

# COLOUR RELATIONS IN BLACK AND WHITE

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Here is an old joke: what is black and white and red all over? A newspaper. Why though? As we assume that nothing could really be black and white and red all over, we infer that ‘red’ should be heard as ‘read.’ In the grand philosophical tradition of making even humour unfunny, I want to take issue with this assumption. My thesis is that it is possible to see two objects in black and white, while at the same time seeing one of them as redder than the other. More generally, I argue that it is possible to perceptually represent colour relations between two objects, without perceptually representing their colours.<sup>1</sup> I call this *primitive relational colour representation* (PRCR). This goes against the orthodox view that we represent colour relations *by virtue* of representing colours. This orthodoxy has been challenged by several authors in the recent literature, and I here add my name to the chorus.<sup>2</sup>

I recently provided an extended argument for PRCR elsewhere (Davies, forthcoming). The plan here is to supplement and extend that work, addressing some foundational issues that were untouched in the original, and considering an alternative to my preferred view of the issues. In Section 1, I argue that under certain assumptions, PRCR is conceptually and even nomically possible. The subsequent Sections consider two concrete theories of

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<sup>1</sup> The arguments focus on visual perceptual representation, rather than visual experience per se. See Davies (2018) for explanation. By ‘visual perceptual representation,’ I mean a state of the visual perceptual system that is type-individuated by its accuracy conditions. An example of a relational colour representation would be a state type-individuated by the accuracy condition that that blueberry is bluer than that raspberry.

<sup>2</sup> Morrison (2015, forthcoming), Papineau (2015).

perceptual representation that allow for this sort of dissociation. Section 2 introduces a *linguaform model*, drawing on work by Mandik (2014) and Peacocke (1992). Section 3 presents my preferred *chromatic edge model*, which is distinctive in utilising iconic rather than discursive contents.

### ***1. The possibility of primitive relational colour representation***

PRCR is a strange notion, and some may think it incoherent. The aim of this Section is to dampen such resistance, by highlighting regions of conceptual space in which PRCR can occur. I first map the space of views on the relationship between monadic and relational colour representation. Roughly: either monadic determines relational, relational determines monadic, or there are no asymmetric dependence relations between these types. I then show that under certain assumptions, the latter two views allow for PRCR.

The orthodox view is as follows:

**Monadic Determination Thesis:** Our visual perceptual representation of monadic colour properties determines our visual perceptual representation of colour relations.

An analogous view of visual spatial perception is that representing the bat and the ball at specific places determines our representation of the bat as being located to the left of the ball. Applied to visual temporal perception, the idea is that representing the click at time  $t_1$  and the clap at  $t_2$  determines our representation of the clap as succeeding the click.

We can interpret ‘determination’ metaphysically or causally. Here is the metaphysical reading:

**Metaphysical Monadic Determination Thesis:** For any visual perceptual representation  $r$  of  $S$  at  $t$  that attributes a colour relation  $R$  between  $x$  and  $y$ , there is a

set  $\Gamma$  of visual perceptual representations of  $S$  at  $t$  attributing monadic colours  $C_1$  to  $x$  and  $C_2$  to  $y$ , such that  $\Gamma$  fully grounds  $r$ .<sup>3</sup>

On this view, monadic colour representation is more fundamental than relational colour representation, and the latter depends on the former. Necessarily, any change in  $S$ 's representation of the colour relations between  $x$  and  $y$  entails some change in her representation of the monadic colours of  $x$  and  $y$ . Fix all the monadic colour representation facts, and you will have fixed all the relational colour representation facts.

A causal interpretation is that our cognitive architecture contains mechanisms taking monadic colour representations as inputs, yielding relational representations as outputs:

**Causal Monadic Determination Thesis:** For any visual perceptual representation  $r$  of  $S$  at  $t$  attributing a colour relation  $R$  between  $x$  and  $y$ , there is a set  $\Delta$  of representations of  $S$  at during the interval  $(t-n, t)$  attributing monadic colours  $C_1$  to  $x$  and  $C_2$  to  $y$ , such that such that computations over  $\Delta$  produced  $r$ .

As a toy example, suppose that  $S$ 's visual system attributes red<sub>23</sub> to  $X$  and orange<sub>17</sub> to  $Y$ . Let us assume that attributing a monadic colour involves attributing proportions or magnitudes of the elemental colours red, green, yellow, and blue. Suppose that the content red<sub>23</sub> attributes a greater proportion of redness than the content orange<sub>12</sub>. Our hypothetical mechanism 'reads off' the proportions of redness attributed to  $X$  and  $Y$ , computes their comparative values, and outputs the representation that  $X$  is redder than  $Y$ .

Let us now consider more unconventional views:

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<sup>3</sup> Papineau (2015) calls this 'the orthodox view'; Morrison (2015) labels it 'colour atomism'.

**Relational Determination Thesis:** Our visual perceptual representation of colour relations determines our visual perceptual representation of monadic colour properties.

An analogous view of visual spatial perception would be that representing objects as standing in certain spatial relations determines our representation of these objects as having particular spatial locations. Applied to temporal experience, the view would be that representing temporal succession is explanatorily prior to representing events as occurring at particular times.

Interpreted metaphysically, the claim is:

**Metaphysical Relational Determination Thesis:** For any visual perceptual representation  $m$  of  $S$  at  $t$  that attributes a monadic colour property to  $x$ , there is a set  $\Gamma$  of visual perceptual representations of  $S$  at  $t$  attributing colour relations between  $x$  and other objects, such that  $\Gamma$  fully grounds  $m$ .

Morrison (2015) defends this view. In an interesting development, Morrison (forthcoming) suggests that our total lifetime experience of the colour relations borne by  $x$  to other objects, up to and including those at time  $t$ , metaphysically determines the monadic colour property perceptually attributed to  $x$  at  $t$ . The determinacy of this monadic colour will depend on the extent of the subject's prior relational colour perception. By analogy to a simple math problem, suppose that Bill, Belinda, and Bruce are drinking litres of beer, and you do not know how much beer any of them has left in their glass. If Bill tells us that he has 200ml more beer left than Belinda, then this tells us that Bill has somewhere between 800ml and 1L, while Belinda must have somewhere between 0L and 800ml left. If Bruce then tells us that he has 300ml more beer than Belinda but 100ml less than Bill, then Belinda must be between 0L and 600ml, Bruce between 300ml and 900ml, and Bill between 400ml and 1L. Adding more drinkers and relations will narrow these regions further.

Interpreted causally, the claim is this:

**Causal Relational Determination Thesis:** For any monadic colour representation  $m$  attributed by  $S$ 's visual system at  $t$ , there is a set  $\Delta$  of relational colour representations attributed by  $S$ 's visual system during the interval  $(t-n, t)$ , such that computations over  $\Delta$  produced  $m$ .

Suppose my visual system represents  $Z$  as three units redder than  $X$ , and  $X$  as five units redder than  $Y$ . These relational representations input to our hypothetical mechanisms, which compute the range of redness values for  $X$ ,  $Y$ , and  $Z$ , on a scale from zero to ten. The possible assignments are  $Z=10, X=7, Y=2$ ;  $Z=9, X=6, Y=1$ ; and  $Z=8, X=5, Y=0$ . The mechanism might recruit additional relational representations, or other cues or information, to settle on one particular assignment. Alternatively, the mechanism could output determinable redness values, such as that  $Z$  is in  $\{10, 9, 8\}$ .

The final view is as follows:

**No-Determination Thesis:** There are no relations of causal or metaphysical determination between our visual perceptual representations of monadic colours and colour relations.

This is consistent with a variety of views on the relationship between monadic and relational colour representation (Davies, forthcoming: §4). On the metaphysical spectrum, at one pole the grounds for monadic and relational colour representation are completely distinct; at the other pole, these grounds are identical. On the causal spectrum, at one pole the mechanisms of monadic and relational colour representation have no causal interaction whatsoever. At the other pole, these representations result from a single computational mechanism.

Having mapped out the conceptual space, I now argue that under certain assumptions, the relational determination thesis and no-determination thesis allow the (metaphysical or

nomically) possibility of PRCR. It is fairly obvious, I assume, that PRCR is not possible on either interpretation of the monadic determination thesis. On the metaphysical reading, the perceptual attribution of monadic colours to  $r$  and  $r+$  is a metaphysically necessary condition for representing a colour relation between  $r$  and  $r+$ . On the causal reading, the attribution of monadic colours to  $r$  and  $r+$  is at least nomically necessary for representing a colour relation between  $r$  and  $r+$ .

Now consider the metaphysical relational determination thesis. On this view, for any monadic colour representation  $m$ , there is a set  $\Gamma$  of relational colour representations that fully grounds, hence metaphysically necessitates,  $m$ . Let  $\Gamma = \{r_i, r_{i+1}, \dots, r_n\}$ . Each member of  $\Gamma$  is a partial ground of  $m$ : no proper subset of  $\Gamma$  suffices for  $m$ . Generalising on this point, it is conceivable that some sets of relational colour representations do not suffice for any monadic colour representation whatsoever. By analogy, if the neurophysiological grounds the mental, then for any mental state  $M$  there is some set  $\Gamma'$  of neurophysiological states such that  $\Gamma'$  grounds  $M$ . This allows the possibility, however, that some collections of neurophysiological states do not suffice for any mental state whatsoever. It is plausible, for example, that sets of neurophysiological states that are not organised or interrelated in the right way, or that lack sufficient complexity, may not suffice for any type of mentality. Similarly, a set of highly localised, patchy, or sporadic relational colour representations might not suffice for any monadic colour representation.

Turning to the causal relational determination thesis, suppose that  $S$  has a cognitive mechanism that takes relational colour representations as inputs and delivers monadic colour representations as output, subject to certain estimative principles. If this mechanism were to break down, this could selectively impair  $S$ 's capacity for monadic colour representation, while preserving her relational colour representation. Moreover, it is conceivable that despite this impairment in monadic representation, the subject's eventual perceptual representation of the

scene includes some of these relational representations. Experience might *take what it can get*, so to speak, even if limited to pure, primitive, relational colour representations. PRCR may occur in such worlds: the subject might represent surfaces in monadic shades of grey, while nonetheless representing one as redder than the other. Of course, we can also conceive of scenarios where these relational representations wallow in subpersonal purgatory. Perhaps the ‘gateway’ to visual experience only opens when the monadic colour mechanism is fully functioning. The causal relational determination thesis does not guarantee PRCR, though it suffices to note that PRCR may occur in some worlds where it is true.

Matters are less clear-cut on the no-determination thesis, given the range of causal and metaphysical views consistent with it. Suppose there is no causal interaction whatsoever between the mechanisms of monadic and relational colour representation. This view, however implausible, allows the nomic possibility of PRCR, as one could impair the monadic mechanism without affecting processing within the relational mechanism. Another view was that these types result from distinct but interacting mechanisms. So long as one could impair the monadic mechanism without *completely* undermining the functioning of the relational mechanism, then PRCR is again nomically possible. The final causal view was that a single mechanism might generate both monadic and relational colour representation. Total breakdown of this mechanism might impair monadic and relational representation in equal measure, precluding the nomic possibility of PRCR. Partial breakdown, however, might allow for PRCR.

One metaphysical view consistent with NDT is that monadic and relational colour representation have precisely the same grounds, and so come and go together. This would preclude the metaphysical possibility of PRCR. Another view, however, is that these types have distinct or partially overlapping metaphysical grounds. If these grounds are distinct, then

PRCR is clearly possible. If these grounds overlap, then if the intersection of these grounds does not necessitate any monadic colour representation, then PRCR is possible.

## ***2. The Linguaform Model***

So far, we have established that PRCR is possible on some views of the relationship between monadic and relational colour representation. This Section makes things more concrete, presenting the first of two models of perceptual representation that allow for PRCR: the *linguaform model*.

We represent colour relations in natural language using sentences such as ‘the tomato is redder than the orange.’ We can token representations of this sentential type without tokening any representations of the form ‘the tomato is red’ or ‘the orange is orange.’ Trivially, then, language allows us to token representations of colour relations without tokening any representations of monadic colours.<sup>4</sup> In contrast, it is initially hard to see how PRCR could be possible within an imagistic or pictorial theory of perceptual representation, on which the primitives or ‘building blocks’ of the representation are coloured points or pixels (Though I shall later argue that it *is* possible on such a theory). As Mandik (2014: 227) observes,

Literal pictures depict nothing at all without doing so in virtue of the spatial distributions of hues and/or shades in the picture itself. This is a key contrast between pictorial representations and non-pictorial, language-like representations: A linguistic representation of a shape can be totally silent as to its shade or hue in a way that a pictorial representation cannot.

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<sup>4</sup> This does not imply that the linguistic capacity for relational colour representation is more fundamental than the capacity for monadic colour representation. The term ‘redder’ is decomposed via the content morpheme ‘red’ and the functional morpheme ‘-er’. In morphemic and syntactic terms, representations of ‘red’ are explanatory prior to representations of the comparative ‘redder’.



As such, he continues (2014: 230),

A language-like scheme can represent Mary as being the same shape as my other cat, Ernest, while being noncommittal as to which shape they both have. And it can represent Mary as having a shape while being noncommittal about her size, color, etc.

Mandik is concerned here with what he calls ‘Akins’s problem,’ whether there can be visual phenomenology that is devoid of both colour phenomenology and black-and-white phenomenology.<sup>5</sup> My question, in contrast, is whether there can be perceptual representations of colour relations without perceptual representations of colour. As should be clear, a linguaform scheme also allows that we might perceptually represent Mary as being redder than Ernest, while being completely incapable of representing their monadic colours. For this reason, a linguaform theory is the obvious starting point for substantiating the possibility of PRCR.<sup>6</sup>

Mandik’s linguaform theory is bound up with his defence of *conceptualism*, the view that conscious perceptual states have ‘conceptual content,’ and that the phenomenal character of such states is ‘exhausted by these conceptual contents,’ (2012: 620). This rather extreme view is overkill for our purposes, and my argument does not require it. To stay more neutral, I shall instead draw on Peacocke’s (1992) theory of *protopositional content*.

Protopositional content is quasi-linguistic content, nonconceptual but nonetheless evaluable as true or false, and ‘contains an individual or individuals, together with a property or relation’, (1992: 77). Peacocke’s examples include properties and relations such as ‘SQUARE, PARRALLEL TO, EQUIDISTANT FROM, SAME SHAPE AS, and

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<sup>5</sup> Akins (2014).

<sup>6</sup> Following Rosenthal (2005: 188–9), Mandik (2012) distinguishes ‘comparative’ and ‘non-comparative’ types of colour representation, arguing that we are capable of many more comparative colour discriminations than non-comparative colour discriminations. Mandik applies this to the phenomenal sorites, and Papineau (2015) presents a similar view.

SYMMETRICAL ABOUT'. I assume he would include colour contents such as RED and BLUE, and relational contents, such as REDDER THAN and BLUER THAN.<sup>7</sup>

Protopositional content is distinguished from *scenario content*, which provides 'a way of locating surfaces, features and the rest in relation to' a labelled origin and set of axes (1992: 64). For each point in the scene, scenario content specifies 'whether there is a surface there, and if so what texture, hue, saturation, brightness and temperature it has at that point, together with its degree of solidity', (1992: 63).

Protopositional content is 'not determined by positioned-scenario content' (1992: 78). Peacocke thus allows that a subject might represent the spatial or chromatic features of an object in protopositional content, without scenario content, and vice versa. Peacocke suggests that the former type of dissociation might occur in 'visual disorientation', in which subjects are 'able to identify and apparently perceive the shape of objects in their environment without experiencing them as having any particular (egocentric) location' (1992: 241-2). Consider a square, *s*, with vertices ABCD. As Peacocke notes, 'even if edge [AB] and edge [CD] are not localised in the subject's perception [i.e. in scenario content], that perception can still have the protopositional content that [AB] IS PARALLEL TO [CD],' (1992: 242). Here, the subject might represent a geometric relation between the edges AB and CD, without localising AB and CD in space. In Peacocke's example, given that the subject can 'identify... the shapes of objects,' I assume that their perception of *s* also has the monadic geometric protopositional content that *s* IS SQUARE. Given the quasi-linguistic nature of protopositional content, however, representing the geometric relations such as parallelism does not necessitate any representation of the square's monadic geometric properties, such as its squareness. We can conceive of a subject with an extreme form of visual disorientation, who does not perceive objects as localised in space, and cannot perceive

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<sup>7</sup> Capital letters denote protopositional contents.

or identify any object's monadic geometric properties, but who can perceive and identify certain geometric relations between objects or their parts, such as their edges, vertices, and interior regions. This subject might have visual perceptions of  $s$  that do not categorise  $s$  as SQUARE, but do represent that AB IS PARALLEL TO CD.<sup>8</sup> Presented simultaneously with another larger square,  $s'$ , she might represent that  $s$  IS THE SAME SHAPE AS  $s'$ , or that  $s$  IS SMALLER THAN  $s'$ . Now, I am unsure whether we can positively conceive the character of such sparse perceptual states: maybe perceptual imagination does not stretch that far. Nonetheless, we can positively conceive of a world in which a subject meets the foregoing description.

Now consider a colour analogue of visual disorientation. Imagine a subject  $S$  who is completely impaired in her ability to attribute monadic colours in scenario content: she cannot 'localise' the colours of objects in the hue and saturation dimensions of colour space. Nonetheless,  $S$  is able to perceive and identify objects' chromatic properties. Presented with a red disc,  $r$ , and an orange disc,  $o$ ,  $S$ 's visual perception has the protopositional content that  $r$  IS RED, that  $o$  IS ORANGE, and that  $r$  IS REDDER THAN  $o$ . Given the quasi-linguistic nature of protopositional content, representing that  $r$  IS REDDER THAN  $o$  does not necessitate any protopositional representation of the monadic colours of  $r$  and  $o$ . We can therefore imagine an extreme case, in which  $S$  is unable to perceive and identify the monadic colours of  $r$  and  $o$ , but is able to perceive and identify the chromatic relations between them. It is difficult to perceptually imagine what this sort of experience would be like for this subject. But we can certainly imagine a world in which  $S$  reports being visually aware of some difference between  $r$  and  $o$ , not attributable to any difference in their shape, size,

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<sup>8</sup> Justin Wong raised the issue that the perceptual system might employ a monadic protopositional content to represent parallelism, which is attributed to shapes rather than pairs of edges. For example, experience might have contents such as X HAS PARALLEL VERTICES. This would undermine the foregoing as a putative case of relational geometric representation without monadic geometric representation. I trust, however, that as long as some genuine, non-redundant spatial relations are admitted into protopositional content, it will be easy enough to generate other examples along similar lines.

texture, or lightness. We can imagine *S* being able to perform certain tasks, such as equating the apparent difference between *r* and *o* with the difference between other objects standing in the same colour relation, and discriminating this difference from that between objects standing in different colour relations. We can imagine neuroscientists finding patterns of neural activity associated with visual processing of such objects, which correlate closely with determinable colour relations such as being redder than, or greener than. All the imagined evidence supports the hypothesis that *S* represents colour relations in protopositional content; none of the evidence suggests that *S* has a capacity to represent monadic colour properties. This case would suffice for a kind of PRCR.

In his discussion of Akins's problem, Mandik describes some possible real world cases of visual shape phenomenology without colour phenomenology. As he explains (2014: 231),

That visual phenomenology can actually be so sparse is evidenced by certain surprising breakdowns of normal functioning... Evidence more directly pertinent to Akins's Problem comes from studies of cerebral achromatopsic patient, M.S., who is able to see shapes defined only by hue contrasts with their backgrounds even though he is not able to see hues (he cannot visually discriminate, e.g., red from green) (Heywood et al. 1994).'

Cerebral achromatopsia, or 'cortical colour blindness,' is a pathology of colour experience arising from a lesion in the vicinity of the lingual gyrus and the posterior portion of the fusiform gyrus on the ventromedial surface of the occipital and temporal lobes. Complete cerebral achromatopsics completely fail standard colour vision tests, such as discriminating isoluminant stimuli, colour naming, and ordering samples of colour chips. As Mandik notes, despite this profound impairment, cerebral achromatopsics are able to see certain *forms*

defined solely by chromatic contrast, such as a red square on an equiluminant green background. This is typically explained by their preserved ‘colour-for-form’ processing, in which chromatic contrast is used to define object contours in early vision.<sup>9</sup> Mandik wants to explain it by appealing to the ‘concepts deployed in having the relevant conscious states,’ (2014: 231). That is, Mandik’s contention is that MS is able to deploy concepts of shape in having certain conscious visual states, though unable to deploy concepts of colour.

Something that Mandik does not discuss is that cerebral achromatopsics are not just visually aware of the *presence* of shapes defined solely by chromatic contrast: they seem to be visually aware of some of their *colour-related properties* as well. I propose that this residual awareness constitutes a type of PRCR. In a study by Heywood and colleagues (1991), MS was able to discriminate sequences of isoluminant squares ordered in respect of colour, from sequences of randomly ordered squares. Interestingly, Heywood and colleagues (1991: 802) reported that MS’s ‘verbal replies showed that he did so by detecting an edge between two stimuli that were, to him, perceptually identical.’ They infer that MS discriminated these sequences via ‘the detection of isoluminant chromatic borders without the registration of the nature of the hues themselves’ (1991: 810). But MS cannot be merely detecting the *presence* of these borders, for chromatic borders are present in both the ordered and random sequences. Rather it seems that MS is discriminating differences in the magnitude of chromatic variation that occurs at these borders. For what distinguishes the sequences is that neighbouring squares in the ordered sequence have uniformly small degrees of chromatic contrast, whereas neighbouring squares in a random sequence will have various different degrees of contrast, some likely quite large.<sup>10</sup> What is striking, moreover, is that MS

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<sup>9</sup> Shevell & Kingdom (2008: 152), Chirimuuta & Kingdom (2015: 226).

<sup>10</sup> Kentridge et al. (2004b: 162). Heywood et al. (1991: 810) suggest that ‘the salience of a chromatic border depends on the difference in chromaticity between the hues that provide the border.’ While they do not explain what is meant by ‘salience’, I take it that the phenomenal character of MS’s experience of these borders varied with changes in the magnitude of colour difference between the squares.

could only complete this task when the individual squares making up the sequences abutted one another. MS's performance reduced significantly when a 2mm achromatic strip was introduced between the squares.<sup>11</sup> MS's ability to discriminate magnitudes of colour variation thus depended on his awareness of the edges formed between neighbouring squares.

MS's abilities in this regard were confirmed by Kentridge and colleagues (2004a). The study probed 'the nature of the local chromatic contrast signals that can be accessed and discriminated by the visual system independently of their role in the perception of constant surface colour,' (2004a: 822). On one task, MS had to identify the odd one out among three coloured discs, presented on a uniform coloured background, as in Figure 1. For example, image (b) consists of three green discs against a yellow background. Two of the discs were identical, with cone-contrasts of 27.5% from the background. The third disc varied between cone-contrast increments of 75%, 62.5%, or 50% from the reference contrast. MS could distinguish the odd one out at all three contrast increments, though his performance was worse for the smaller increments (2004a: 825-6). They also found that MS could discriminate contrasts of equal magnitude in the opposing directions of redness and greenness, as in image (d). MS viewed three discs with equal cone-contrasts of 27.5% from the yellow background, but two of the discs were red (green) and one of the discs was green (red). MS successfully discriminated the odd disc on 80 out of 96 trials, considerably better than chance (2004a: 826). The authors strikingly conclude that 'a cortically colour blind observer [MS] *perceives* chromatic local-contrast signals,' (2004a: 829, italics added). I suggest that this capacity constitutes a basic kind of relational colour representation.

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<sup>11</sup> MS was able to discriminate ordered from random sequences of achromatic stimuli when presented 2mm apart; only his ability to discriminate chromatic sequences was affected. Heywood et al. (1991: 809).

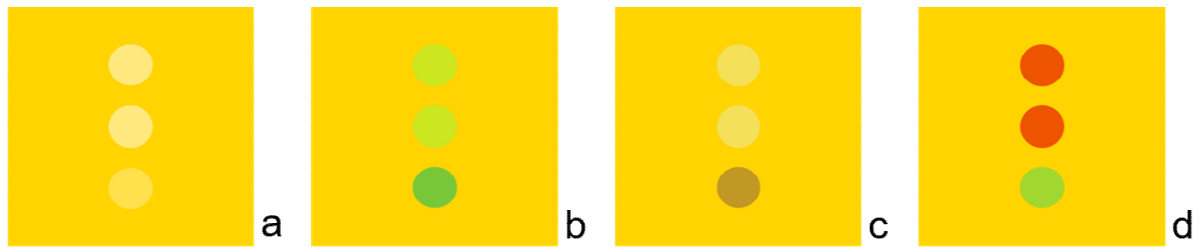


Figure 1 (Reprinted with permission from Kentridge et al. 2004a)

As with the earlier study, Kentridge and colleagues conjecture that MS performed these tasks by discriminating differences in the appearance of the edges of the discs.<sup>12</sup> Other interpretations are, of course, available. One is that MS is displaying a kind of *blindsight* for colour. Another is that MS might have some residual experience of *partial* colours, qualities defined by at most two of the three standard dimensions of hue, saturation, and lightness.<sup>13</sup> Finally, he might experience *alien* colours, defined by a different quality space to our own.<sup>14</sup> I consider these alternative interpretations elsewhere (Davies, forthcoming: §3.2). In the remainder of the paper, I work on the assumption that the edge-based interpretation of MS's abilities is correct.

Now, it is not immediately obvious how the linguaform model of perceptual representation can explain these findings. One problem with the linguaform model is that the representation of colour relations is not spatially localised at the edges of objects – at least, not in any clear way. We might become visually aware that the bottom circle in image (b) is  $N$  units greener than the background by representing that THE BOTTOM CIRCLE IS  $N$  UNITS GREENER THAN THE BACKGROUND, and aware that the top circle is  $M$  units greener than the background by representing that THE TOP CIRCLE IS  $M$  UNITS GREENER THAN THE BACKGROUND. But nothing about these putative protopositional representations predicts that the difference between these two experiences

<sup>12</sup> Personal communication.

<sup>13</sup> Brown (2014).

<sup>14</sup> MacPherson (2015: 120).

should manifest in a difference in the appearance of the *edges* formed between the circles and the background.

In order to explain the role of edges in driving MS's discriminations, then, I want to turn to a theory of iconic or imagistic perceptual representation, rather than discursive representation. The problem, however, is that our paradigms for iconic representation are ordinary pictures, composed out of coloured points or pixels. This suggests that the syntactic primitives in a theory of iconic representation will have monadic colour content built in, precluding the possibility of PRCR.<sup>15</sup> My response to this limitation is to expand the set of primitives to include edge or boundary elements, which lack monadic colour content, but may have chromatic contrast content. This allows the representation of colour relations 'at' the edges of surfaces. The next Section develops this view.

#### ***4. The Chromatic Edge Model***

When we visually perceive an object, do we represent its boundaries: its surfaces and their edges? Many philosophers seem to think so. Goldman (1977: 280) takes the differentiation of objects from their backgrounds to involve the 'representation of an edge or boundary.' Tye (1995: 141; italics mine) holds that perceptual phenomenology represents features such as '*being an edge*, being a corner, being square, being red'. Burge (2014: 492, fn.7; italics mine) assumes a class of 'basic, perceptual, space-based attributives... for *edges*, 2- and 3-dimensional shapes, lengths, sizes, textural units, bodies, and so on.'<sup>16</sup> This issue is controversial, however, for there is a long history of *boundary-free* views of perception, tracing back to Aristotle, through Ockham, Russell, Whitehead, Broad, James, and Peirce. These authors denied that visual spatial perception involves awareness of points or lines, in the

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<sup>15</sup> Kosslyn et al. (2006: 11-12): 'symbols belong to two form classes: points and empty space... The points can vary in size, intensity, and colour.'

<sup>16</sup> For empirical precedents, see Marr (1980) and Jackendoff (1987: Appendix B).



geometers' sense of entities with neither length nor breadth (points), or length but no breadth (lines). They took the basic units of spatial awareness to be three-dimensional bodies – or four-dimensional, in the case of Whitehead (1929). This is an interesting debate, which I consider in more depth in other work (Davies, m.s.). For now, I shall simply assume with Casati and Varzi (1999: 71) that edges are '*bona fide* spatial entities' that 'enter the content of our perceptions.'

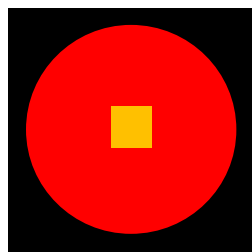
I also assume that when we perceive an edge between a figure and its ground, that edge is typically seen as, in some sense, *owned* by the figure. This idea traces back to Gestalt views on figure-ground organisation, such as in Koffka (1936: 181),

[A] closed contour line, although separated from the rest of the field on either of its sides by the same leap of stimulation, *belonged* to the enclosed figure and segregated it from the surrounding field.

In topological jargon, the figure appears 'closed,' in the sense of containing its boundary with the ground, while the ground appears 'open' in the region of its boundary with the figure.

Now, let us sketch a model of iconic edge representation. Iconic representations are *holistic*, in that they lack canonical decompositions into syntactic constituents that separately denote individuals and features. Take a picture of Boris Johnson. There are no constituent parts of this image that separately represent parts of Boris Johnson and the features of those parts, such as their shape, size, and texture. Rather, any constituent part of the image will *jointly* represent a part of Boris, together with the features of that part. Now, let's assume that this image has two types of primitive: there are *surface region primitives*, which represent parts of the surface of Boris, and *edge primitives*, which represent segments of the edges of Boris's surfaces. Surface region primitives holistically encode size, shape, texture, and monadic colour information. Edge primitives, in contrast, holistically encode curvature, length, orientation, and

chromatic contrast information. We can think of these edge-based chromatic contrast contents as directed magnitudes in colour space: vectors from one location (though no particular location) in colour space to another. The vector might tell us, for example, that there an edge marks a contrast of  $+N$  units along the red-green axis, or  $-M$  units along the yellow-blue axis. This leaves open the spatial direction or ‘polarity’ of the contrast.<sup>17</sup> In figure 2, for example, the boundary between the disc and the black background marks a strong +red contrast in the direction of the disc-shaped figure. To accommodate this, recall that on the Gestalt figure-ground assumption, edges are represented as belonging to just one of the surfaces that they bound. In this example, the circular boundary is represented as belonging to the disc, which appears ‘closed,’ rather than its background, which appears ‘open’. This edge-ownership feature determines the spatial polarity of the +red contrast: the edge representation ‘says’ that things get a certain degree redder in the direction of the figure that owns the boundary.<sup>18</sup>



*Figure 2*

This chromatic contrast content is unidirectional, in the following sense. Consider again the circular boundary of the red disc. My view is that our perceptual representation of this edge has the content that things get a certain degree redder in the direction of the figure that owns the edge. This representation does not simultaneously represent that things get *less* red in the direction of the background. Intuitively, the chromatic contrast vector tells us how to get from the background to the disc, but not how to get back. Of course, the visual system

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<sup>17</sup> On the neural representation of chromatic contrast polarity and border ownership, see Davies (forthcoming, §3.3), Zhou et al. (2000), and Friedman et al. (2003).

<sup>18</sup> Compare Clark (2000: 128), and see Davies (forthcoming, §2.3) for further discussion.

could easily derive this information by computing the inverse of this vector; but the view is that this information is not explicit in the original edge representation. Although this is an inessential feature of the view, one rationale is that visual perception prioritises the features of figure over those of ground. Figures, rather than grounds, tend to capture attention as the objects of perception. Accordingly, chromatic contrasts always ‘point’ in the direction of the region owning the edge: towards the figure, away from ground.

The chromatic edge model is supported by a range of empirical evidence, which I discuss in detail in Davies (forthcoming). The present aim is simply to show that it does a better job of explaining the data concerning cerebral achromatopsia, than the alternative linguaform model. The experimental data suggest that MS is able to discriminate both magnitudes and directions of chromatic contrast by attending to the edges of objects. The problem with the linguaform model was that protopositional representations of colour relations are not spatially localised at the edges of surfaces. In contrast, the chromatic edge model is expressly designed to represent chromatic contrasts at surface edges. To be clear, then, in applying this model to MS, the hypothesis is that he is able to pick the odd one out among the three discs in Figure 1, because he consciously perceives the boundaries of these discs, and represents these boundaries as having different local chromatic contrasts. Specifically, the circular edge of the bottom disc is represented as having a larger magnitude of +green contrast than the edges of the other two discs. The hypothesis is that this difference in chromatic contrast content determines a difference in the visual appearance of the edges of the discs, to which MS is sensitive in making his discriminations. MS is thus able to discriminate both magnitudes and directions of chromatic contrast, despite being completely unable to discriminate any differences in the monadic colours of the discs. Now, there are important limitations and complications with this view, which I discuss in Davies

(forthcoming). For now, however, our comparison of the chromatic edge model with the linguaform model tells firmly in favour of the former.

## **6. Conclusion**

The idea of primitive relational colour representation is admittedly unusual. The aim of this paper has been, firstly, to show that there are regions of conceptual space in which PRCR could occur. These include versions of the relational determination thesis and the no-determination thesis. Further development of these views must await another occasion. I substantiated these possibilities by presenting two models of perceptual representation that allow for PRCR: the linguaform model and the chromatic edge model. I argued that the chromatic edge model provides a better explanation of some surprising data concerning patients with cerebral achromatopsia. Once again, however, more detailed discussion of these issues lies beyond the scope of the present work.

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