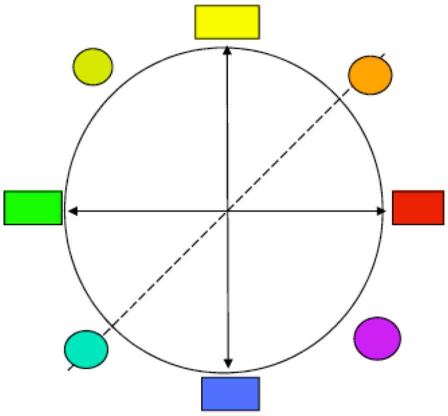
5. Conclusion

What further empirical research is needed? Ideally, we should like to hear from people who view the world through hue-inverting spectacles, especially those who have worn them from birth! If people who have always worn red–green inverting spectacles judge that (what we call) red things look warm and green things look cool, then our thesis is seriously undermined, but is confirmed if they make opposite judgements. We can likewise ask if diagonally inverted percipients associate the terms 'sharp', 'fresh', and 'citrusy' with colours in the same way as the rest of us. We can also ask people who try on any kind of hue-inverting spectacles in midlife whether after a time things start to look as they did before (compare this with studies that show that people acclimatize gradually to up–down inverting spectacles). If so, then the whole notion of a colour *quale* will be placed in jeopardy; but it would also suggest, and for just that reason, that we do not have the kind of explanatory gap that provoked the discussion in the first place. In the absence of the necessary technology, more down-to-earth studies of the kind undertaken by Sivik, Katra and Wooten, and others are desirable, where normal subjects are asked how well they think a given term is associated with a given colour. But terms may need to be restricted to phenomenal terms relating to non-visual senses (it is unclear how else to guard against irrelevant external associations). We also need to learn more about inter-sensory connections in general, and research on synaesthesia may be of help here.[9] With such research in place, we are better able to see if the brain connections mirror the sensory associations.

What of the philosophical conclusions, in particular with regard to the explanatory gap? It should be noted that no attempt has been made to close the gap completely, and it is hard to see how to do this. Explanations tend to be contrastive, and there are too many potential contrasts. That is to say, instead of simply asking questions of the form 'Why X?' we tend to ask questions of the form 'Why X as opposed to Y?', and there are too many candidates for 'Y' here. Even if we can explain why green looks like green as opposed to red (we can talk about warmth and coolness), that will not explain why green looks like green as opposed to blue. I have suggested ways in which we could extend a similar type of explanation here; but even if that were successful, it would not explain why green looks like green as opposed to some wholly alien hue, such as Levine's 'cool red', for example. Nor does it address David Chalmers's (1996) 'hard problem', namely of why green should look like green as opposed to nothing at all (more generally, why physical processes should give rise to any *qualia* of any kind in the first place). But the 'hard problem' is not the only problem of interest, and explanatoriness comes in degrees. Just because we have failed to explain everything, it does not follow that we have explained nothing, and we should not belittle the significance of coming to understand how and why our ordinary colour vocabulary links with other sensory words. And brain processes certainly play an explanatory role here, even if the mind–body problem remains alive and unsolved.

[9] It is often said that we are all weak synaesthetes, and this weak synaesthesia is evidently crucial to the Hardin strategy for traversing the explanatory gap. Full-blown synaesthesia is evidently irrelevant to such a project if only because there is such variation between subjects as to how different modalities connect. However, Marks (1978: 218–20) claims that synaesthesia is not what is at stake here.

Appendix: The world as seen through hue-inverting spectacles



The following slides contain normal photographs together with red-green and diagonal inversions.

Red-green inversion involves reflection in the vertical axis of the colour circle.

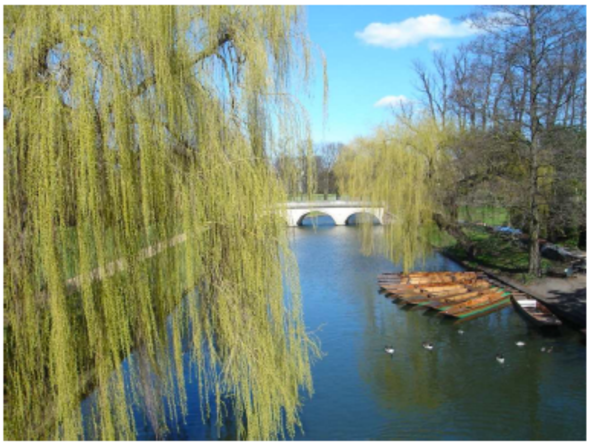
Diagonal inversion involves reflection in the dotted axis. Red is thus exchanged with yellow, and green with blue.

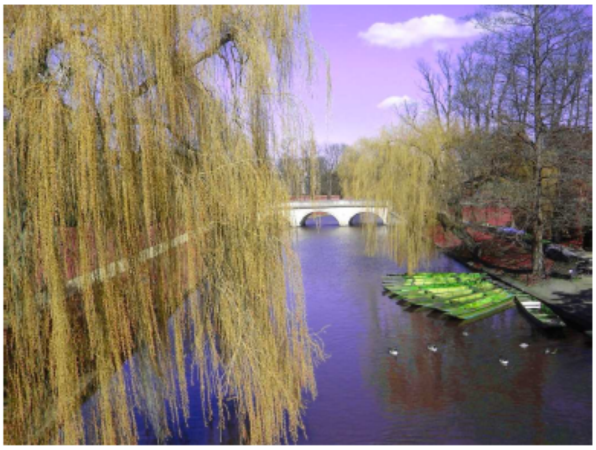
A Hawaiian sunset

Holy Island, Northumbria

Abbey at Lindisfarne, Northumbria

The Backs, Cambridge

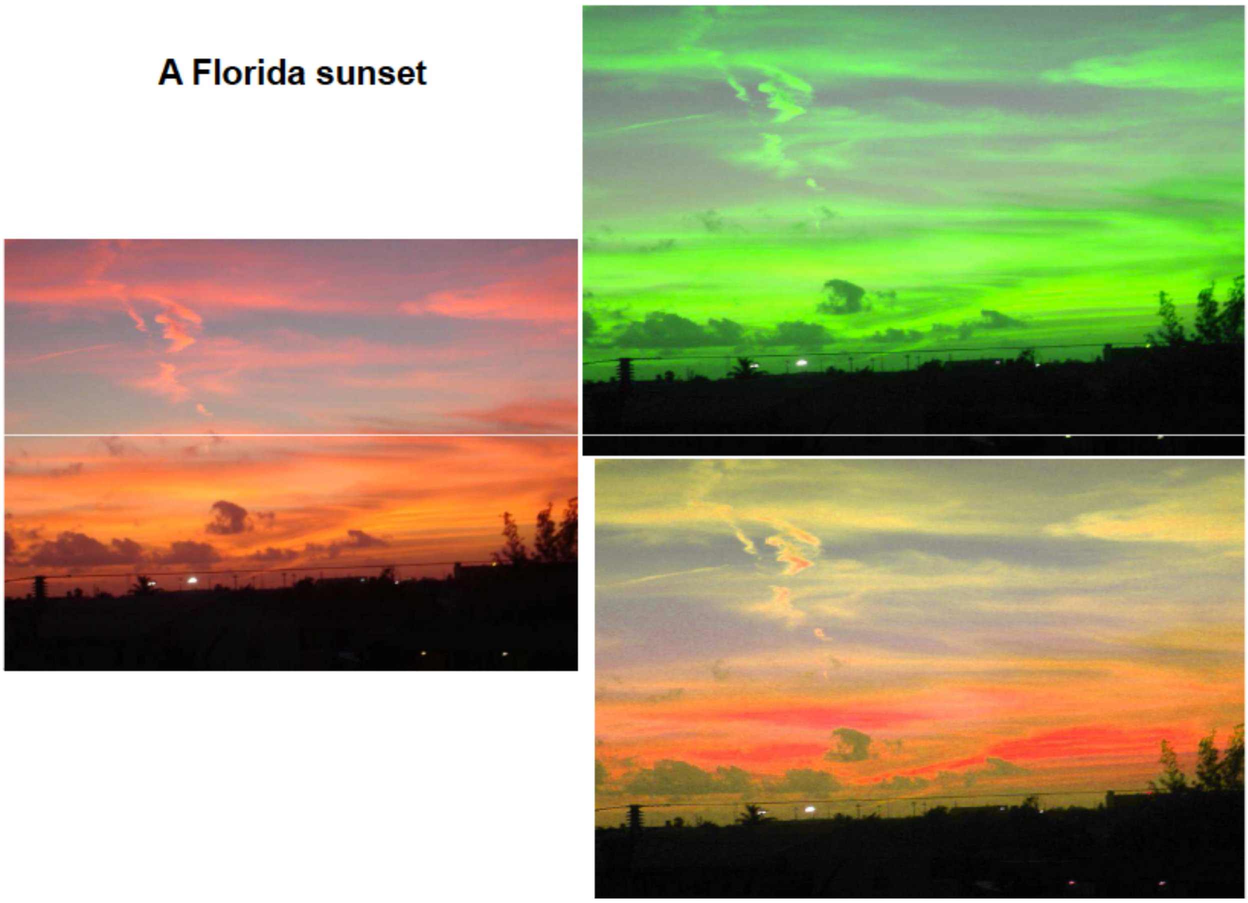




Rivington reservoir, Lancashire

A London street

A Florida sunset



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