Why Don't Synaesthetic Colours Adapt Away?

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Abstract: Synaesthetes persistently perceive certain stimuli as systematically accompanied by illusory colours, even though they know those colours to be illusory. This appears to contrast with cases where a subject's colour vision adapts to systematic distortions caused by wearing coloured goggles. Given that each case involves longstanding systematic distortion of colour perception that the subjects recognize as such, how can a theory of colour perception explain the fact that perceptual adaptation occurs in one case but not the other? I argue that these cases and the relationship between them can be made sense of in light of an existing view of colour perception. Understanding colours as ways in which objects and surfaces modify light, perceived through grasping patterns and variations in colour appearances, provides a framework from which the cases and their apparent disanalogy can be predicted and explained. This theory's ability to accommodate these cases constitutes further empirical evidence in its favour.

Keywords: Colour Perception; Enactivism; Perceptual Adaptation; Synaesthesia

1. Synaesthetic Sensations and Special Spectacles

Synaesthesia is a condition where some class of veridical perceptions is accompanied by sensations of another type. For example, colour-grapheme synaesthetes' visual perceptions of words or numbers are accompanied by colour sensations, or 'photisms'. In colour-phoneme, or coloured-hearing synaesthesia, photisms accompany the auditory perception of certain sounds. Just how these

photisms are experienced varies across different subjects and different varieties of synaesthesia. Some synaesthetes report experiencing a generic coloured shape, or a coloured visual image of the word or letter being seen or heard. Different synaesthetes describe their photisms as non-localised, overlaid upon or filling a visually presented letter, "bound to the sound" of an aurally presented one, or as located upon an invisible plane located at arms reach (Grossenbacher and Lovelace (2001))[1].

It is empirically well established that such sensations are genuine features of the experience of synaesthetes – subjects are not speaking metaphorically, or delusional, when they claim that they experience (for example) letters as accompanied by specific colours. For example, verbal description of, and matching behaviour with respect to, the photisms that accompany specific stimuli are almost completely consistent over time, in contrast to the poor performance of non-synaesthetic control groups[2]. But despite the fact that

[1] Part of my aim in this paper is to argue for a particular way of understanding synaesthetic colour experience in general. Given this variety in forms of such experience, one might wonder whether a general account is possible. However, as we will see, I attempt to account for synaesthetic experience in terms of general considerations concerning the relationship between apparent and objective properties in colour perception. This account could, as far as I can see, be applied equally to any of the forms of synaesthetic experience listed above. For simplicity's sake, however, my examples shall concern synaesthetic experiences roughly as of colours overlaid upon graphemes. 'Roughly' since, as as I will argue, the way synaesthetic colours figure in experience prevents them from having objective spatial purport. This eventual consequence of my account might be used to explain how and why some synaesthetes experience their photisms as non-localised. Thanks to an anonymous referee for prompting clarification here.

[2] Synaesthetes also exhibit priming and interference effects on perceptual tasks that support the hypothesis that they genuinely experience the illusory colours. There is also evidence that synaesthetic colours can contribute to pop-out effects that aid visual search. See Edquist et al (2006) for a useful review.

photisms are genuine and persisting features of synaesthetic experience, and experienced in perceptually familiar colours, synaesthetes do not mistake synaesthetic experiences for experiences of real, worldly colours. It seems they are automatically and implicitly aware that the synaesthetic colours with which aspects of their world are suffused are not a reflection of reality.

One of the many puzzling aspects of synaesthesia is its apparent disanalogy with a comparably exotic fact about colour perception. As part of a series of famous experiments on perceptual adaptation, Kohler (1964) claimed that subject's colour categorizations and experiences adapted over time to the distortions created by wearing two-toned spectacles. Subjects wore goggles with vertically-bisected lenses, each of which had a blue-tinted left half and a yellow-tinted right half. After several weeks of wearing the goggles whilst going about their daily business, subjects reported that the predictable disruption of colour perception caused by the goggles had faded away. For example, one subject reported that, by the 36th day of wearing the goggles "Even though a great variety of yellow and blue stimuli are transmitted by my spectacles and keep impinging on my fovea, I no longer experience the corresponding colour sensations," and that by the 46th day, "If I look first at the blue part and then at the yellow part of my visual field, the latter does not increase in intensity no matter how long I have looked at the former" (Kohler (1964), p.111-112).

The subjective reports of participants were borne out by a test requiring the subjects to adjust a colour wheel to a neutral shade of grey, using a button that varied the colour of the wheel between shades of blue, yellow, and neutral grey. The initial donning of the goggles predictably disrupted the subjects' abilities to perform this task, but after adaptation they could perform the task with similar

proficiency to their attempts before the goggles were donned (Ibid, p.106, 114). When the goggles were removed, subjects experienced the opposite sort of distortion in their colour perception to that which occurred when the goggles were first donned – in this case, the left half of the visual field was experienced as tinted yellow, and the right half as tinted blue. For example, after removing the goggles Kohler reported that "Whenever I open up a book, I am amazed to find that the left page looks yellow, and that it looks white with a bluish tinge as soon as I turn it over to the right," and that "When I take a walk, I am always conscious of a peculiar glare on my left, as if someone carrying a lighted candle were accompanying me; on my right, nothing of this kind occurs" (Ibid, p.115). Over time, this distortion also fades away, and subjects' colour perceptions return to normal[3].

There appears to be a puzzling tension between these two cases. In each case subjects' colour-experience of the world is accompanied by regular and predictable patterns of illusory colours[4], patterns which the subject knows are

[3] Bompas and O'Regan (2006) note that there has been some difficulty in replicating Kohler's results. However, the main study they cite in support of this claim (McCollough (1965) – the other study cited is an unpublished Master's thesis) confirms that the colour sensations caused by distorting goggles subjectively fade away over time, questioning only Kohler's claim that new dependencies of colour perception on eye-movement occur as after-effects of adaptation. Bompas and O'Regan (ibid.) succeeded in inducing such dependencies via a short period of conditioning without goggles. The fact that the distortions caused by the goggles adapt away over time is the most important aspect of Kohler's results for the case I make in this paper, and seems well established. In what follows I'll be taking the results that Kohler reports at face value.

[4] It's not quite right to label the colour appearances that characterise each case 'illusory'. Subjects wearing Kohler's goggles really are looking through tinted lenses, and seeing the world in just the way they should in light of this fact. A consequence of the position for which I'll argue in this paper (particularly in

not reliable guides to the real colours in their environments. However, in Kohler's cases, with exploration, habituation and time, the way things appear to be coloured falls into line with this knowledge. In contrast, synaesthetes continue to experience the same patterns of illusory colours throughout their life, despite the fact that they know them to be illusory, and display no inclination to think otherwise. How can a theory of colour perception account for both of these cases? I want to suggest that the apparent asymmetry between these cases can be elegantly predicted and explained by an existing theory of colour perception[5]. According to enactive views of perception endorsed by Susan Hurley and Alva Noë (among others), perception is a matter of grasping our relationship to our surroundings through understanding the interdependence between our unfolding sensory experience and our actual and potential bodily activity. Kohler's results appear to support such a view by showing that veridical perceptual experience returns as familiarity with the new patterns of dependence between movement and perception is achieved (Hurley (1998), Noë (2004)). However, synaesthetic colour experiences appear to provide a counterexample to the view – synaesthetes experience photisms with perceptually familiar colours

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section 3) is that synaesthetic sensations are not strictly 'illusory' in that they are not experiences that purport to be of how things are actually coloured, and so don't make a claim about colour properties that can be assessed as true or false. Both sorts of appearances are, however, 'illusory' in being unreliable guides to the way external things are really coloured. With these caveats in mind, I'll continue to describe the relevant colour appearances as illusory in what follows.

[5] One disanalogy between the two cases is that the causes of perceptual distortion are constantly present for the wearer of the goggles, but only present in certain contexts for the synaesthete. It might be thought that such a difference in reliable presence of perceptual distortion and its causes can explain the fact that adaptation occurs in the former case but not the latter. However, as we shall see in section 4, there are nuances in Kohler's data on perceptual adaptation which this hypothesis can't account for. Thanks to Conor McHugh for prompting clarification on this point.

whilst understanding that the experienced colour neither varies with their movement, nor directly bears on the ways they might engage with their perceptible environment (Hurley and Noë (2003, 2007), Gray (2003), Noë and Hurley (2003)). In what follows, I argue that an enactivist view of colour perception can explain both cases and their relationship. Synaesthetic colour experience and its puzzling relationship to Kohler's results are not a counterexample to enactivism about colour perception, but a novel source of empirical support for it.

2. Colours as Ways of Changing Light

An important reason for the longstanding philosophical intrigue surrounding colour and its perception is the way that colour seems uneasily poised between a subjective and an objective feature of the world. On the one hand, we think of colours as real properties of objects, obtaining out in the environment, independently of our perception of them. On the other, we know that mind-dependent phenomena such as after-images and, it seems, synaesthetic sensations can be perceptibly coloured, and that in many cases the way a thing appears to be coloured to a perceiver is an unreliable guide to any of its objective properties. Problems arise when theories of colour perception neglect either aspect of this duality. Accounts that attempt to index colour to some physically specifiable property of objects appear to do justice to the way that colours usually present themselves to perceivers as real and enduring properties of objects, but have trouble accommodating the fact that afterimages and synaesthetic sensations can appear perceptibly coloured without any external

object instantiating a candidate corresponding physical property[6]. Additionally, we can be made to perceive afterimages with impossible colours, such as supersaturated hues of orange, or impossibly dark shades of yellow, where constraints of physics preclude there being an object with reflectance properties that could stimulate our visual system in the ways required to perceive those colours[7]. Problems such as these can motivate subjectivist accounts of colour perception, according to which colours are appearances – ways things look to perceivers – that might somehow correlate with physical properties of objects, but are not to be identified with them. Focusing on appearances in this way allows such views to accommodate cases such as the afterimages mentioned above, but makes it difficult to accommodate the perceived objectivity of colour. When we see colours, it usually seems that we see not appearances, but enduring and objective properties of objects and surfaces, which can help us identify and keep track of them over time[8].

We can contrast objectivist and subjectivist accounts of colour perception, and the problems that face them, by considering what each of them says about the phenomenon of colour constancy. When I see, for example, a uniformly coloured cream wall in natural light, it displays patterns of light and shadow across its surface that we might describe as variations in the way its colour appears to us. But the wall also looks to be a single colour across its surface, lit and shaded in a certain way. Accounts of colour that focus on some objective property of the wall's surface can easily accommodate the perceived uniformity of the wall's colour, but struggle to account for the sense in which the lit and shaded portions

[6] See e.g. Byrne and Hilbert (2003) and the commentaries by Cohen, Decock and van Brakel, and Matthen.
[7] See Churchland (2005) for a fuller account of these colours and how they can be produced, complete with colour plates that let interested readers experience the relevant afterimages for themselves.
[8] See e.g. Cohen (2000), McLaughlin (2003) and the related discussion in Matthen (2005), ch. 11.

of the wall appear different. Accounts emphasizing subjective colour looks or appearances can account for those differences, but struggle to accommodate the natural sense in which we see the wall as uniformly coloured across its surface. A recent family of proposals (Broackes (1992, 2008), Noë (2004, 2008), Philipona and O'Regan (2006), Ward (2009)) suggests a natural way of doing justice to these two aspects of colour perception. An object or surface's colour is its property of modifying incident into reflected light in a certain regular way. We are able to perceive this property by understanding the way colour appearances systematically vary with lighting conditions. Put differently, we perceive objective colours by understanding the significance of the colour appearances presented to us for the way in which objects and surfaces in our environment modify light. So, the wall before me looks to be a uniform colour since I understand the significance of the patterns of light and shade across its surface for its constant way of modifying light. There is also a sense in which the lit portions of the wall appear different to its shaded portions with respect to their colour – the appearance of a portion of my cream wall in shadow might differ from the appearance of a portion in good light by being just the same as the appearance of a brown wall in good light. But my understanding of the significance of the patterns of light and shade upon the wall means that the shaded portion of the wall does not look to me as if it *is* brown – rather it looks to me like a cream wall in shadow.

Colour, on this view, is an objective property that we perceive by understanding patterns of colour appearances. We'll go some way towards fleshing out this claim in the following sections, by seeing how it provides a framework that accommodates the problem cases with which we began. But two brief points of clarification might be helpful. Firstly, how does such a view characterize the nature of the appearance properties to which it appeals – the properties we refer to when characterizing the sense in which the lit and shaded portions of the wall look different with respect to colour? The way a colour appears to a perceiver is

a function of its reflectance properties, the way it is illuminated, the perceiver's location relative to it and facts about her perceptual apparatus and current state of adaptation. The fact that properties of the perceiver and her relation to the coloured object are determinants of appearance properties secures a subjective aspect of colour perception. The presence of such a subjective aspect is compatible with various views about the way in which colour appearance properties and objective colour properties are related in experience. We might hold that colour appearances, as they figure in experience, are purely subjective properties – 'qualia' that are causally dependent upon, though logically independent of, the above facts about the coloured object and the perceiver's relation to it. Alternatively, we might hold that colour appearances figure in experience only as objectively specifiable properties of coloured objects and their current relationship to the perceiver, eschewing talk of non-representational qualia. On the first sort of view, the experiential difference between looking at the lit and shaded portions of the wall is due to a difference in qualia caused by objective properties of the wall, lighting conditions and perceiver. On the second sort of view the experiential difference is simply due to a difference in the objects of perception – a lit portion of wall in one case and a shaded portion in the other. The account in this section, and which follows, is intended to be neutral with respect to these two options[9].

The second point of clarification concerns the account's appeal to understanding. To perceive an object's colour, according to the view under

[9] For an instance of the first view, see Block (2007). For an instance of the second, see Schellenberg (2008). For what it's worth, my own sympathies lie with a view according to which apparent and objective properties must be defined interdependently – objective colour properties must be specified in terms of the patterns of appearances which make them up, whilst appearances must be specified in terms of the objective properties which they can help to disclose. See McDowell (2004) for a view with this structure. Noë (2008) is also suggestive of such a view. Unfortunately, spelling out and defending this view is beyond the scope of my task here. As just noted, the account of colour experience developed here is intended as compatible with each of these various possibilities.

consideration, it is not enough for there to simply *be* patterns of colour appearances for a perceiver as they survey and move around their environment. The perceiver must also understand the way in which the objective colour properties of her environment are revealed through those patterns. However, the exercise of such understanding doesn't require conscious thought or deliberation about colour on the part of the perceiver, or an ability to articulate the patterns and relationships that it concerns. When a painter uses paint that is almost yellow to depict a portion of a green book in bright sunlight and paint that is almost blue to depict its shaded part, they rely on our understanding of the ways in which green objects appear in different lighting conditions. It is this understanding that lets us see what they paint as a book with a certain shade of green, lit in a particular way, rather than as a book that is half yellow and half blue. But in order for us to see it in this way we do not need to think about appearance properties and their relations, or be able to articulate what it is about the way in which the book has been painted that lets us see it as green. The kind of understanding to which the view under consideration appeals consists just in this ability to see an object's true colour through the appearance properties it presents. Such understanding would be absent if a perceiver were to see the depicted book as differently coloured across its surface, or as changing colour when it was moved with respect to the light source[10].

The view of colour perception just sketched has much to recommend it. It can make sense of our tendencies to view objects from different angles and in different lighting conditions when trying to accurately perceive their colour, and the fact that colour-blind (and normal) perceivers make far fewer errors in colour

[10] Clearly there is much more of interest to be said about the sort of understanding to which I appeal here – in particular about its relation to more advanced, conceptual forms of understanding. However, this brief characterization suffices for our purposes here: making the view under consideration tolerably clear, and setting the stage for the account of synaesthesia and perceptual adaptation which follows.

perception when freely exploring their environment in daily life than they do when classifying samples in uniformly lit and artificially constrained laboratory conditions[11]. Identifying colours with functions of the way objects modify incident light into reflected light within certain parameters fixed by the limits of human colour vision yields accurate predictions of both the colours most likely to be given names across cultures and which hues will be judged to be 'unique' – unmixed with any other colour (Philipona and O'Regan (2006)). Lastly, it can accommodate the motivations for both objectivist and subjectivist approaches to colour, and the intuitive observation with which we began this section – that colour is a feature of the world poised between the objective and the subjective. Colours are objective properties of objects and surfaces, but the boundaries of those properties are located via reference to the range of wavelengths to which we are perceptually sensitive, and we perceive those properties by understanding their relationship to patterns of appearances. In the remainder of this paper, I want to suggest that this view also affords a promising account of the relationship between the two cases with which we began, and an answer to our titular question – why don't synaesthetic colours adapt away?

3. Why Synaesthetic Colours Don't Adapt Away

A more accurate but unwieldy title for this paper might have been 'Why don't synaesthetic colours adapt away, whilst the illusory colours caused by Kohler's goggles do?' – for we might think that the fact that synaesthetic colours don't adapt away only requires explanation when we note that systematic patterns of colour appearances that the perceiver recognizes to be illusory *do* adapt away in

[11] This observation and several other facts about colour perception that are elegantly explained by this view are nicely discussed in Broackes (1992). See also Myin (2001) and Broackes (2008) for arguments that the view shows inverted spectrum hypotheses to be wrongheaded.

other cases. Another question we might think relevant here is why synaesthetes never mistake the colours of their photisms for real colours, obtaining in the world. Whilst we might be puzzled about exactly *how* the illusory colours caused by Kohler's goggles adapt away, there is no mystery over *why* they do – the new patterns of colour appearance adapt away because they mess up the useful abilities of perceivers to tell what colours things are by looking at them. The colours that pervade the perceptual world of the synaesthete do not do this – synaesthetes perceive the true colours of objects and surfaces around them just as well as normal perceivers do[12]. In some sense, this serves to explain why synaesthetic colours don't adapt away – since those colours don't constitute a severe obstacle to veridical colour perception, no adaptation is required. Again, there only seems to be a puzzle in this neighbourhood when we view the synaesthetic case alongside Kohler's adaptation results. Even if we take the persistence of synaesthetic colours to be explained by perceivers' reliable abilities to distinguish them from real colours, we might still wonder what explains the disanalogy with Kohler's case. Why can't Kohler's subjects learn to live with their patterns of illusory colour looks as synaesthetes do? Why should a pattern of illusory looks disappear in one case, but not in another?[13] In this section I

[12] In the majority of situations - as noted above (n.1) synaesthetic colours can be made to help or hinder certain perception and classification tasks via stroop or priming effects in carefully controlled lab conditions. See Gray (2003) for a description of the Alien Colour Effect, where the colour-naming abilities of coloured-hearing synaesthetes are marginally slowed by incongruity between the colour to be named and the colour of the photism induced by real or imagined perception of the first phoneme in the colour's name. The presence of these small functional differences between the colour naming and classification behaviours of synaesthetes and non-synaesthetes is compatible with the point I am making here – that synaesthetes perceive objective colour properties sufficiently well that their lack of adaptation only looks puzzling when compared to Kohler's cases.

[13] Of course, there are important differences between the two sorts of case. For example, as an anonymous referee notes, Kohler's subjects are in the throes of coping with a new perceptual distortion, whereas adult synaesthetes have a lifetime of experience of their synaesthetic sensations. Perhaps, then,

want to suggest that the view of colour perception just sketched – as a matter of seeing an object or surface's way of modifying light through understanding the patterns of appearances it presents – allows us to make sense of these questions together.

That view of colour perception suggests that the peculiarity of each of our two cases lies in its pulling apart the subjective and objective aspects of colour perception. If perceiving colour is a matter of seeing how things modify light through understanding the appearances they present, then synaesthetic colour experiences suggest that colour appearances can be divorced from their usual role of indicating, as part of a larger pattern of colour looks, objective colour properties. Kohler's adaptation results show that perceptual grasp of objective colour properties can, given sufficient time, adapt to radical distortions in the usual patterns of looks underlying those properties. Thus, our account suggests, synaesthetic colours fail to adapt away because synaesthetes do not take them to be indicative of objective colour properties in the same way as standard subjective colour looks, since synaesthetic colour looks fail to figure in larger patterns of subjective looks or vary with changes in colour-critical conditions in the usual ways. Whilst aspects of the synaesthete's perceptual world are suffused with illusory colour appearances, the view of colour perception outlined in the previous section gives us reason to believe that seeing colour appearances and seeing coloured objects and surfaces are different matters.

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synaesthetic colours are experienced as distortive in infancy, or would be so experienced if suddenly induced in a mature perceiver. The account to be developed below is compatible with these possiblities – it aims to explain how synaesthetic colour appearances figure in the experience of mature perceivers in a way that does not compete with their perception of objective colour. In developing this view, we will achieve a clearer picture of the two cases and their relationship. The juxtaposition of the two cases here serves only to set the stage for an account which adequately explains them both.

According to that view, seeing objective colour properties is a matter of understanding patterns and regularities in the colour appearances presented to one. Perceivers understand facts about the relationships between the apparent colours they currently experience, about how such appearances might change given changes in viewing conditions, and about how such interrelations between patterns of appearances and viewing conditions bear on the distribution of objective colour properties in their perceptible environment. The colour appearances that accompany synaesthetic experiences are unusual in that they fail to figure in the kinds of patterns and relations through which perceivers see objective colours, and so do not bear in the usual way on how synaesthetes take things to be objectively coloured. When a synaesthete sees the appearance of a colour as overlaid upon a letter, or 'in their mind's eye', or as located upon a vertical plane in front of them, the understanding of relationships obtaining between colour appearances that characterizes perception of objective colours is inappropriate, and not exercised. Synaesthetic colours, on this view, are experienced as isolated colour appearances, and thus lack objective purport. This observation makes it intelligible why synaesthetic colour experiences do not interfere with normal colour vision, and thus why they don't need to adapt away. We noted above that the supposition that synaesthetic colours *should* adapt away gained plausibility from the assumption that synaesthesia involved some kind of systematic perceptual distortion that perceivers could learn to filter out, as in other cases of perceptual adaptation. But understanding synaesthetic experience in light of our view of colour perception lets us see that this assumption is misguided. Synaesthetic colour experience does not constitute a distorted perception of the way things in the environment are coloured, since the way in which synaesthetic colours figure in experience, floating free of the crucial patterns, relationships and regularities that usually obtain between colour

appearances, means that they are not presented to the subject as worldly colours at all. Thus, the special ways in which things appear to synaesthetes need not interfere with veridical perception of the way the world is, since seeing colour appearances and seeing worldly colours are very different perceptual achievements. The way the synaesthete sees things to be coloured does not need to adapt since that way is not properly described as distorted.

By contrast, adaptation to the distortion in the perception of objective colour properties caused by Kohler's goggles is advantageous for the perceiver, since the illusory colour appearances they introduce *do* constitute an obstacle to veridical perception of objective colours, as shown by the predictable disruption of the colour categorizations and judgements of Kohler's subjects. They do so by introducing a complex new set of relationships between apparent colours, viewing conditions and objective colour properties. Adaptation consists in the perceiver's acclimatizing to the new patterns of subjective looks that are now indicative of particular objective colour properties, and thus coming to see objective colour properties as distributed in the way they did before donning the goggles. Perceivers thus come to manifest an automatic perceptual grasp of a fact that they explicitly knew all along – that the aberrant looks caused by donning the goggles do not reflect the way objective colour properties are distributed. When the goggles are removed, they must relearn the old sets of relations between subjective appearances, viewing conditions and objective properties, and thus go through another period of perceptual distortion and eventual adaptation.

On the view being proposed, the relation between colour appearances and objective colours is akin to the relation between letters and words in a language

that we understand. You are able to take in the words on this page in virtue of your perceptual ability to discriminate various sorts of letters, coupled with your understanding of the way relationships between letters and the contexts within which they appear govern the way that they combine to form meaningful words. Similarly, you are able to see the colours of objects and surfaces in the world around you in virtue of your perceptual ability to discriminate various colour appearances, and your understanding of the way in which the relationships between, and the contexts of, such appearances bear on the way things are objectively coloured. Note that this view does not imply that we experience only apparent colours, then go on to infer facts about objective colours on that basis. It would be implausible, I think, to suggest that when reading your experience is first and foremost of the letters on this page, with the words the letters make up inferred by you as a result. Rather, your experience is directed straight at the words. But holding this is surely compatible with holding that we can only see the words in virtue of abilities to see letters and understand the ways in which they combine to make words. In a certain sense, exercise of such abilities is just what is involved in directly experiencing words. Similarly, on the view being proposed, we directly experience objective colours – we have just given a certain story about what such direct experience amounts to, and how it is possible[14].

[14] Noë (2004, 2008, 2009) also uses this example to shed light on the relationship between apparent and objective properties in perception, and the role played for the perceiver by sensorimotor understanding. As noted above, I offer the account of colour experience developed here as an elaboration of his enactive view. Note that the above does not imply that letters or apparent colours cannot be direct objects of experience. If you like, it's possible (though, I think, surprisingly difficult) to focus only upon the letters on this page, bracketing their significance as constituents of words. But this is certainly not how we usually look at things. Similarly, it's possible (though difficult) to focus on the ways in which the lit and shaded portions of my wall appear different, bracketing the fact that they are both aspects of the wall's one true colour. Again, it seems clear that this is not the way apparent colours usually figure in our experience.

According to our analogy, attempting to perceive colours through the distorting lenses of the goggles is like attempting to read words in a language you understand that have been written in a particular kind of code. Familiar letters make up the words, but the way those letters combine to stand for sounds and words has changed. Adaptation here would consist in gaining an understanding of the new way in which familiar letters stand for familiar sounds and words. Matters are complicated with Kohler's goggles, though, by the fact that the ways in which patterns of appearances signal colour properties depend on the portion of the goggles through which things are currently seen. Adaptation to the distortions caused by the goggles thus consists in coming to understand a complex new set of relations between head and eye positions, colour appearances, and objective colours. Pursuing our analogy, this would be akin to learning to read familiar words, written in familiar characters, but in a code where the way those characters correspond to sounds and words varies systematically with the way in which the perceiver views them. Kohler's demonstrations of adaptation suggest that, in the case of colour perception, understanding of such complex sets of novel relationships can, over time, become automatic and unthinking, allowing direct perception of the objective colour properties responsible for the new patterns of appearance. After adaptation, when the goggles are removed, perceivers' understanding of the new ways in which appearances convey information about objective colour properties is no longer appropriate, and results in a complementary set of systematic distortions in colour perception to those which occurred when the goggles were first donned. These distortions also fade away over time, as perceivers once again come to manifest their old understanding of the standard ways in which objective colours are revealed through apparent ones.

Now, consider a perceiver who was somehow hardwired so that their perceptions of certain objective colours were systematically accompanied by

visual sensations as of certain letters[15]. In such a case, the illusory letters have been wrested from their usual roles as embedded constituents of words. We would not expect colours to have unusual semantic significances for such a perceiver, since letters only contribute to the perception of semantic properties when they figure as constituents of words in a language which the perceiver understands. Our perceiver might still see the illusory letters as the sorts of things that are potential constituents of meaningful words. But we would not expect the accompaniment of her colour perception by a series of isolated illusory letters to result in her perception of the world as having an extra layer of semantic significance. Likewise, when a synaesthete perceives a printed letter as accompanied by the appearance of a particular colour, we need not expect this appearance to inform or compete with their perception of the letter's true colour since we have good reason to think that perceiving colour appearances and perceiving objective colours are different matters. Colour appearances convey information about objective colour properties in just the same way that letters convey information about semantic properties – by occurring as constituents of patterns that perceivers view with the right sort of understanding. Synaesthetic colours do not figure in such patterns, and so aren't perceived as having purport for the way in which things are objectively coloured. And, as we've noted, recognizing this distinction between apparent and objective colour removes the motivation for supposing that they should adapt away.

So, why don't synaesthetic colours adapt away? Because there's little reason why they should[16]. There's little reason why they should because the unusual

[15] Such a perceiver would, of course, be the opposite of a colour-grapheme synaesthete. To my knowledge, no cases of this kind exist.

[16] Little rather than none since, as noted above, synaesthetic colours can cause small impairments in colour naming and categorisation in certain circumstances. Once we see that synaesthetic colour experience can happily coexist with veridical perception of objective colours in the way outlined above there is little temptation to suppose (or so it seems to me) that such small impairments could

way in which they figure in the experience of synaesthetes is such as to automatically distinguish them from experiences of real, worldly colour. Synaesthetic and worldly colours are no more in competition in the experience of a synaesthete than are your visual experiences of the words and letters on this page. Before proceeding, two clarifications might be helpful. First, as noted above (fn. 13), this view is compatible with the possiblity that synaesthetic infants and children experience the colours of their photisms in a way that competes with their experience of objective colour, with their synaesthetic experiences only acquiring the benign character outlined above with learning and habituation. Whether or not this is so depends on whether perceivers' understanding of how patterns of colour appearances disclose objective colour properties is innate, or achieved at least in part through habituation and exploration. The view developed here is neutral on this issue (though Kohler's results show that such understanding can adapt and evolve when required to). I aim only to show how the synaesthetic colour experiences of mature perceivers, however they are arrived at, need not compete with their experience of objective colour. Second, this view is compatible with there being illuminating neuroscientific explanations of why synaesthetic colour experiences fail to adapt away. For example, Hurley and Noë (2003) moot that the V4/ V8 activity that accompanies auditory perception in coloured-hearing synaesthesia could not adapt away or come to subserve only auditory phenomenology on pain of disrupting the veridical visual perception subserved by the same brain area. The view developed here is compatible with this suggestion, complementing it with an explanation of why the synaesthetic colour experiences do not compete with

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constitute a sufficient pressure toward adaptation. Non-synaesthetes can be made to exhibit analogous impairments in naming and categorisation as a result of stroop effects (as when identifying the colour of the word 'green' typed in red ink), but since semantic and chromatic properties usually coexist happily in perception we need not assume that such cases constitute a pressure toward either semantic or chromatic perception adapting away.

veridical colour perception.[17] Our work here, however, is not yet done. Attentive readers might have noticed that something in this section's treatment of Kohler's adaptation results does not quite add up. Before we can be satisfied with our diagnosis of synaesthetic sensations, we must address the fact that philosophical discussions of Kohler's results thus far, including our own, have suppressed certain subtleties.

4. Special Spectacles Reassessed

The last section made the case that synaesthetic colour appearances and veridical colour perception can coexist. Once we appreciate the different way that colour appearances and objective colour properties figure in experience, we can see that experiences of synaesthetic and veridical colours need not get in each other's way. It was also suggested that adaptation to Kohler's coloured goggles consists in coming to understand the new way in which objective colours are revealed through patterns of apparent colours that vary according to head and eye position. But this account of adaptation seems to imply an account of the adapting subject's phenomenology at odds with both our description in section one, and existing discussions of these results in the philosophical literature. Standardly, interpreters of Kohler's results speak as if colour vision returns entirely to normal over the course of adaptation (Hurley (1998), Myin (2001), Pettit (2003), Hurley and Noë (2006)), and whilst we have not explicitly endorsed this assumption in our discussion of these results, neither have we questioned it. However, since our account claims that adaptation consists in learning to see the way objects modify light *through* the aberrant patterns of colour looks introduced by the goggles, shouldn't we expect subjects in the experiment to report that

[17] My thanks to an anonymous referee for prompting both these clarifications.

objective colour properties appear to be distributed as they did before the goggles were donned, whilst the patterns of colour looks presented by the world through the goggles remain distorted? Our account of synaesthetic experiences suggests that veridical perception of objective colour can coexist with illusory perception of colour appearances. It seems, then, that the natural prediction of the account developed in the last section should be not that the colour experiences of the adapting subject return completely to normal, but that their experiences of objective colour properties adapt, whilst the illusory colour appearances caused by the goggles remain.

Does this prediction – that objects appear to be veridically coloured whilst the subject's colour sensations remain distorted – even make sense? Is there any evidence in its favour in Kohler's reports? In fact, strange as our prediction may sound, it appears to square very well with how subjects describe their experiences of adaptation. For example, even after 60 days, at the height of his adaptation, and whilst reporting that objects appear veridically coloured, Kohler says that:

> "The distracting effect which the spectacles had in the beginning is completely gone now. Now I actually feel comforted by the sight of a table which looks blue on one side and yellow on the other. I am so used to it that I would get upset if it were otherwise…" (Kohler (1964), p.113)

This suggests that whilst he perceives objects to be coloured as they were before he donned the spectacles, a focus on the way things subjectively appear to him – on patterns of colour looks or appearances – reveals that the illusory appearances caused by the spectacles are still present. Similarly, twenty days after the

spectacles had been removed (with full re-adaptation occurring after thirty days), Kohler reports:

> 'I have become totally immune to the distracting influence of all these novel impressions. I can now work for hours on end without being the least bit inconvenienced by this great variety of discolourations. However, I am still aware that they are there.' (Ibid. p.115)

This again suggests that adaptation consists in learning to see objective colour properties *through* the distortions in colour appearances that have been put in place, not in an alteration of those appearances themselves. These kinds of reports are just what we would expect were the view defended in the previous section correct.

We also noted in section 1 that subjective reports of perceptual adaptation are supported by improved performance at a task where the subject must manually adjust the hue displayed by a colour wheel until it contains no traces of blue or yellow. However, we did not mention there that subjects' performance at this task improves by only fifty percent, a finding apparently at odds with their reports about the extent of their adaptation[18]. But, if our diagnosis of Kohler's case is correct, this too is just as it should be. This is because it seems that such a matching task probes the subject's experience of *both* apparent and objective colour. To see this, consider what we know about apparent colour on the basis

[18] "A blue of one half its initial intensity on the colour wheel was sufficient to compensate for the yellow of the spectacles, and the blue of the spectacles was judged to be completely equal to gray – in other words, the subject no longer perceived it as colour." (Ibid. p.114) This fact is also neglected in existing philosophical discussions of Kohler's results.

of our characterization thus far. Apparent colour, on our account, is that through which objective colour is revealed. Whilst apparent colours are unreliable guides to objective colour properties when taken in isolation, understanding patterns of such appearances and how they might vary with lighting and other conditions lets a perceiver see the objective colours of objects and surfaces – their constant ways of modifying incident into reflected light. We know that apparent colour can vary according to the background against which a colour is viewed (the same patch will look lighter against a black background than it does against a white one), according to lighting conditions (the same patch will appear differently in bright sunlight, artificial light, and dusk) and the state of adaptation of the perceiver (everything appears darker when we first come indoors from bright sunlight), and that all these parameters can vary whilst a subject's perception of objective colour remains unchanged. Probing a subject's discriminatory capacities with regard to apparent colour will thus involve holding all these factors constant as best we can. By contrast, we should let those factors vary if we are interested in obtaining a measure of the objective colour properties a perceiver can discriminate[19]. Kohler's matching task consists in a stationary perceiver categorizing single colour patches, presented against a uniform background, under fixed lighting conditions. Our view thus predicts a discrepancy between the accuracy of subjects' colour discriminations in these

[19] Recall the observation from Broackes (1992) about colour-blind perceivers, mentioned in section 2, above. Their colour discrimination is markedly better in free vision than in constrained laboratory settings, suggesting that the impairment in their ability to perceive objective colours is less severe than the impairment in their ability to perceive apparent colours.

circumstances and the discriminations they make whilst freely exploring a naturally lit environment. And such a discrepancy is just what Kohler found[20].

These important nuances in Kohler's findings, so far neglected in existing philosophical work on those results, are thus predicted and explained by the theory we have been developing. If perceiving colour consists in coming to understand how colour appearances presented in a particular context signify objective colour properties, Kohler's results are exactly what we should expect.

5. Conclusion

Perceiving colour, according to the view we have been considering, involves grasping how objective colour properties are revealed through patterns of colour appearances. Perception of worldly colour is perception of an objective property – the way an object or surface modifies light. But we lock onto this property in perception via an understanding of appearance properties – properties determined by facts about our current perceptual relationship with our environment, such as our current state of adaptation and location with respect to objects and light sources. Colour perception thus has a subjective and an objective aspect. We see objective properties by understanding how we, as perceiving subjects, are related to our environment. If this view were correct, we

[20] Kohler (Ibid. p.45) explicitly notes the discrepancy between subjects' reports of adaptation and their abilities in the discrimination task, but offers no explanation of it. A consequence of our view here is that we should expect tests of adaptation to differ in their results according to the extent to which they hold the parameters that fix appearance properties constant, and that the measures suggesting greatest adaptation will be those most closely approximating free vision.

might expect to find cases where such understanding can be mistaken or manipulated, or where the subjective and objective aspects of colour perception come apart. I have suggested that we should understand synaesthetic colour experience, Kohler's adaptation results, and the relations between them in just these terms. The colour-grapheme synaesthete sees the letters on this page as systematically accompanied by illusory appearances of colour. But as skilled perceivers of colour they also implicitly understand that colour appearances disclose objective colour properties only by figuring as constituents in patterns of appearances that evolve and change in ways that reflect changing relations between perceivers, objects and light sources. Synaesthetic colour appearances don't figure in such patterns, and so don't present themselves as carrying information about the colours of objects and surfaces in the synaesthete's environment. This, I suggested, explains why synaesthetes don't mistake their photisms for worldly colours, and thus why there's no need for synaesthetic colours to adapt away.

How things appear with respect to colour is also systematically distorted for the wearer of Kohler's coloured goggles. The goggles introduce a new determinant of the way things appear to the perceiver with respect to colour – the part of the coloured lenses of the goggles the perceiver is currently looking through. But the ways objects are coloured – the ways in which they modify light – remain constant. Adaptation consists in regaining a perceptual grasp of this fact, and this is made possible by the fact that objects reveal their surface colours through patterns of appearances in an invariant way once the goggles are donned. This way differs from the way in which colours are revealed through patterns of appearances without the goggles, since gaze direction is now a partial determinant of appearances and the ways in which those appearances vary. We

thus have an account of colour perception that lets us see why one sort of perceptual distortion adapts away whilst the other does not. In the previous section, we noted that our view implies an account of Kohler's adaptation results at odds with that which we find in existing discussions, which suggest that the colour experiences of adaptees return completely to normal. Our view instead suggests that the way things appear with respect to colour for Kohler's subjects will continue to differ from normal perceivers – as we might expect, given that they continue to view the world through tinted spectacles. But, our account suggests, this need not prevent the way they experience objects as being coloured from adapting. This unorthodox view of the perceptual experience of adaptees is borne out well by a closer look at the reports of Kohler's subjects.

We thus have an account that predicts and explains both nuances in Kohler's results that existing discussions ignore, and the apparent disanalogy between Kohler's cases and synaesthetic colour experience. Seeing an object's colour consists in understanding the significance of patterns of colour appearances for the way it modifies light. It is in light of this view, I have suggested, that we can arrive at a proper understanding of these cases and their significance for our thinking about colour and perception.

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