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ORIGINAL RESEARCH

A Study in brown

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Abstract
Philosophers rarely write in an extended way about particular colors. So, why write about brown? We shall see that an investigation of brown unsettles some established ideas about color in significant ways. In particular, I will (i) explore reasons for thinking that brown is an elementary color, (ii) reassess attitudes in color science that are taken to rule that possibility out, and (iii) present a new reason for rejecting most forms of color realism.

Keywords Perception · Vision · Color

1 Introduction

Ordinarily, the experience of brown is understood as an experience of "blackened orange" (Hardin, 1993, p. 141) or "a kind of darkened yellow". (Westphal, 1982, p. 420) But now and then it has been observed that brown doesn't really look like a version of orange or yellow at all. Comparing brown to other dark chromatic colors (such as dark blue, dark green, and so on), R. M. Boynton noted: "[o]f these brown is certainly the most surprising because it ceases almost entirely to resemble the original bright color". (Boynton, 1975, p. 316) C. A. Padgham and John Saunders write, "[w]e can … describe … [browns] as low luminance orange-yellows but they certainly do not look like this." (Padgham & Saunders, 1975, p. 143.) C. L. Hardin observes, "the perceptual difference between 'standard' yellow or orange and their blackened counterparts is striking." (Hardin, 1993, p. 141)[1] The HSL diagram (Fig. 1) gives a

[1] Hering instead found that it is the "blackness" in brown that is difficult to discern: "the distinguishing feature of brown, namely, its blackness, never shows up clearly as an independent quality added to the yellow hue" (Hering, 1964, p. 58) I put Hering's unusual observation aside here.

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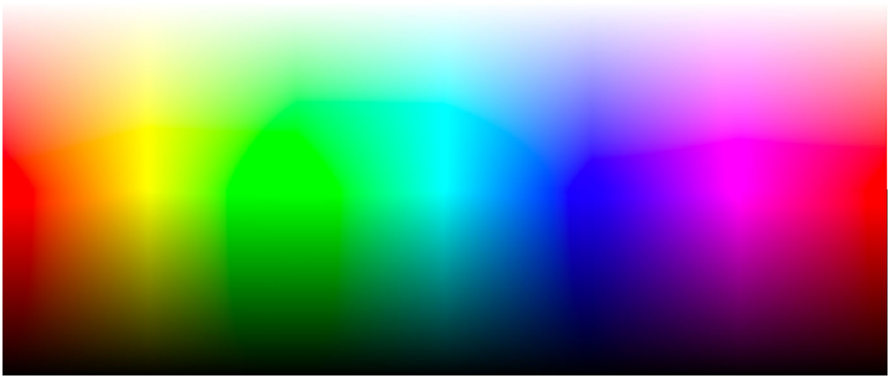

Fig. 1 HSL (Hue, Saturation, Lightness) diagram

sense of what these writers mean.[2] Look along the bottom, just above where it fades to black. The colors of the spectrum are all present and correct, but in dark versions. But some viewers, at least, will note an exception. Before the columns of orange, and perhaps yellow, fade to black, they first blend into another color: a diaphanous blur of brown. As Boynton and Hardin say, the other colors do not seem to change in this way. They just become darker, or blacker, as they move towards the black band. The brown blends into the other colors around it: red, orange, yellow, black, and maybe even green. It is difficult to see exactly its bounds. But to some observers it will remain a rather different kind of color to those dark hues to its left and right: a resolutely brown smudge on the rainbow of the spectrum, that resists attempts to see it as just a version of orange or yellow.

My position is that brown is not a version of orange or yellow. Rather, it is an "elementary" color in its own right. The colors usually regarded as elementary – defined as red, green, yellow, blue, black and white by Ewald Hering (1964) are those that cannot be understood as mixtures of other colors. I linger over what is meant by "mixture" here, as it is a crucial concept in this context. It is not the *physical* mixture of colors – either subtractive mixture (as in mixing paints) or additive mixture (as in the mixture of colored lights. Rather, it is what I call *phenomenal* mixture. A phenomenal mixture of two colors is just a matter of one color being comprised of two different colors in our visual experience. For example, bluish green is a phenomenal mixture of blue and green: it appears both bluish and greenish. Phenomenal mixture does not necessarily accord with either subtractive or additive physical mixture. For example, a bluish green can be achieved using paints by mixing a little yellow with blue. But the resultant subtractive mixture doesn't appear to us at all yellowish; rather, it will appear greenish. Equally, an additive mixture of red and green, produced with overlapping colored lights, yields yellow. But that yellow does not necessarily appear to us at all reddish or greenish.

[2] The HSL diagram is an arrangement of colors by hue, saturation, and lightness (hence, HSL). The chromatic colors are arranged from left to right. About halfway up, they appear fully saturated. Above this line they appear lighter, fading to white at the top, and below it they appear darker, fading to black at the bottom.

The elementary colors are those that are not phenomenal mixtures of other colors. All other colors can be understood as phenomenal mixtures of the elementary colors. This paper considers whether *brown* should also be understood as an elementary color. Like Hering's elementary colors, I argue that brown cannot be understood as a phenomenal mixture of other colors, though it is (like Hering's elementary colors) often experienced as mixed or tinted with other colors (yellow, orange, red, and black, as we have seen in the HSL diagram).

Sections 1, 2 and 3 unpack what I call the standard view of brown, indicated above by Hardin and Westphal. Section 3 collects and examines evidence supporting my claim that brown is an elementary color. Section 4 addresses an obstacle to my claim: the opponent process theory. The opponent process theory constrains color experience so that the only elementary colors allowed are the six specified by Hering, ruling out the possibility that brown is elementary. We shall see that recent developments in vision science suggest that color is encoded in a different way deeper within the visual system, and this opens up the possibility of more elementary colors than Hering allowed for. Finally, Sect. 5 shows that the brown being an elementary color poses a significant challenge for color realism, and so should push us to consider other views.

2 The standard view: brown's purported "darkened" quality

The standard view takes the experience of brown to be a phenomenal mixture of other colors. As I have said, Hering held that our experiences of all chromatic colors can be understood as either experiences of one of four elementary chromatic colors: red, yellow, green and blue, or (much more often) a phenomenal mixture of these.[3] It is in this context that brown is understood as a "blackened orange" or "a kind of darkened yellow", to repeat Hardin's and Westphal's formulations.[4] Orange here is understood as a phenomenal mixture of yellow and red, and "darkened" or "blackened" indicates a phenomenal mixture with black. (I will say more about this shortly, since the process of darkening or blackening a color is different from that of achieving other phenomenal mixtures.) So, in Hering's strict terms, brown is a phenomenal mixture of either (1) yellow and black, or (2) of yellow, red and black. The remainder of this section looks at what is meant by brown's supposed "black", "blackened" or "darkened" quality, and Sect. 3 examines at its supposed yellow or orange quality.

What does it mean to say that brown has a "black" component, or is "blackened" or "darkened"? It does not mean *dark*, for while browns are often dark, they need not be. Tan and fawn are lighter brown colors, and beige can be a very pale color.

I begin with a curious fact that drew Wittgenstein's attention. In his *Remarks on Color*, Wittgenstein asks: "Why is there no brown … light?" (Wittgenstein, 1977, pp. 3–215)[5] If we take it that Wittgenstein is implying that there are no brown lights, the observation is not quite correct, or not quite correctly expressed – but I come to

[3] Hering also placed constraints on how the elementary colors can be mixed, but these are not relevant in this context.

[4] Westphal seems also to echo Wittgenstein's characterization of brown. (Wittgenstein, 1977, pp. 3–62).

[5] Wittgenstein draws his observation of the non-existence of brown light from Philipp Otto Runge's letter to Goethe. (Goethe, 1810).

that shortly. First, note that "light" here can have two meanings: it can be a light cast on a surface (e.g., a torch's beam, or patch of sunlight), or it can be a luminous body (e.g., a glowing filament in a bulb, or a star). I mostly focus on the first kind of light below. Richard Feynman, in his broad-ranging introductory lectures on physics, makes much the same point as Wittgenstein: "one never sees a spotlight with brown light" (Feynman et al., 2013, vol. 1, lecture 35, §3). Shining a white light through a colored film or glass, so that the resultant light is cast onto a white screen, is an effective way of making a spot of light colored with any of the spectral colors. But it does not work with brown. Cast onto a white screen, the light transmitted through the brown glass or film instead appears orange. (ibid.) As I mentioned, Wittgenstein's implied point that there is no brown light is not quite right: projected light can appear brown in certain circumstances. The images of analogue color film, for example, are projected light, and they often include areas that appear brown. Without that, they would not be able to depict things as brown, which of course they readily do. (If examples are needed, consider Katharine Hepburn's hair (as it appears in color films), Indiana Jones's hat, or the chestnut brown horse in *National Velvet*).

How can the apparent impossibility of a spotlight casting brown light be reconciled with the presence of brown light in film? The answer can be found in the fact that we can, in a sense, create a brown spotlight: take an orange spotlight and engineer a brighter light so that it creates a bright white halo on the screen around the orange spot. The orange will then appear brown. Feynman describes this demonstration:

> [M]erely increase the brightness of the annular background against which we see the very same [orange] light, and we see that that is, in fact, what we call brown! Brown is always a dark color next to a lighter background. (ibid.)

Even bright, saturated oranges and yellows can be turned into a deep chocolate brown in this way, with a bright enough surround. The reverse of this transformation – turning brown into orange or yellow – can be achieved in the opposite way. Isolate areas of brown in a film projection, so that they are surrounded with darkness rather than light, and they lose their brown color and become orange or yellow. So, as Feynman says, brown is unusual among colors in that it depends on the colors surrounding it for its identity: it must be surrounded by colors lighter than itself for it to appear as brown.[6]

[6] This, we shall see in Sect. 5, is not quite right. Michael Tye is also sceptical of Feynman's claim, although for reasons that I do not find compelling:

> Brown normally is experienced where there is contrast, but it seems to me false to assert unequivocally that one cannot experience brown without an appropriate contrast. Consider, for example, the case in which one is surrounded by a light brown fog. Of course, in such a Ganzfeld, the brown will "wash out" of one's phenomenal field very quickly. But then the same is true for colors such as red and blue. So, while much is puzzling about the nature of the color brown, nothing in the objection we are considering should lead us to deny that soil and shoes, for example, are ever really brown. (Tye, 2000, p. 158.).

Brian McLaughlin rightly corrects this line of argument: "Tye is misled here by his visual imagination. There are no visual perceptions (as) of only light brown fog." (McLaughlin, 2003a, p. 119, n. 50.) Those who have spent time in dense dust-storms know that brown dust produces an orange effect once the dust envelops you (an effect strikingly captured in many YouTube videos).

This allows us to understand why brown is often a dark color, but can be light. Darker colors are more often seen against relatively lighter backgrounds. But, as is the case with beige, pale colors can be subject to this "browning" effect too. Seen against a white or otherwise relatively bright background, they can appear brownish. However, replaced with a dark ground, the beige would turn into a very pale yellow or orange.

We can also see now what Westphal means by brown being a "darkened" color: it is "dark relative to the brightness of the surrounding field." (Westphal, 1982, p. 419) These are the conditions needed for a color that would otherwise appear orange or yellow to appear brown. In the context of the standard view, being "blackened", or being "blackish" (phenomenally mixed with black) are also synonymous with being "darkened." One may wonder, why call brown "blackened" or "blackish" rather than merely "darkened"? That is because for proponents of the standard view, brown must appear at least slightly blackish – that is what being darkened looks like. It is also related to the fact that the condition required to turn yellow or orange into brown, turns neutral colors black. (Hardin, 1993, pp. 24–25) For example, many computer screens, at their darkest, are only ever grey. However, if you are reading this text on screen, it will probably appear black to you. That is due to the contrast with the bright light around the text. So, some of these greys (such as text) appear black when there is bright light around them.) The fact that this kind of contrast turns a neutral grey into black suggests to those holding the standard view that this blackening occurs in the same way in the case of chromatic colors too – which is to say, that all colors subjected to such contrast will appear as blackish, and that the transformation of orange and yellow to brown is properly understood as simply being the phenomenal mixture of these hues with black.[7]

3 The standard view: brown's purported yellowness or orangeness

The standard view holds that brown is a phenomenal mixture of either (1) yellow and black, or (2) orange and black (which is to say yellow, red and black, accepting Hering's account of orange as a yellow–red color). It should be said right away that there is

[7] Some notes on how the claim that "there is no brown light" applies in the case of luminous bodies: If one looks at brown glass or film in a spotlight, so the source of light is seen through the glass or film, the source of light will appear yellow or orange. Wittgenstein was mindful that his claim applied to luminous bodies in this way: "'Brown light'. Suppose someone were to suggest that a traffic light be *brown*." (Wittgenstein, 1977, 3-65). His implication that luminous bodies never appear brown also needs finessing, since there are exceptions. For example, parts of a computer screen can appear brown (as will be obvious from images in this paper, when viewed on screen). What is the right way to put Wittgenstein's point, then? I suspect it is as follows: luminous bodies never appear both luminous *and* brown.Wittgenstein's remark also provides a nice pretext to debunk a famous haunting: the Brown Lady of Raynham Hall. The ghost is said to be pictured in a well-known photograph published in 1936 in *Country Life*. The photograph, which is black and white, appears to show a luminous figure descending the stairs of the country house. The debunking proceeds as follows:1. *The Brown Lady, if she exists, appears luminous*. The *Country Life* photograph, which shows a glowing apparition, confirms this. (Ghosts, it may be added, are usually said to glow: "If a ghost appeared to me during the night, it could glow with a weak whitish light". (Wittgenstein, 1977, 3-231)).2. *The Brown Lady, if she exists, appears brown*. Otherwise, how could she have come to be known as the Brown Lady?3. *However, bodies can never appear both luminous and brown.*4. *Therefore, the Brown Lady cannot exist.*

something curious about the fact that there are two versions of the standard view, and I will make more of this in the following section. Here, I lay out the reasons proponents give for supporting one view or another. These reasons are of two types. First are accounts which justify it in terms of the way a brown appearance is generated, and second are direct reports of phenomenology. The two reasons tend to work together, and are not always clearly distinguished.

One writer who does clearly distinguish them is Westphal. Westphal sees brown as a phenomenal mixture of yellow and black. We have already seen how the "blackening" influence of the contrast needed to create brown can suggest it is right to see brown as being a blackish color. Westphal's first reason for understanding brown as a kind of yellow is shaped in a similar way. Here he draws on Helmholtz, who gave an account of "making the homogenous golden yellow of the spectrum look brown." (Helmholtz, 1924–25, vol. 2, p. 131). This was achieved by a now familiar process: surrounding the area of yellow with a bright white light. Westphal describes his "definition" of brown as "based on" Helmholtz's experiments. (Westphal, 1982, p. 417) Thus, for Westphal, "[b]rown is yellow of low luminosity" relative to its surrounds and that is how it appears – as a darkened yellow. (Westphal, 1982, p. 420, drawing on the wording of Helmholtz, 1924–25, vol. 2, p. 130) That brings Westphal to the second reason for supporting the "yellow" version of the standard view – that brown seems yellow to him: "to me, brown does *not* cease to resemble the original color in *hue*." (Westphal, 1982, pp. 428–429, original italics).

The second version of the standard view, the "orange" version, holds that brown is a phenomenal mixture of orange and black. If one can judge from discussion of brown on the internet, it is much more common now to see brown as a kind of orange, than yellow. For example, in response to a question on Quora, "Is brown a dark orange, a dark yellow, or its own color?", most replies, made by a variety of interested amateurs, declare it dark orange. (We have seen that "darkened" is preferable, but I put that aside here.) The color scientist Stephen Westland weighs in, agreeing with them: "brown and orange are the same hue and therefore brown is dark orange." (https://www.quora.com/Is-brown-a-dark-orange-a-dark-yellow-or-its-own-color-Simple-answers-please, 6 September 2020).[8]

Here, the phenomenological reasons run together with reasons based on various methods of how to make brown. There is a widespread sense among the commenters that the orangeness of brown is phenomenologically obvious. But at the same time, explanations are given for its orangeness in terms of how brown is made. Color mixture with paints is cited: mixing orange with black produces brown (and, indeed, yellow paint tends to turn greenish when mixed with black). Another mentions Feynman's

[8] I am unsure what Westland's reasoning is here. Much depends on what he means by "hue". It may simply be a term used in analysing the experience of brown (i.e., the experience of its chromatic component). If he means (in the case of an opaque surface) reflecting wavelengths of light at around 600 nm (which is to say, what we usually think of as orange), many browns do have this reflectance property. But, as Helmholtz's experiment shows, browns can also reflect wavelengths of light around 580 nm (which is to say, what we usually think of as yellow).

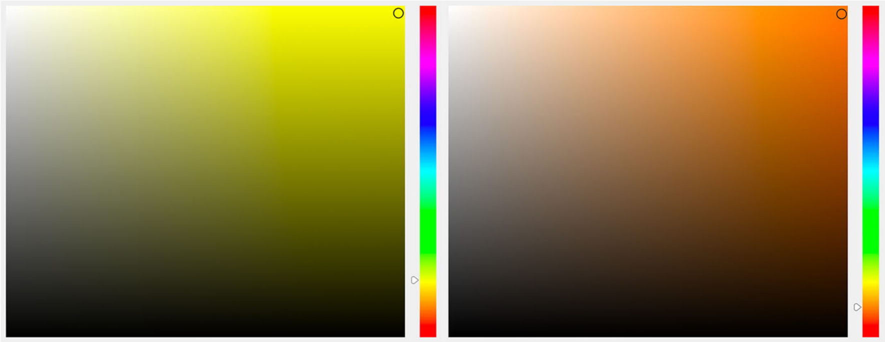

Fig. 2 Color Pickers showing yellow and orange grading into black on the right-hand edge of the color squares. Only orange appears to gradate through brown to reach black

demonstration. A further response shows images of Color Pickers, a widespread tool in graphics programs. These allow one to select a chromatic color and see how it appears with white, grey and black added. Figure 2 shows Color Pickers for yellow and orange.

Here too we can see how this way of thinking about making brown can guide a preference for the "orange" standard view. In the Color Picker for yellow, we see pure yellow, or something close to it, at top left. Looking down the right-hand side, yellow is darkened until it turns into black. Viewers tend not to reliably see brown in this transition. The Color Picker for orange is different: the orange at the top right of the square appears to grade through brown before becoming black in the bottom right corner.[9] That shows how to reliably make brown using graphics programs.[10]

What does this discussion show? It suggests that for those inclined to the standard theory such demonstrations of how to make a brown percept are a good guide to the phenomenology, and that, accordingly, brown is a blackish version of either yellow or orange. But we can already see that there will be a problem here, for we have seen that there are different ways of making brown, and in particular that one can begin with different "ingredients" – either yellow or orange – depending on the method used. I will come back to this point in the next section.

[9] The appearance of brown here also depends on proximity to lighter tones, as described in the previous section.

[10] The following internet query on a Photoshop website illustrates this nicely. The writer wants to make parts of a black and white image brown: "I am trying to fix it by increasing yellow … The result is the illustration becomes yellow but not brown. When I increase red, it becomes too reddish but not brown." (michaelvs on https://www.photoshopgurus.com/forum/threads/how-to-boost-brown-color.48201/, 8 November 2011.) As the Color Picker images show, the answer is that one must choose orange hues to reliably produce brown.

4 Is brown an elementary color?

That then, is the standard view: brown is a darkened yellow or orange. Why does it fail to satisfy me? Here are three reasons.[11]

(1) When I look at many browns, and no matter how hard I interrogate my perceptions, I am just not sure I see a darkened orange. In the past, I did my best to talk myself around, or simply overlook this. There are good reasons to do that. Hering's phenomenology has been the standard way science thinks of color experience for a long time, and as we shall see in the next section, revising that also involves rejecting well-established accounts of the physiology of vision. So, to believe that brown is not darkened yellow or orange is to reject rather more than that. But all this has never quite persuaded me. When I see a deep, rich brown – the kind of brown seen in chocolate, coffee beans or polished leather – it often does not seem yellow or orange. Rather, it appears an entirely different color. This observation, we have seen, is shared by some others. Recall Hardin's observation – "the perceptual difference between 'standard' yellow or orange and their blackened counterparts is striking." And Boynton's remark comparing brown to other versions of dark or darkened hues: "[i]t ceases almost entirely to resemble the original bright color".

I have already spoken about the strange presence brown may appear to have in the HSL diagram (Fig. 1) The orange Color Picker (Fig. 2) gives another occasion to interrogate one's experience of brown. Look along the right edge as the orange fades to black. Can one describe the colors there as a straightforward gradation from orange to black? Or does orange grade into another color, a blur of dark brown – that resists being seen as darkened orange – and which in turn grades into black?

Of course, one can be wrong in judgements about color. We are easily influenced by certain kinds of contextual factors. A striking example is Brentano's mistaken belief that green is a phenomenal mix of yellow and blue (Brentano, 1907), which was presumably due to being influenced by familiarity with paint mixture. Another influence on Brentano's view was the Young-Helmholtz trichromatic theory, which suggested that all chromatic colors are a combination of three colors, red, yellow and

[11] I do not include among my three reasons the experimental findings of Fuld, Werner & Wooten (1983). Fuld et al. argue that brown could be an elementary color. However, a similar study by Quinn, Rosano & Wooten (1988) was less sanguine about this conclusion. Both studies showed a small group of subjects samples of brown, asking them to identify its phenomenal components. Fuld et al. found that subjects could not describe browns using only the terms "yellow" and "black", concluding that brown may be an elementary color. Quinn et al. changed the order in which descriptive terms were offered to subjects – holding off offering brown as a descriptive term – and found that subjects could describe brown using only "yellow" and "black". Quinn et al. observe: "[w]riters and theorists have speculated about whether brown is elemental or not, but the paper by Fuld et al. and our study seem to be the only empirical attempts to solve the issue. Unfortunately, neither attempt is definitive. The results of Fuld et al. are consistent in terms of brown's being elemental or nonelemental, but exceedingly difficult to resolve into components. It is possible, however, … that by having the subjects use [the words] yellow and black before they saw [the word] brown, we trained them to artificially fractionate the elemental color brown. (Quinn, Rosano & Wooten, 1988, p. 164) So, following Quinn et al., I take these two studies to be inconclusive. A suggestive recent study, of US and Somali subjects is consistent Fuld et al., finding that "some observers … might have considered … brown to be elemental in some way … contrary to Hering's theory." (Lindsey, Brown & Lange, 2020, p. 20).

blue.[12] Could it then be that contextual influences mislead me to judge brown as an elementary color? Unlike Brentano's case, there are no obvious contextual influences that would cause me to judge brown as elementary. Rather, if anything, the reverse is true. Brown is the product of various different paint mixtures, and can, as we have seen in the previous section, be induced in other ways too. So, if I am susceptible to these influences, they could only dispose me to believe that brown is a phenomenal mixture of other colors, and so not an elementary color. In addition, familiarity with the opponent process theory could only push me in the direction of judging brown to be a composite of other colors.

(2) Another piece of evidence is found in the *World Color Survey* (Berlin & Kay, 1969; Kay et al., 2009), which discovered shared features of color naming in languages. This project, as Hardin has described it, found that "[color] categories whose foci lie close to the six elementary Hering colors get named before categories focused near the binary colors such as orange." (Hardin, 2013, p. 2) Roughly speaking, Hering's elementary colors are named before any others.[13] The next term that languages adopt is for brown. (Berlin & Kay, 1969, p. 19) That comes ahead of orange, and also well ahead of distinctions between light and dark versions of other chromatic colors. If this order of inclusion corresponds to a color's obtrusiveness in experience, then brown is as obtrusive as any outside Hering's elementary colors. A color's presence in language may well be a complex matter – perceptual salience, and cultural and other environmental factors may all have an influence. But as the prominence of Hering's elementary colors suggests, being elementary seems to play some role, directly or indirectly, in a color's order of inclusion in languages. (Hardin, 2013, pp. 2–3) By this measure, brown is also rather more prominent in experience than colors such as dark blue, dark red, and so on. It is also more prominent than orange, which it is supposedly the darkened version of on one version of the standard view. So far as this kind of obtrusiveness in experience corresponds to a color's elementary character (which it seems to be in the case of Hering's elementary colors), Berlin and Kay's work is suggestive of and consistent with brown being elementary. Moreover, if brown is not elementary, some explanation is required to explain its prominence in the World Color Survey.[14]

These cross-cultural similarities are usually explained by the existence of common neurophysiological features that underlie the processing of color (Ratliff, 1978; Kay & McDaniel, 1978, pp. 617–621) That is also a commitment of my approach, although I subscribe to another neurophysiological account, as will become apparent in Sect. 4. This kind of explanation can be criticized as neglecting the role that environment plays In particular, if the early adoption of terms for brown simply reflects its wide presence in the natural environment, that would provide an alternative to a common

[12] Boring says of this work of Brentano's: the "entire book is really about this matter." (Boring, 1942, p. 151) Brentano's idea that green is a phenomenal mixture of yellow and blue is widely rejected. One reason for rejecting the view is found in reports of yellowish blue, which observers describe as being not at all greenish (Billock, Gleason & Tsou, 2001; Crane & Piantanida, 1983).

[13] For an apparent exception, see Lindsey, Brown & Lange, 2020, p. 19.

[14] One may wonder if this suggests anything about the color terms that are adopted next by languages: purple, pink, orange and grey, which are adopted in no particular order. (Berlin & Kay, 1969, p. 23) I return to this thought in the next section.

neurophysiology. (Yendrikhovskij, 2001) But I see the prevalence of brown in the natural environment as consistent with the idea that brown is an elementary color. The ability to recognize brown things, whether objects or backgrounds, and quickly distinguish them from other things in the environment, helps us negotiate a physical environment where brown is prevalent. So, the prevalence of brown is consistent with, and helps explain why, brown could be an elementary color.[15]

(3) We have seen that there are two versions of the standard view of brown: that brown is either darkened yellow or darkened orange. The existence of the two versions unsettles the standard view. Proponents of the two versions simply do not agree on what they are experiencing. How can this be? We have seen that conditions under which brown is generated play a role in shaping the two versions of the standard view. To my mind, this is the only way one can explain the disagreement about phenomenology. That is to say, the two versions of the standard view are shaped not by phenomenology, but by contextual facts about brown – methods of generating a brown percept. This is supported by the fact that, as we have seen, those who favour one version, tend to highlight corresponding methods of making brown. That choice, we can now point out, is simply arbitrary. Proponents of the "yellow" version of the standard view focus on methods of making brown that start with yellow, and proponents of the "orange" version of the standard view focus on methods that start with orange. Both groups avoid those methods that would trouble their version. So, both versions are shaped by factors external to the phenomenology of brown, and the existence of the two versions seems to be the result of arbitrarily favouring one kind of factor over another.

Proponents of the standard view could respond by claiming that darkened yellows and oranges are simply different kinds of brown. One could call this a disjunctive view: any brown is either a darkened yellow or darkened orange. But that comes up against another problem, for then the two kinds of brown would have no distinctive phenomenal property in common. We aren't ordinarily inclined to group these chromatic colors together on the basis of a distinctive single phenomenal property – why should we do so when they are darkened?

Another response that proponents of the standard view can make is to claim is that there is in fact a distinctive single phenomenal property that fulfils this role: yellow – since on the standard view, orange is a yellowish-reddish color. But this produces three problems. First, not everyone sees darkened yellows as brown. I have often found that viewers of yellow Color-pickers, such as that on the left of Fig. 2, do not see brown. Second, if darkened yellowish colors are brown, then that requires that darkened yellowish greens, as much as orange, should be seen as brown. But does this color appear brown? Sometimes it is described as olive, but I haven't found any description of darkened yellowish green as brownish in the literature on color. Third, this approach fails to explain why reds that have no yellow component can be seen as brownish. This was noted by Helmholtz, who found that red could be perceived as

[15] Hardin also makes much this point. (Hardin, 2013, p. 3) For another discussion of the possible elementary character of brown in the context of the *World Color Survey*, see Ratliff, 1976, p. 324. Ratliff follows Hering in seeing brown as a phenomenal mixture of black and yellow, and tentatively suggests that the brightness of yellow could explain why the typically much darker brown seems so distinct. Recall, though, that some browns are quite bright, so I doubt this is a sound explanation.

a "red-brown" when surrounded with a bright white light (just as yellow and orange can be). (Helmholtz, 1924–25, vol. 2, p. 131).

5 Beyond opponent processing

I turn now to a significant obstacle that lies in the way of acknowledging brown as an elementary color. Hering developed his description of color experience into the basis for a theory of color vision – the opponent process theory – which holds that colors are encoded in the visual system as combinations of those six colors that he identified as elementary (Hering, 1964). A neural basis for such encoding was discovered by Hurvich and Jameson (1957), and it is clear that signals are encoded this way in the optic nerve and into the brain. On this account, the neural mechanisms needed to encode a further elementary color simply do not exist. Brown, like every other color, must be encodable in terms of Hering's elementary colors. Vision science, and philosophy, are therefore very resistant to the idea that brown could be an elementary color.

But some recent science has suggested that within the brain there is a different way again of encoding color – and that this might allow for brown to be encoded as an elementary color. The simple pattern of color that opponent processing encodes as it exits the eye does not accord with colors as we experience them, and so must be enriched and developed in other parts of the brain. Information about color constancy, illumination, surface color and transparency – all of which change our experience of colors – must be encoded later. In the 1970s and'80 s, Semir Zeki discovered that a significant part of the visual system, V4, plays a substantial role in color processing. (Zeki, 1980) More recently it has become apparent that opponent processing at the early stage of visual processing does not even accurately encode Hering's elementary colors as we experience them. As J. D. Mollon and Gabriele Jordan observe, "most color scientists are agreed that the chromatically opponent cells of the early visual system … do not correspond colorimetrically to red-green and yellow-blue processes." (Mollon & Jordan, 1997, p. 382) According to Arne Valberg, opponent processing cells at this early stage are "not the correlate for seeing a particular hue quality, say unique [i.e. elementary] red. This latter correlate, if it exists as a separable entity, must be associated with yet unidentified, higher-level neural activities." (Valberg, 2001, p. 1645) Since then, scientists have been trying to find locations that more precisely correspond to our experience of Hering's elementary colors with limited success (see Kuehni (2012, p. 284) for a survey of these efforts). This has led some to think that the brain could encode color in a substantially different way deeper in the visual system.

Recent studies, based on experiments on macaques, have found layered, retinotopically-mapped regions in V2 and V4, each sensitive to specific chromatic colors.[16] According to one group of authors "[o]ur finding suggests that thin strips in V2 contain functional maps where the color of a stimulus is represented by the location of its response activation peak." (Xiao et al., 2003). But these strips of tissue,

[16] It should be noted that macaques are commonly used as subjects in studies on neural correlates of visual experience.

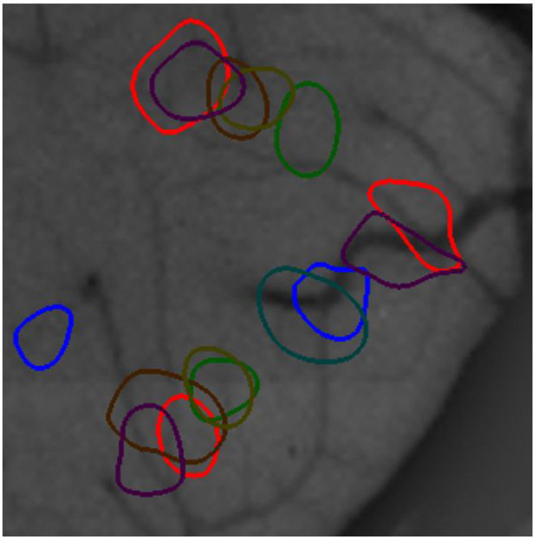

Fig. 3 'Perceptual Color Map in Macaque Visual Area V4' From Li et al., 2014, detail of Fig. 14

each a map of part of the visual field, are tuned to respond not to four elementary chromatic colors, but to a continuum of chromatic colors, and are arranged so that those strips sensitive to similar colors are closest to one another.[17] Another study, of special interest here, found "rainbows of patches" that are part of more complex structures in V4, responsive to an even wider range of colors. (Li et al., 2014) According to this study, among these are maps of parts of the visual field tuned to respond to the color brown. Figure 3 shows two such areas, indicated with a brown outline (the image shows patches sensitive to colors of relatively similar luminosities, so along with brown, there is olive and deep purple, among other colors).

On the opponent processing theory, such a discovery makes little sense. Specialized cells in the visual system responding to brown (or other combinations of elementary colors) are simply not needed: it should be enough that cells responsive to Hering's elementary colors can be triggered together.[18] So, the existence of "brown detector cells" seems to open the way for a neuroanatomy capable of encoding brown as a elementary color. It also suggests that there may well be further colors, in addition to brown, that could also be encoded in this way, and so could also be considered elementary. The study's authors appear open to this idea: "These results … may explain

[17] The descriptions in the studies used here of retinotopic maps align neatly with Mohan Matthen's account of such maps as used by the visual system to categorize visible properties. (Matthen, 2005, pp. 54–57).

[18] One may, of course, still ask how it is, on an opponent processing account, that we experience and identify a color as both blackish and (say) yellow without the benefit of a "detector" cell for the combination of the two properties. That is an example of a much broader problem in computational neuroscience: the binding problem. This asks how the brain is able to process information, sometimes "detected" or "represented" in relatively distant parts of the brain, so that perceptual properties are associated with one another in the right way in our visual experience. There are various possible solutions, but they mostly avoid proposing the existence of arrays of detectors for combinations of properties. The reason for that is that we are capable of recognizing a vast array of combinations of perceptual properties, and the brain cannot accommodate such a large number of different kinds of "detector" neurons. See Cleeremans (2003) for various solutions to the binding problem.

why we perceive pink, brown, and red as three different colors, rather than one color with different lightnesses." (ibid.)[19] Here one may turn again to the HSL diagram (Fig. 1) and ask whether there are further colors there that could also be described as elementary. Does the band of violet really seem to be exhaustively described as reddish and bluish? Does the saturated band of orange really seem to be merely reddish and yellowish? This recent research thus sketches out a neuroanatomy that could encode a richer color phenomenology than Hering allows: one that admits an elementary brown – and perhaps a broader palette of elementary colors beyond that.[20] However, the crucial point that I draw from this research is a less ambitious one: that there is evidence that the visual system may be capable of encoding brown as an elementary color, rather than merely as a combination of Hering's elementary colors.

6 Implications for theories of color

What would be the implications for philosophy of color, if we take seriously the claim that brown is an elementary color?

My account of brown presents a challenge to the broad collection of views known as color realism or objectivism. Color realism, as I call it here, endorses the pre-theoretical intuition that colors are themselves properties of objects. They might ordinarily be immediately and wholly apparent to those of us with normal vision [this is primitivism or naïve color realism (e.g., Allen, 2016)], or they might be identified with physical properties of a surface, such as reflectance properties [this is physicalist color realism (e.g., Hilbert, 1987)].[21] These views allow that we may not always see colors correctly – we might be misled by effects of illumination, illusion or hallucination. But on both views, the pre-theoretical idea of color is preserved – colors are out there in the world, mind-independent, intrinsic features of any object's surface that reflects light in the visible spectrum.[22]

Whatever form it takes, color realism must square the pre-theoretical idea that motivates it with the complex and sometimes counterintuitive data that the various kinds of systematic examination of color yield. David Hilbert puts the color realist's task in the following way:

[19] Note that Li et al.'s analysis does not make a distinction between dark colors and darkened colors. As this passage indicates, they also see brown as being allied with red (rather than orange and yellow).

[20] This is broadly congruent with the *World Color Survey*'s findings that after brown other colors adopted by language groups are for purple, pink, orange and grey (Berlin & Kay, 1969, p. 23). But it also leaves unanswered questions: why it is that some colors are more prominent in our experience than others? This, of course, was already an issue for Hering's elementary colors – why do they appear in the order they do in the survey (a problem explored by Ratliff, 1976, pp. 320–325)? So, the same question in the context of an expanded list of elementary colors is not any more of a problem than it is in the context of Hering's theory.

[21] Westphal can be understood as a physical color realist provided one "in effect widens the concept of the physical by changing what it is to be regarded as the physical base for the color." (Westphal, 1982, p. 418) He identifies brown not merely with a particular reflectance property, as he does spectral colors, but also with the darkness "relative to the brightness of the surrounding field" that produces the appearance of brown. (p. 419).

[22] Here I leave aside other kinds of colored things – such as transparent colored substances and colored sources of illumination – which complicate these views somewhat.

> [T]he question of the objectivity of color is in the end a conceptual one. To settle the question, we need to discover which way of conceptualising color allows us to account for both pre-theoretical intuitions regarding color and the wide range of known color phenomena. (Hilbert, 1987, p. 16)

Brown's elementary character, so the foregoing sections suggest, is one such color phenomenon that needs to be reconciled with the pre-theoretical intuition that colors are properties of the surfaces of objects, if some form of color realism is to be maintained. I argue that the elementary character of brown places such pressure on this intuition that color realism is difficult to defend.

My line of thinking here accords with Jonathan Cohen's "master" argument from perceptual variation. (Cohen, 2009, p. 24) Cohen's argument is as follows: 1. A single color stimulus can produce different color perceptions. 2. There is no well-motivated reason for preferring one such perception as veridical over others. 3. An "ecumenical reconciliation of the variants is preferable to an unmotivated stipulation in favour of just one of them". 4. Such a reconciliation rules out color realism.[23]

The examples of color variation used by Cohen concern contrast effects that cause stimuli to vary their appearance. A grey patch seen against a light ground will appear darker than it otherwise would, and seen against a green–blue ground it will appear to take on a slight red tinge. As we have seen, the perception of brown depends on contrast, but the changes that it produces can be more conspicuous than the relatively delicate contrast effects that draw Cohen's attention. In particular, the elementary character of brown implies that a surface may have two completely different colors (brown and a spectral color, such as yellow or orange), depending on the context in which we see it. If the surrounding colors are bright enough to create a contrast effect, a surface will appear brown. If not, it will appear to be either yellow or orange. This differs from the subtle contrast effects that Cohen discusses, for brown can take on in its most characteristic, rich, deep appearance, yet, when the contrast effect is removed, it may appear as a highly saturated yellow or orange. Recall Boynton's words: that brown "ceases almost entirely to resemble the original bright [yellow or orange] color." It should be added that if brown is understood as non-elementary – as a darkened yellow or brown – this poses no problem for color realism: despite the observations of Boynton and others, we simply see brown as it is: as a kind of yellow or orange, blackened in one case, and not in the other. But if brown is an elementary color, it means that brown surfaces in fact have *two* different colors – brown and either yellow or orange – which become visible under different conditions.

Applying the second step of Cohen's argument involves showing that there is no well-motivated reason that can distinguish one of these colors as the veridical color and the other as non-veridical. One way of distinguishing the veridical color is to understand this as the color that appears under "normal" viewing conditions. Any other colors, which then appear only under "abnormal" conditions, can then be discounted as non-veridical, illusory. What contenders are there for such normal viewing conditions? One might consider the colors that surfaces take on when viewed through a reduction tube – which isolates an observed color from those adjacent to it. But this will not do,

[23] I truncate the final step of Cohen's argument, which adds that the best version of this reconciliation is color relationalism. I won't commit to that conclusion, as I discuss below.

for it would remove brown entirely from the realm of veridical color experience. The contrast colors, including brown and black, are never seen under such circumstances, and so would always be non-veridical colors on this approach. No surface could ever actually be brown, a conclusion that I assume color realists would reject. [Cohen makes this point (2009, p. 23)] In response, the realist might acknowledge that brown is illusory, but that other colors still have the reality that color realism attributes to them. However, that would be ad hoc, for how could one justify making a special case of brown in this way, when one has acknowledged it is an elementary hue akin to blue, green, red and yellow?

One might instead search for examples of normal viewing-conditions among the cases I have considered earlier. We saw that a surround of bright white light transforms a saturated yellow or orange into brown. But surrounding a colored area with an annulus of bright light is a straightforwardly unusual condition for perceiving colors. So, it seems reasonable to identify this as an abnormal viewing condition, allowing us to identify the surface in this example as either yellow or orange, rather than brown. A surface we ordinarily see as dark brown will maintain that appearance under most viewing conditions, since its darkness will produce a contrast with its comparatively bright surrounds. So, it seems reasonable to identify some or all of these viewing conditions as normal.

However, this approach will not do either, for no such normal viewing conditions can ever be relied upon to distinguish all instances of brown from yellow or orange. The trouble is that the smallest variation in viewing conditions can cause brown to turn to orange or yellow, or vice versa. This can be seen in Fig. 4, a version of Adelson's Checker Shadow Illusion. The two dots present the same stimulus to the eye. (And so, despite appearances, do their immediate surrounds – the grey squares in which they sit. I return to this point below.) Nevertheless, the upper dot appears brownish, perhaps an orange-brown – and the lower dot appears orange – a luminous orange that is not at all brownish. Differences in the broader context in which the dots and their surrounding squares are placed markedly change the appearance of the spots' appearances.

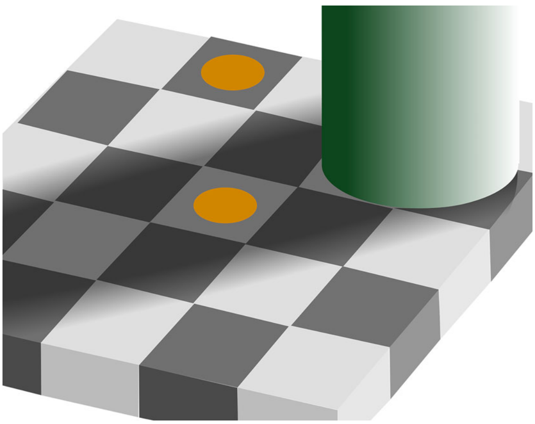

Fig. 4 Edward H. Adelson, A version of the Checker Shadow Illusion. https://commons.wikimedia.org/wiki/File:Optical_grey_squares_orange_brown.png

Suppose there are normal viewing conditions that will reveal the true color of these dots? Does it hold for the upper dot or the lower dot? I cannot see any way to answer that question. Neither of the patterns of light and dark surrounding each dot suggest themselves as unusual or abnormal viewing conditions in any sense. One is gently shaded, and the other fully illuminated, but both are entirely typical of the kinds of contexts that we encounter in everyday life, and in which we feel confident in judging color. So, I see no way to define one set of viewing conditions as abnormal. In such circumstances, calling one configuration of surrounding colors and represented illumination normal, and another abnormal can only be an arbitrary stipulation. Here, there is no well-motivated reason for identifying one set of viewing conditions as providing a veridical perception, and one as non-veridical, for they are both entirely typical of viewing conditions in everyday life. As I have said, this issue does not arise for every instance of brown – a chocolate bar may seem brown under all ordinary viewing conditions. But if it is a problem for just some cases, that is enough for brown to form the basis for an argument from perceptual variation.[24]

So much for appealing to normal viewing conditions to set a standard for determining what is and is not brown. Let me consider another approach. Westphal holds that brown appears precisely in those circumstances that produce the required contrast effect to transform yellow (or orange, we may add) into brown. So, for brown objects, "the proportion of incident to reflected light is relatively low" in comparison to their surrounds. (Westphal, 1982, p. 421)[25] But this approach also has difficulties. Consider again Fig. 4. This provides a counterexample to Westphal, for the *squares surrounding each of the dots have the same luminance* – yet one dot is brownish, and the other is not.[26] This, clearly, is an unusual counterexample to the requirement for contrast. But it is a counterexample nonetheless, and shows that the perception of brown does not always require a lighter surround. Other factors must here be responsible for the perception of brown. There is little research on this that I have been able to find, but it is consistent with Gregory's position that the conditions for the perception of brown are complex: "Brown normally requires contrast, pattern and preferably interpretation of areas of light as surfaces of objects (such as wood) before it is seen". (Gregory, 1966, p. 127; see also Buck et al., 2013) Could it be that Westphal's account of the required viewing conditions can be adjusted, so that they accord with whatever conditions would be described by a fully-developed account of the circumstances under which brown is perceived? I accept that it could, but I do not see that as a satisfactory solution to a realist account of what brown is – for, whatever shape such an account will take, as it deals with this complexity, and the complexities Gregory suggests, it will come to be shaped by facts about our visual system as much as the features of

[24] A color realist could respond by suggesting that the brown of the chocolate bar, and other surfaces that appear brown under all normal viewing conditions, could present us as with real instances of brown, while other experiences of brown are illusory. To my mind, that would produce an awkward implication, for it would mean that all light brown colors – tan, fawn, beige – are illusory, since the application of a dark background (often a feature of normal viewing conditions, however construed) can readily change their appearance to a pale yellow or orange.

[25] This produces the blackening effect on Westphal's account.

[26] The two squares appear different shades of grey, but this is an illusion (albeit a powerful one). (Adelson, 1995).

the surfaces we see as brown. For as the list of all those features in the visual environment that tend to contribute to our ability perceive brown – reflectance, contrast, pattern, illumination, etc. – becomes more complex it will become increasingly clear that the list is an arbitrary conjunction of features, united only by the fact that they are all features to which our visual systems are sensitive. The particular complexity of this list – its particular combination of an array of different physical features – can only be explained by facts about the visual system – at an objective level it is simply arbitrary, and therefore cannot form a basis for a well-motivated justification for realism about brown. Thus, it is impossible to find a well-motivated justification in every case for accepting a perception of brown as veridical. Cohen's master argument can then quickly proceed. An "ecumenical reconciliation of the variants" – an account that allows that a surface can be colored both brown and orange or yellow – is to be preferred over an unmotivated stipulation that the surface is either one or the other.

This conclusion allows for one form of color realism: that some surfaces have more than one color, each of which becomes visible under different viewing conditions. This, it seems to me, is an unappealing redoubt for the color realist, for it defies our pre-theoretical view of color. Pre-theoretically, we think of unchanged physical objects as characterized by just one set of colors, much as they have just one set of shape properties, one set of textural properties, one mass, and so on. But this view has its defenders (e.g., Kalderon, 2007) Here, I limit myself to observing that as well as damaging the pre-theoretical view of color, there is an uncomfortable multiplication of an object's properties beyond what is ordinarily considered necessary to describe its character. One set of shape properties, of texture properties, one mass, and so on, is enough to fully outfit an object in these respects – why should a plurality of colors be needed here if they too are objective properties? In the case of brown, adopting this position seems ad hoc in another way: why would this multiplication of colors apply to brown, and not in the same way to other darkened chromatic colors?

So, I conclude that the elementary character of brown is evidence against color realism. By contrast, it is straightforwardly encouraging to non-realist theories of color. Broadly speaking, it is not surprising to find that the visual system can respond in a plurality of ways to certain stimuli. Accordingly, theories holding that color is partly or wholly dependent on the operation of the visual system will be untroubled by the claim that we can in some cases experience different colors in response to the same stimuli. Theories that hold that color is partly dependent on the visual system include relationalism, a broad group of accounts that see color as a relation between a viewer's visual system and the objects perceived. (Cohen, 2020) Recent articulations of the view include Matthen (2005), McLaughlin (2003b) and Cohen's own account (Cohen, 2009). Equally, brown's status as an elementary color supports views that take color to be wholly a product of the operation of the visual system, a useful illusion in navigating a physical environment that is not in truth colored at all. That position – color subjectivism – is argued for by Hardin (1993).[27]

[27] Having given some support here to Hardin's general theory of color, I should add a few notes to reconcile my more particular views on brown with those of Hardin. The preceding sections have only stressed my disagreements with his views: his description of brown as "blackened orange", and his endorsement of the idea that the complexities of color experience must be encoded in opponent processes. But my differences with Hardin are milder than this suggests, for he is also clear about being open to the possibility of revising

7 Conclusion

I have argued that there are reasons to take seriously the idea that brown is an elementary color. Observers have long remarked on brown's distinctive appearance, and at the same time have sought to ignore or explain this away, so that it would fit within the strictures of Hering's phenomenology. With the development of new views in color science questioning the physiological basis of that phenomenology, Hering's elementary colors lose some of their authority as the exclusive descriptors of color experience. That makes it easier to give credence to pre-theoretical intuitions about the elementary character of brown. But while contemporary approaches in color science are now friendlier to elementary brown, we have also seen that elementary brown does not sit happily with all philosophical theories of color. It is consistent with anti-realist views, such as relationalism and subjectivism, but it sits uneasily with the realist outlooks popular in philosophy of color today.

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Footnote 27 continued
these two positions. After discussing Hering's elementary colors in the forward to the expanded edition of *Color for Philosophers*, he reserves "perhaps… a special place for brown" (Hardin, 1993, p. xx), and he also signals that opponent processing may need to be enriched by a further account of how the visual system encodes color. (Hardin, 1993, p. 125) So, I am hopeful that Hardin's views are accommodating of the possibilities I have raised.

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