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How Does Color Experience Represent the World?

Adam Pautz

There is no call to treat illusory sensible qualities, and in particular colours, as actual qualities of actual entities.

David Armstrong (1984)

Many favor *representationalism* about color experience. To a first approximation, this view holds that experiencing is like believing. In particular, like believing, experiencing is a matter of representing the world to be a certain way.

Once you view color experience along these lines, you face a big question: do our color experiences represent the world as it really is? For instance, suppose you see a tomato. Representationalists claim that having an experience with this sensory character is necessarily connected with representing a distinctive quality as pervading a round area out there in external space. Let us call it "sensible redness" to highlight the fact that the representation of this property is necessarily connected with the sensory character of the experience. Is this property, sensible redness, *really* co-instantiated with roundness out there in the space before you?[1]

Since the development of the new mathematical physics of 17th century, many prominent thinkers have returned a negative answer. Galileo, for instance, famously said that "tastes, odors, colors, and so on reside in consciousness", not the external world. Following this tradition, some contemporary representationalists hold that tomatoes and other objects are just collections of particles and fields lacking sensible properties. We evolved to have experiences that habitually misrepresent objects in space as having various sensible colors, only because this helps us to discriminate them from one another.

However, other representationalists resist this radical irrealist view. They think representationalism about color experience goes best with "realism" about sensible colors. The tomato's surface really does exemplify sensible redness. In general, our color experiences typically represent objects as they really are.

We will look at these different versions of representationalism. But first I will explain in more detail the basic representationalist approach they share.

[1] A note on terminology: Most representationalists, for instance Byrne and Hilbert (2003) and Tye (2000), think that ordinary color terms in English like "the color red", or "redness", or "that color" refer to what I'm calling "sensible redness". If they are right (and I think that they are), then we could drop the cumbersome term "sensible redness" and simply use "redness". But other representationalists, for instance Shoemaker (1994) and Chalmers (2010, essay 12), deny that ordinary color terms to refer to this property. So, to refer to this property, they invent special technical terms, like "phenomenal redness" (Shoemaker), or "perfect redness" (Chalmers). We all have the same property in mind; we just use different terms to refer to it. To stay neutral on this terminological disagreement, I have decided to introduce the neutral term "sensible redness" to refer to this property.

I. Representationalism about Color Experience: The Basic Idea

To understand representationalism, it is best to start with non-veridical color experience. Suppose that someone – call her "Mary" – suffers from "Charles Bonnet syndrome", a condition which involves having vivid hallucinations. Suppose in particular that she hallucinates a tomato. Intuitively, having this phenomenal experience is essentially connected with having an experience as of a *reddish* and *round* item in a certain location. But, in this case, no *physical* round and reddish thing is present. So how come it is correct to say Mary has an experience as of a *reddish* and *round* item?

Before representationalism became popular, the dominant view was the *sense datum theory*. On this approach, what Mary experiences is a *non-physical* round and reddish item created by her brain – a "sense datum" or "mental image". In general, sensible colors do not qualify ordinary physical objects, but such mental images of them created by the brain. However, this view faces well-known puzzles.[2]

Enter the representationalist alternative. On representationalism, all that is going on is that Mary's experience "represents" that there is something before her with the properties *being round* and *reddish*. This doesn't require that there really is an item – a peculiar mental "sense datum" – that has these properties. On representationalism, Mary's hallucination is like a belief in that it is a "representational" state that can represent properties belonging to no real (physical or mental) thing.

But, of course, Mary's hallucinatory experience is a representational state of a kind very different from belief. Hallucination, unlike mere belief, involves a *vivid impression* of the *real presence* of a thing. To explain this, representationalists would claim that, in having her hallucination, Mary stands in a very *unique* representational relation to the properties *being round* and *being reddish*, even though those properties are not presently instantiated before her. I will call it the "perceptual representation relation". This hypothesized relation is unique in that, when one bears it to some properties, one has the vivid impression that there is an object present with those properties. Indeed, on a simple form of representationalism, Mary's having her tomato-like hallucination *is just identical with* her perceptually representing (or "perceptually predicating") a cluster of tomato-like properties such as *being reddish* and *being roundish* (where these properties can exist even if they aren't instantiated by any real thing). Representationalists, then, do not appeal "sensations", or "qualia", that are distinct from and lie behind perceptually representing the world to be a certain way (*pace* Campbell, this volume); rather, they say that experiencing is *nothing but* representing.

In general, most representationalists hold that, necessarily, if two individuals have phenomenally different visual experiences, then they perceptually represent different clusters of sensible properties. Other representationalists advocate weaker versions of representationalism that allow for some exceptions to this general principle (e. g. cases where you perceptually represent the same properties but there is a change in which ones you *attend to*).

[2] However, the sense datum theory of color experience has recently been defended by Brown (2010) and Robinson (1994, 59–74), among others.

Representationalism about color experience has many virtues. It accommodates the undeniable fact that, necessarily, in having standard visual experiences, it seems that sensible colors are co-instantiated with certain shapes and location properties. For instance, necessarily, if one has a tomato-like experience, then one has an experience that matches the world only if a reddish, round item is present at a certain place. It also explains how both veridical and non-veridical experience can provide a subject with the capacity to think about and learn truths about sensible colors and shapes, even when they aren't instantiated by physical objects before the subject (Russell 1912, chap. X; Johnston 2004, 130; Tye 2014, 51-2). At the same time, it avoids the "sense data" of traditional sense datum theory.

For the sake of discussion, let us assume that representationalism is right. This view implies that every sensory experience has two elements: (i) the *perceptual representation relation*, and (ii) a complex of sensible properties that are the *relata* of this relation (sensible colors, shapes, audible properties, and so on).[3] So once we accept representationalism, we face a pair of difficult questions. For color experience, they are as follows.

First, the *sensible colors question:* what is the nature of the "sensible colors". For instance, what is the nature of the "sensible redness" which Mary perceptually represents as co-instantiated with roundness? Is it a property that tomatoes and other objects sometimes really have?

Second, there is the *representation relation question*. What is the nature of "the perceptual representation relation" that we bear to sensible redness and other perceptible properties? For instance, when Mary hallucinates a tomato, she bears this relation to *being reddish* and *being round*. How does Mary's brain enable her to "reach out" and perceptually represent these properties, so that they seem present before her, even though they are not really present before her? Is this "perceptual representation relation" a spooky non-physical relation between her mind and these sensible properties? Or can it be identified with some kind of unproblematic physical relation (e. g. the kind of "tracking relation" we'll discuss in the next section)? As Mark Johnston has observed (2011, 215-216), a central puzzle about the mind is how to "explain the relation of sensory intentionality".

Let us now to turn to different versions of representationalism about color experience. They differ in how they answer these twin questions.

2. Response-Independent Representationalism

I will explain *response-independent representationalism* by way of a simple argument for it based on considerations of *uniformity*. The argument starts with an account of our experience of shape, and then generalizes that account to the experience of color.[4]

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[3] Here and in what follows, I work with the simple *property-complex* formulation of representationalism. See Chalmers (2012, 343), Bealer (1982, 235-239), Dretske (1995, 101-2), McGinn (1999, 319-23), Tye (2014). On another formulation, representationalism is the view that having an experience consists in standing in a special relation (the "perceptual entertaining relation") to a *complete proposition* attributing sensible properties to things.

[4] Armstrong (1987, 36) and Byrne and Hilbert (2003, 7) stress the desirability of a uniform account of *color* and *shape*. The point to be developed is that it is desirable to have a uniform an-

Above we supposed that Mary has a hallucination of a tomato. Let's now suppose that she has an ordinary, non-hallucinatory experience of one. Let's start with the question: how does Mary perceptually represent the shape, *being round*? This is the "representation relation question" concerning shape.

Most philosophers are realists about space as we perceive it: they think that the shapes we perceptually represent are real properties of objects that are detected by our visual systems (but see footnote 26 for dissent). So the simplest answer would seem to be that Mary perceptually represents this property in much the same way that a thermometer represents a temperature. Very roughly: she perceptually represents the property of being round by virtue of undergoing an internal state (namely, a neural pattern) that, under biologically normal conditions, is typically caused by ("tracks") the instantiation of that shape in the environment. (Likewise for more primitive spatial features, like edges and angles.) This is a simple version of what we might call the "tracking" theory of how we perceptually represent shape.

Once we accept this "tracking" model of how Mary perceptually represents roundness, considerations of uniformity suggest using that same model to explain how she perceptually represents the reddish quality that seems to her to be co-instantiated with roundness. On such a uniform view, sensible redness, like roundness, is a real, objective property of the tomato that our visual system causally detects or tracks. What could this property be? Our visual system tracks *reflectance properties:* that is, *dispositions to reflect certain amounts of incident light across the visible spectrum*. Objects that have different colors will have different reflectances (see Figure 1 below). So if we say that sensible redness *just is* a particular reflectance property of the tomato, the payoff is that we can then say that Mary perceptually represents this property *in the same way* she represents the property of being round.

This view may seem immediately implausible because sensible colors seem to be *non-dispositional*, *simple* properties that you can't define in other terms. But maybe this is just wrong. On the basis of ordinary experience, it doesn't seem to us that water is H_20. But that is what water is. Similarly, maybe sensible colors are in fact complex dispositional properties involving light, even if this is not visually evident.[5]

This approach also applies to illusion and hallucination. For example, return to Mary's tomato-like *hallucination*. How can she stand in the perceptual representation relation to the property *being reddish* (and also the property *being round*), even though it is not instantiated before her? What is it for this sensible property to be *ostensibly present* to her? On the tracking view, the answer is that the property *being reddish* is just a reflectance property. And Mary stands in a *tracking relation* to this property, even though she is hallucinating and this property isn't instantiated before her. Roughly, this consists her

swer to the question of how we manage to *represent* color and shape ("the representation relation question").

[5] Due to "metamerism", the best view in the vicinity is that colors are extremely unnatural *disjunctions* or *types* of reflectances (Byrne and Hilbert 2003, Tye 2000). There is a serious problem about how we might "track" and represent such unnatural properties (Armstrong 1987, 42 and Byrne and Hilbert 2003b, 792). But, for the sake of simplicity, I will ignore this issue.

standing in this relation to it: she undergoes a neural pattern that is *normally* caused by its instantiation (when she sees the tomato, for instance).[6]

This yields *response-independent representationalism* about color experience. It combines representationalism with the hypothesis that sensible colors are (like shapes) real properties objects that are totally independent of how we respond to them.[7]

Response-independent representationalism is *externalist*. On this view, the characters of your color experiences are not fixed by the intrinsic features of your neural processes. Rather, they are fixed by what reflectance properties those neural processes track in the extracranial world. For instance, Tye, a leading proponent, says that "[the brain] is not where phenomenal character is to be found" (1995, 162-3). Instead, his slogan is "phenomenal character is in the world" (2009, 119). So, for instance, the phenomenal character of your experience of red is not constituted by a neural pattern, but by a reflectance property (see Figure 1 below).

Response-independent representationalism, in the version we are considering, is also *reductive*. It combines representationalism with a reductive physicalist approach to experience. It holds that sensible colors are *identical with* complex physical properties (namely, reflectance properties) and the perceptual representation relation is *identical with* a complex physical relation between subjects and those complex physical properties (namely, a "tracking" relation). So it is attractively simple.[8]

However, there are also arguments against response-independent representationalism. Here we will look at two types of argument: the *structural-mismatch argument* and *arguments from variation*.

First, the *structural-mismatch* argument. To illustrate, suppose that someone – call him *Maxwell* - consecutively experiences a purple-looking grape, a blue looking ball, and finally a green-looking leaf. Now suppose Maxwell says, "blue resembles purple more than green". This is an evident truth about the *resemblance structure* of the sensible colors.

But it is a truth that response-independent representationalists apparently cannot accommodate. For the actual reflectance types typical of such objects

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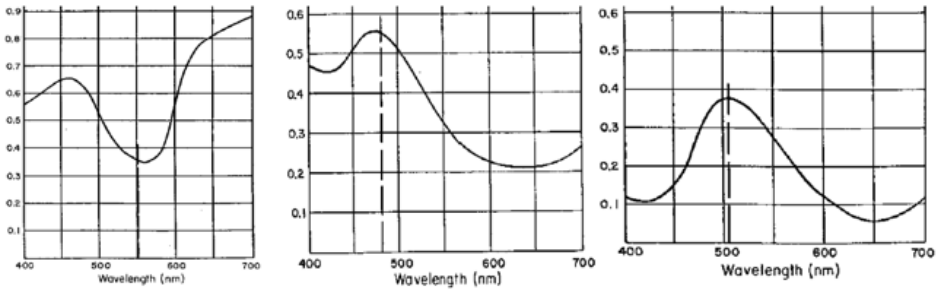
[6] More exactly, proponents of the tracking model identify the dyadic perceptual representation relation between individuals and sensible properties with a complex relation along the following lines: $\lambda x \lambda y$(*x* is in a internal state that is poised for cognitive access and that has the systemic biological function of tracking property *y*). See Dretske (1995,19-20), Tye (2000, 62), and Tye (2014, 51-2). This is a very simple sketch. Indeed, Byrne and Hilbert (2003) claim that *all* existing accounts are too simple. (MacPherson (2003) also raises a difficult puzzle about "novel colors".) However, I will use "tracking" generically to name *whatever* physical relation it is that we bear to reflectance properties which enables us to perceptually represent them, under the assumption that colors are reflectance properties. In this generic sense, even Byrne and Hilbert hold that perceptual representation is a matter of "tracking".

[7] David Armstrong (e. g. 1984) is originator of response-independent representationalism. More recent proponents of some form of this view include Byrne and Hilbert (2003), Dretske (1995), Hill (2009), Lycan (2001), Tye (2000).

[8] On one general formulation, "reductive physicalism" about some property or relation *R* (*being reddish*, *being a city*, etc.) is the view that *R* is identical with a *complex property* built up from the properties on some short list of "basic" physical properties and relations (e. g. the fundamental physical properties, together with various "topic-neutral" properties and relations such as *causation* and *similarity*). For different conceptions and defenses of reduction, see Lewis (1994), Jackson (1998, especially 62, 123), Sider (2011, chaps. 7 and 13), and Dorr (2008).

are shown in Figure 1 below. On response-independent representationalism, the sensible colors purple, blue and green *just are* these reflectance-types. So, on this view, Maxwell's statement is true just in case the blue *reflectance type* (in the middle) resembles the purple *reflectance type* (on the left) more than the green reflectance type (on the right). But, somewhat surprisingly, this is apparently not true. In fact, if anything, the blue reflectance type resembles the *green* reflectance type more than the purple reflectance type. So the identification of the sensible colors with the corresponding reflectances types implies that Maxwell's statement "blue resembles purple more than green" is *false*. Indeed, it seems to imply that "blue resembles *green* more than purple" is true! Since these implications are incorrect, the fact of structural-mismatch shows that sensible colors must be *distinct from* the corresponding response-independent reflectance types of objects.[9]



Purple reflectance Grape | blue reflectance ball | green reflectance leaf

Figure 1: Reflectances typical of purple, blue and green objects (from MacAdam 1985).

Why is there such a surprising mismatch between resemblances among the apparent colors of objects and the resemblances among those objects' reflectances? The answer seems to lie in our neural responses to those reflectances. For instance, even though the blue reflectance and the green reflectance are very similar, they lead to quite different neural responses in the brain, and this is why they lead to experiences of quite different sensible colors. This strongly suggests an alternative to response-independent representationalism. In particular, it suggests an account of sensible colors, and of their resemblances, in terms of our *neural responses*. We will return to these points later.

Some response-independent representationalists have tried to answer the structural-mismatch argument. In particular, Byrne and Hilbert (2003) have tried to give a response-independent account of the truth of "blue resembles

[9] Philosophers who have put forward the structural-mismatch argument include Hardin (1988, 66-67) and Thompson (1995, chap. 3). Scientists have long recognized the point when it comes to other sensible properties. For instance, Stevens *et al.* (1937) famously argued that *perceived pitches* cannot be identified with response-independent *frequencies*, on the grounds that the relations (in particular, equal intervals) among apparent pitches do not match those among frequencies.

purple more than green" in terms of reflectances. First, they assert that there are four basic *hue-magnitudes*, namely, *being reddish*, *being greenish*, *being yellowish*, and *being bluish*. They identify each of these four hue-magnitudes with a disjunction of reflectances (2003, 55). Thus, *being bluish* is just the disjunction of reflectances possessed by bluish objects (e. g. blue objects, purple objects, etc.). Then they say that the truth of "blue resembles purple more than green" amounts to the following: the blue reflectance-type and the purple reflectance-type, but *not the green reflectance-type*, imply a common hue-type (in this case, *being bluish*), that is, belong to one of the aforementioned disjunctions of reflectances. In short, they hold that when we say "blue resembles purple more than green", what we are saying is true just in case the relevant reflectance-types stand in the *hue-difference relation*, that is, the relation *x and y, but not z, imply belonging to a common hue-type (that is, imply having one of the aforementioned disjunctions of reflectances)*.

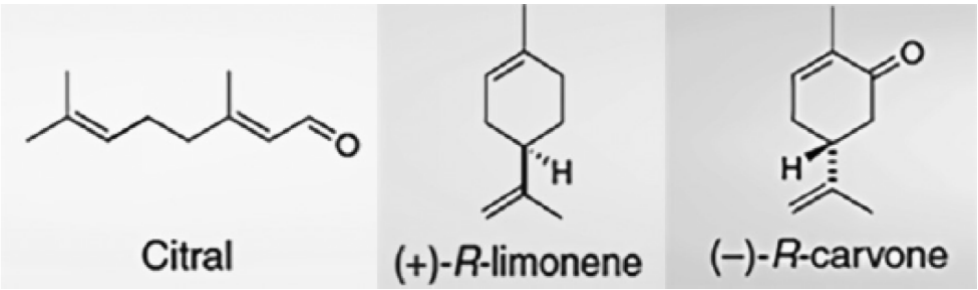
Byrne and Hilbert's response to the structural-mismatch argument faces several problems of detail.[10] However, here we will focus on one general worry about their discussion. Although we are focusing on sensible colors, it is important to realize that the structural-mismatch argument poses a g*eneral* problem for response-independent representationalists. Therefore, to answer the argument, it is not enough to focus just on the case of sensible colors, as Byrne and Hilbert do.

Let's look at the experience of smell. Byrne and Hilbert (2003, 59) note that, because we expect a uniform account of different sensible properties, re-

[10] Here are three main problems of detail facing Byrne and Hilbert's hue-magnitude proposal. (1) Byrne and Hilbert give no response-independent account of truths involving *degree* such as: *the degrees bluishness and reddishness in the ball are roughly equal* (so that *the ball roughly equally resembles a pure blue object and a pure red object*). Intuitively, this is not a truth about *numbers*, any more than *the height of the rectangle is equal to (or double, etc.) to its width* is about numbers. But if degrees of hue-magnitudes are not numbers, then what are they, and what is it for them to be "equal"? Byrne and Hilbert (2003, 55) apparently hold that *the degree of reddishness* that the ball possesses is just *a certain disjunction D1* of reflectances, namely the disjunction of the reflectances of all objects (all balanced blue-red objects, all balanced blue-green objects) that are bluish to this same degree. Likewise, they hold that *the degree of bluishness* that the ball possesses is just another *disjunction D2 of reflectances*. This implies that *the degrees bluishness and reddishness in the ball are roughly equal* iff *D1* is *roughly equal to D2*. But if *D1* and *D2* are just distinct (but overlapping) disjunctions of reflectances, as Byrne and Hilbert claim, then what is it for *D1* to be "roughly equal to" *D2?* (2) Byrne and Hilbert also give no response-independent theory of degrees of *brightness*. One idea would be to equate brightness with physical luminance. But this idea fails. At equiluminance, reds are brighter than greens (Corney et al. 2009). Indeed, a yellow patch might be brighter than a white patch, even if the yellow patch has lower luminance (Conway 2013, 11). So how would Byrne and Hilbert analyze "color *x* is brighter than color *y*" in response-independent terms, in particular, in terms of reflectances? (3) Finally, any adequate account must accommodate the truth of *general* claims of color resemblance such as "every color on the hue-circle resembles nearby colors more than farther away colors". But Byrne and Hilbert's hue-difference account of color resemblance is unable to accommodate the truth of such a general claim (Pautz 2011, p. 423-424, fn. 6). For instance, there are shades of purple *P1*, *P2*, and *P3* on the hue-circle such that that *P1* resembles *P2* more than *P3*; but they certainly don't satisfy the hue-difference relation as explained in the text. In response, Byrne and Hilbert might suggest that, for arbitrary colors *x*, *y* and *z*, *x* resembles *y* more than *z* iff there is some hue-magnitude *h* such that the *degree* of *h* of *x* is more similar to the *degree* of *h* of *y* than the *degree* of *h* of *z*. (Here I'm indebted to Keith Allen.) But this too is open to counterexamples: for instance, let *x* = R60, Y40, *y* = R63, B37, and *z* = R70, Y30. For other problems with Byrne and Hilbert's proposal, see Allen (2017, chap. 6).

sponse-independent representationalism about the experience of colors stands or falls with response-independent representationalism about the experience of other types of sensible properties. So if response-independent representationalism is right for the experience of color, you would expect a parallel account to apply to the experience of smell. On such an account, smell qualities (citrus, minty, etc.) are response-independent chemical types, and we perceptually represent them because our olfactory systems track them.

However, the structural-mismatch argument against response-independent representationalism rears its head here as well. To illustrate, let's take another example based on our actual resemblance judgments. Suppose that, after seeing objects with the reflectances shown in Figure 1, Maxwell consecutively smells the chemical types shown in Figure 2 below:



$citrus_2$ $citrus_1$ minty

Figure 2: From Margot (2009).

As a matter of fact, even though the first two chemical types are very different, they produce very similar neural responses in us. They cause in us experiences of similar, but distinguishable, citrus-like qualities (Howard *et al.* 2009). The third chemical type smells minty. So, Maxwell will judge "the middle smell ($citrus_1$) resembles the first smell ($citrus_2$) more than the third smell (minty)". This statement is evidently true. But, again, response-independent representationalism seems to have the absurd implication that it is false. For, on this view, the smell qualities that Maxwell experiences *just are* the *external response-independent chemical types* shown in Figure 2, which his olfactory system tracks. And the middle chemical type does *not* resemble the first chemical type more than the third – if anything, it resembles the third more than the first. Given the empirical facts, response-independent representationalism about smell just seems clearly wrong.

Response-independent representationalists like Byrne and Hilbert haven't responded to the structural-mismatch argument in the case of smell resemblance. Nothing like their "hue-difference" account applies here. As is well-known, there simply are no privileged "basic smell categories" in the way that Byrne and Hilbert think that there are four basic hue categories.

Here is another element of the structural-mismatch problem for response-independent representationalists. To illustrate, suppose that we encounter an island where all humans lack the experience of chromatic colors – they only experience black-white-grey – and also lack the sense of smell. Still, because

they do experience many *other* qualities (achromatic colors, taste qualities, audible qualities), they can acquire a general, topic-neutral concept of comparative resemblance among qualities, "quality *x* resembles quality *y* more than quality *z*". Now, suppose that we tell one of the islanders – call him "Larry" - about the colors and smell qualities I've discussed above, which are unlike any qualities he's experienced. And suppose we ask him to just guess the resemblances of these qualities that he cannot experience. Employing his general concept of comparative resemblance among qualities, he makes the following guess:

> [#] Blue resembles purple more than green and the citrus$_1$ smell resembles the citrus$_2$ smell more than the minty smell.

Intuitively, Larry's guess is (determinately) *true*. Analogy: given a finite number of examples of arithmetical sums, Larry can acquire a general concept of *plus*, which he can then use to make true (or false) claims about new cases.

However, response-independent representationalists cannot explain how Larry's guess [#] could be determinately true. For, on this view, the qualities his guess is about are the *reflectance-types* and *chemical properties* represented in the figures above. So, on this view, Larry's guess is true just in case the ordered-triple <the blue reflectance, the purple reflectance, the green reflectance> *and* the ordered-triple <R-limonene, citral, R-carvone> both satisfy a general, topic-neutral relation of comparative resemblance that is expressed by his use of the resemblance-predicate in [#]. But how could Larry's history on the island (his interaction with other physical properties) determine that his use of the resemblance predicate picks out a relation *that is satisfied by both of these trios of disparate physical properties*, *physical properties he has never interacted with*? The problem is not that there are *no* relations that are satisfied by these trios. Since relations are abundant, there are in fact *infinitely* many such relations; they are extremely disjunctive, unnatural relations, since they are instantiated by trios of disparate physical properties. Rather, the problem is that there are also infinitely many relations defined over reflectances and chemical properties *that are not satisfied by these trios*. And *since all these relations are equally unnatural and disjunctive*, *it's very hard how Larry's history on the island could have determined that his use of the resemblance predicate picks out a relation of the first sort rather than a relation of the second sort*. (It is not the case that relations of the first sort are more "natural" than relations of the second sort, in the way that *plus* is more natural than *quus*, and therefore easier for Larry to refer to: see Lewis 1983, pp. 375-376.) That is why, on response-independent representationalism, it's hard to see how Larry's guess [#] could be determinately true.[11]

[11] The argument here is not that response-independent representationalists must show that the truth of Larry's guess [#] can be deduced *a priori* from the response-independent character of the physical properties shown in Figures 1 and 2. In fact, they certainly should reject this *a priority* claim for standard reasons (see Davies 2014, 301-303). Rather, the argument is that, even if they do reject this *a priority* claim, they still must at least gesture at an *a posteriori* account of how Larry's managed to make a *true claim*, rather than a false (or indeterminate) one. Compare: a type-type neural identity theorist for pain needs to gesture at an *a posteriori* account of truths like "my second pain was more intense than my first pain" in terms of neural firing rates or whatev-

In the next section, we will see that alternative forms of representationalism avoid these problems concerning structural-mismatch.

Let us now turn to a second type of argument against response-independent representationalism: *arguments from variation*. We will consider a few different arguments of this kind.

Consider first an argument from *actual* cases of variation. While we are trichromats, some birds have a tetrachromatic color vision system that is sensitive to UV light. There is reason to think that, when a human and such a bird see a tomato, they experience different sensible colors. There is also variation *among* normal humans. For instance, the color chip might look pure blue to John and greenish blue to Jane, where John and Jane both have normal color vision. On representationalism, such variation means that different perceivers disagree concerning what sensible colors they perceptually represent objects as having. But if so, then it looks like they are stuck with saying that some perceivers are getting it right and the others are getting it wrong. But this kind of misrepresentation is implausible. All the perceivers have equal claim to being veridical perceivers of color.

However, this argument is unpersuasive. Response-independent representationalists have another option: they might accommodate such cases by accepting *color pluralism* (Tye and Bradley 2001, Byrne and Hilbert 2003, 16). To explain why the tomato looks different to us and to the birds, they might say that the tomato objectively possesses the color red *and* it also objectively possesses an alien color that we cannot imagine constituted by UV light. We track and thereby perceptually represent the red color while the bird tracks and thereby perceptually represents the alien color. So there is no color misrepresentation. Byrne and Hilbert (1997, 272-273) and Kalderon (2011) extend pluralism to variation among humans. The color chip viewed by John and Jane is *both* pure blue and slightly greenish blue, where these shades are identical with distinct but overlapping ranges of reflectances. John and Jane's different visual systems track and thereby represent these *different* but equally real properties of the chip.[12]

Because actual cases do not clearly undermine response-independent representationalism, some rely on the conceivability of certain *hypothetical* "altered experience" cases to try to undermine the view. One prominent example is

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er, even if they deny that such truths are *a priori* deducible from truths about firing rates and the line.

[12] There is evidently no formal contradiction in the pluralist view of Byrne and Hilbert (1997) that the color chip has one color that is completely bluish and a distinct color that is not completely bluish but rather a bit greenish as well as bluish. But it is very counterintuitive. For this reason, more recently, Byrne and Hilbert (2003) have converted to *inegalitarianism* about this case: they now assert that the chip does *not* have both shades. So, given response-independent representationalism, either John or Jane must be misrepresenting the chip. But now a new problem arises: since John and Jane are both normal perceivers, it is hard to see what could make it the case that one but not the other is guilty of misrepresentation (Cohen 2009). Byrne and Hilbert (2007, 90) reply that this is a general problem faced by anyone who accepts that John and Jane represent fine-grained colors. But, since Byrne and Hilbert also accept inegalitarianism instead of pluralism, they do face an *additional* question about John and Jane that others (for instance, pluralists) do not face, namely: what is the general theory of perceptual representation that entails that one of them perceptually represents a reflectance-type that the chip *possesses*, while the other perceptually represents a reflectance-type that it *does not possess*?

David Chalmers. To illustrate, let's turn back to the example about Suppose Maxwell. Maxwell looks at the ball with the middle reflectance shown in Figure 1. Then it looks *bluish* to him. Chalmers (2010, 415-416; and 400, n. 7) would say that it's conceivable that there should be another individual – call him *Twin Maxwell* – belonging to another human-like species who bears the *tracking relation* to *the very same* response-independent reflectance property of the ball as Maxwell, but who *phenomenally represents* a totally different sensible color - say, *being greenish*. If the conceivability of this "altered experience" case shows that it is really possible, then of course the phenomenal representation relation cannot be identified with a tracking relation, and sensible colors cannot be identified with reflectance properties.

In response, response-independent representationalists like Tye (2000, 109-111) have said that, when it comes to such cases, mere conceivability doesn't establish possibility. According to this response, such altered spectrum cases are *conceivable*, but maybe they are not *really possible*. Chalmers himself concedes (2010, 152) that such conceivability arguments may fail because we are ignorant of the true nature of the physical world. So there is reason to doubt that the mere *conceivability* of hypothetical "altered spectrum" cases refutes the externalist approach of response-independent representationalism.

This brings us to a final type of argument against response-independent representationalism based on variation in color vision. This argument is similar to the previous one, except that it relies on *research in neuroscience*, rather than mere conceivability, to argue for the possibility of a certain kind of "altered spectrum" case that is inconsistent with response-independent representationalism. This argument may succeed where the previous arguments from variation fail.

To illustrate the relevant research in neuroscience, we can use the same example that we used to illustrate the structure argument: the example where Maxwell consecutively experiences a grape, a ball, and a leaf with the reflectance-types shown in Figure 1. He then experiences purple, blue and green. His color experience of the ball resembles his color experience of the grape more than his color experience of the leaf. This phenomenological fact cannot be explained in terms of the reflectances of those objects tracked by his visual system: as we noted before, the reflectance of the ball does *not* resemble the reflectance of the grape more than the reflectance of the leaf. Now here is a question that we haven't looked at yet: what then *is* the explanation? Recent neuroscience supports the hypothesis that the explanation lies in his *neural responses* to those reflectances. In particular, Brouwer and Heeger (2009) and Bohon *et al.* (2016) found that, in brain area V4, neural similarity among distributed patterns of activity predicts phenomenal similarity among color experiences. In fact, if you order these distributed neural patterns by overall similarity, then they form a circle akin to the "color circle". So we can conjecture that the reason why *Maxwell's color experience of the ball resembles his color experience of the grape more than his color experience of leaf* is that his internal *V4 neural representation* of the ball is more like his *V4 neural representation* of the grape than his *V4 neural representation* of the leaf. The explanation is to be found inside, not outside.

Now we can use this research to construct a two-step argument for the possibility of a hypothetical altered spectrum case that is inconsistent with the externalist approach of response-independent representationalism.

First step. Imagine that Maxwell has a twin, Twin Maxwell, in a hypothetical human-like community that evolved differently than humans. Just like Maxwell, Twin Maxwell consecutively experiences a grape, a ball, and a leaf with the reflectances shown in Figure 1. Let us suppose that Twin Maxwell's V4 neural representations of the grape and the leaf are identical with Maxwell's. However, because of naturally evolved differences in this community's postreceptoral wiring, let us suppose that Twin Maxwell's V4 neural representation of the *middle* object only – the ball – differs from Maxwell's. Specifically, while Maxwell's V4 neural representation of the ball resembles his V4 neural representation of the grape more than his V4 neural representation of the leaf, in Twin Maxwell the *opposite* his true: his V4 neural representation of the ball resembles his V4 neural representation of the *leaf* more than his V4 neural representation of the grape. As a result, while Maxwell sorts the ball with the grape, Twin Maxwell sorts it with the leaf. At the same time, we can suppose that Twin Maxwell's V4 neural representation of the ball, although it is different from Maxwell's V4 neural representation, *tracks* exactly the same reflectance-type as Maxwell's V4 neural representation, namely a reflectance-type that includes the reflectance shown in the middle in Figure 1. Therefore, on viewing the ball, they bear the *tracking relation* to the very *same reflectance-type*. Analogy: two people, in who belong to different language communities, can use different words to track the same type of object.[13]

So far, we have only stipulated the physical facts about the case. We have left open how Twin Maxwell's color experiences of the objects compare to Maxwell's. That is the crucial issue.

Second step. What is the most reasonable view on this issue? Well, when it comes to the first and third objects, namely the grape and the leaf, everything is physically the same between Maxwell and Twin Maxwell: they respond to the reflectances of these objects with the very same neural processing and the very same V4 neural states. So, presumably, the grape looks *purplish* to both, and the leaf looks *greenish* to both. But what about their experience of the ball in between? We know that, while Maxwell's V4 neural representation of the ball resembles his V4 neural representation of the *purple-looking grape* more than his V4 neural representation of the green-looking leaf, in Twin Maxwell the opposite is true: Twin Maxwell's V4 neural representation of the ball resembles his V4 neural representation of the *green-looking leaf* more than his V4 neural representation of the purple-looking grape. We also know that similari-

[13] Let me clarify this case a bit. As I noted before (see footnote 5), because of metamerism, response-independent representationalists identify the blue color of the ball with a general "class" or "disjunction" of reflectances. This might be called a "reflectance-type" or "reflectance-class" (Byrne and Hilbert 2003, Tye 2000). This reflectance-class includes the reflectance of the ball shown in Figure 1 (call this *R1*) *and* all the other reflectances (*R2*, *R3*, *R4*) of objects that normally have the same effect on the visual system and so look the same shade of blue. So, here is a more complete description of the case I'm imagining: When Maxwell views the ball, he has a V4 neural representation that tracks (is normally caused by), and thereby represents, this *reflectance-class* (that is, it can be caused by *R1 or R2 or R3 or R4*). When Twin Maxwell views the ball, his V4 neural representation, although different, tracks (is normally caused by) this very same *reflectance-class* (*R1*, *R2*, *R3*, *R4*).

ty among the reflectances tracked by the color system is a very poor predictor of phenomenal similarity and that similarity in V4 neural states is the only good predictor of phenomenal similarity. So, the most reasonable view is that, on viewing the ball, while Maxwell experiences *blue*, Twin Maxwell experiences a *greenish color*. This verdict is also supported by their different sorting dispositions.

But this most reasonable verdict about the case is inconsistent with response-independent representationalism. On response-independent representationalism, they should the very same color experience, *because they bear the tracking relation to the very same reflectance-type*. The neural difference shouldn't make a difference to the character of their experiences, because it doesn't make for a difference in what they track. Since this verdict is not reasonable, we must reject response-independent representationalism. Even though they *track* the *same* response-independent *reflectance-type*, Maxwell and Twin Maxwell *experience* different *sensible colors*, contrary to response-independent representationalism.

Let us use "internal-dependence" to name the thesis that there are possible hypothetical cases in which two individuals have different experiences (and hence, given representationalism, phenomenally represent different properties) because they have suitably different neural states, even though those neural states track exactly the same response-independent properties. In general, the present argument has two steps. First, many different lines of research, across the sense-modalities, provide overwhelming support for internal-dependence.[14] Second, response-independent representationalism is incompatible with internal-dependence. Call this *the internal-dependence argument*.[15]

Notice that the internal-dependence argument against response-independent representationalism differs from the structure argument, even if we used the same example to illustrate both arguments. The structure argument was that response-independent representationalism cannot accommodate the truth of claims like [#], given the mismatch between our judgments of similarity among sensible properties and the similarity relations among the corresponding response-independent physical properties. The internal-dependence argument is different. The internal-dependence argument is that response-independent representationalism, as an externalist theory of phe-

[14] For research on color vision supporting internal-dependence, see Brouwer and Heeger (2009), Conway (2013), Danilova and Mollon (2016), Forder *et al.* (2017), and Schmidt *et al.* (2014). For research on audition, taste, smell and pain supporting internal-dependence, see Chang *et al.* (2010), Crouzet *et al.* (2015), and Howard *et al.* (2009), and Coghill et al. (1999). For an overview, see Kriegeskorte and Kievit (2013). Since internal-dependence is especially well-supported for non-visual modalities, it is unlikely that color vision is an exception.

[15] For the internal-dependence argument, see Pautz (1998), (2003) and (2010). For discussion, see Allen (2017, pp. 68-73), Cohen (2011, 82-88), Fish (2013, 58-59), and Kalderon (2011, 250-256). Kalderon (this volume) suggest that Shoemaker (2003, 269) uses a similar argument. But Shoemaker's argument is quite different. In fact, Shoemaker (2003, 269) gives no argument at all thinking that the relevant kind of "altered spectrum" case is possible except that we can conceive of it (he says "we can imagine" such a case). So he seems to defend the conceivability argument discussed above. We saw that this argument is vulnerable to the response "conceivability doesn't entail possibility". By contrast, the internal-dependence argument relies on *empirical research* across the various modalities to argue that such a case is possible, not mere conceivability. Therefore, it is not vulnerable to the response "conceivability doesn't entail possibility".

nomenal character, cannot accommodate an additional fact: the empirically-supported role of the brain in shaping the phenomenal character of experience.

The internal-dependence argument may succeed where other arguments from variation fail. It is invulnerable to the "pluralist" response that response-independent representationalists may use to handle *actual* cases of variation. For, even if the ball has a plurality of chromatic properties, we have stipulated that Maxwell and Twin Maxwell track exactly *the same* one when they see the ball. So response-independent representationalism inevitably delivers the mistaken verdict that they experience the same sensible color, despite the radical neural and behavioral differences between them (Cohen 2009, 86).[16] Further, the internal-dependence argument is invulnerable to the "mere conceivability doesn't entail possibility" response that can be used to answer David Chalmers's argument against response-independent representationalism. In fact, the internal-dependence argument doesn't rely on conceivability at all to establish the possibility of individuals experiencing different sensible colors while tracking the same response-independent properties. Instead, it provides a two-step *empirical argument* for this possibility.[17]

Given internal-dependence, *internal neural responses* play a big role in determining what sensible colors we perceptually represent in external space. This brings us to response-dependent representationalism.

3. Response-Dependent Representationalism

I will introduce *response-dependent representationalism* by way of explaining how it might accommodate "internal-dependence". Recall that, given internal dependence, Maxwell and Twin Maxwell track the same reflectance property of the ball, but nevertheless perceptually represent it as having different sensible colors, namely *being bluish* and *being greenish*, due to their differing internal neural states.

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[16] For the same reason, the response-independent representationalist cannot in this case use the inegalitarian response that Maxwell or Twin Maxwell is *misrepresenting* the color of the ball, contrary to Byrne and Tye (2006, 253). For this point, see Cohen (2009, 86).

[17] There is another important problem for response-independent representationalism quite different from the empirical problems I have focused on. In particular, Chalmers (2010, 354-355) suggests that this view faces a problem about *experiential indeterminacy*. Here is an especially difficult case (not considered by Chalmers). Consider the well-known "inverted earth case". (For details, see for instance Lycan 2001, 30-31.) But let's add a twist. To begin with, suppose that there is an Earthian male whose neural representation *S* of the sky has the biological function of tracking *blue*, and an inverted Earthian female whose neural representation *S* of the sky instead has the biological function of tracking *yellow*. Strictly speaking, they belong to different species, which evolved on the different planets independently. However, let us suppose that, by an outstanding coincidence, they are genetically nearly identical (except for their different color vision), so that they can interbreed and have a child. Now here is the problem: on response-independent representationalism, it will presumably be *indeterminate* whether the *child's* neural representation of the sky, *S*, represents yellow or blue, since it is indeterminate whether in this creature *S* has the *historical*, *biological function* of tracking yellow or blue (for we may suppose that there is nothing that could settle whether the child belongs to one parent's species rather than the other's). If so, it will *indeterminate* whether it has a yellowish or bluish color experience. But it is deeply counterintuitive that color phenomenology could be radically indeterminate in this way.

In one version, the proposal of response-dependent representationalists is that the different sensible colors that Maxwell and Twin Maxwell perceptually represent are identical with the different dispositions of the ball to cause their differing internal neural states (call them "*N1*" and "*N2*").[18] So, the bluish sensible color that Maxwell experiences is identical with a response-dependent property of the ball along the lines of: *normally causing neural state N1 in members of one's kind.* (Or maybe *normally causing N1 in members of some kind or other*.) By contrast, the greenish sensible color that Twin Maxwell perceptually represents is identical with a different such property: *normally causing neural state N2 in members of one's kind.* On this view, the visual system is narcissistic: it represents how objects affect the visual system.

So response-dependent representationalism shows more promise in accommodating internal-dependence than response-independent representationalism. Unlike response-independent representationalism, it may also be able to accommodate our "structure judgments". On this view, judgments about the resemblances among sensible colors are not about response-independent reflectances properties of objects like those in Figure 1, as on response-independent representationalism. Rather, they are judgments about response-dependent properties of objects of the form *normally causing neural response N*. Now, such response-dependent properties resemble insofar as the responses in terms of which they are defined resemble (Johnston 1992, 240). So if, as empirical research seems to indicate (Brouwer and Heeger 2009), the resemblances among our internal neural states in the color vision system match our judgments of resemblances among sensible colors, then those judgments come out true. Response-independent representationalists can generalize the same account to our judgments of resemblances among other sensible properties, such as judgments about the resemblances among smells considered in the previous section.

However, response-dependent representationalism faces problems of its own. We will focus on two.

First, response-dependent representationalists have focused almost exclusively on what I have called the "sensible colors question". But what is their answer to the "representation relation question" about how we *represent* sensible colors?

As noted in §2, it is natural to use a broadly "tracking" model to explain how we can perceptually represent spatial properties, and considerations of uniformity suggest generalizing this account of the perceptual representation of sensible colors. But response-dependent representationalists cannot accept a tracking model for the perceptual representation of sensible colors.

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[18] This might be called "the neural response version" of response-dependent representationalism. Harman (1996, 10) and Kriegel (2009, 90) are proponents. Shoemaker (1994) defends a different version, on which the relevant responses are *color experiences*. But it faces a serious circularity problem that is avoided by the neural response version. For discussion of this point, see Harman (1996, 10), Kriegel (2009, 88) and Levine (forthcoming). For these reasons, I will focus on the superior "neural response" version, which avoids the circularity problem. *Fregean representationalism about color experience* (Chalmers 2010, essay 11) is very similar to response-dependent representationalism. It holds that one has a bluish experience iff one has an experience that represents that something has the property *having the unique property that normally causes bluish experiences.* I will not discuss it separately here.

To see this, return to the case of Maxwell and Twin Maxwell. On response-dependent representationalism, they perceptually represent the ball as having different sensible colors, identified with relational properties of the form *normally causing so-and-so neural state*. But they do not in any sense *track* these different complex, relational properties. For instance, Maxwell's internal neural state *N1* is not *caused*, under biological normal conditions, by the instantiation by the ball of the relational property*: normally causing that very neural state*, *N1*, *in Maxwell's population*. For the property of *normally causing N1* isn't itself casually efficacious in causing *N1*. Our visual systems are not causally sensitive to such properties. Furthermore, *N1* arguably doesn't have the *biological function* of tracking this specific ecologically insignificant relational property. Similar remarks apply to Twin Maxwell. On the contrary, Maxwell and Twin Maxwell's different internal neural states are caused by, and have the function of tracking, the *same reflectance property* of the ball (Cohen 2009, 86), since the color system is geared to recovering surface reflectances. Since response-dependent representationalists claim that they *perceptually represent* different response-dependent properties, it follows that they cannot identify the perceptual representation relation with a standard tracking relation.

But if Maxwell and Twin Maxwell's visual systems do not have the function of tracking the relevant response-dependent properties of the ball, then what is the alternative account of how they perceptually represent them? Sydney Shoemaker, a prominent defender of this approach, candidly admits, "I have no fully satisfactory answer" (1994, 37). Call this the *representational problem*.

The problem is made more difficult by the fact that the ball has *multiple* response-dependent properties of this sort involving different subjects, different responses, and different conditions: for instance, it *normally causes certain V4 neural responses in Maxwell under certain conditions*, it *normally causes certain V4 neural responses in Twin Maxwell under certain conditions*, it *normally causes certain retinal activity in Maxwell*, and so on. What makes it the case that Maxwell perceptually represents one *specific* response-independent property on this list, and Twin Maxwell perceptually represents another? What makes it the case that certain *specific* response-dependent properties are visually represent to them?

In fact, the problem is even more difficult than this. For, in addition to perceptually representing sensible colors, we of course perceptually represent *spatial properties*, such as shapes, positions, and distances. These spatial properties are evidently *not* response-dependent properties of the form: *normally causing neural response X*. So, response-dependent representationalists must answer the following question: what is the *single*, *uniform* reductive theory of the perceptual representation relation that implies that in some cases we perceptually represent funny *response-dependent* properties of the form *normally causing neural response X in individuals with color system S* (or whatever response-dependent with which they identify the sensible colors), while in other cases we perceptually represent *response-independent* spatial properties of a radically different sort? It would be implausible to answer by saying that the shape-system has the function of indicating response-independent shape properties, while the color-system has the sole function of indicating these entirely different, funny response-dependent properties (rather than, say, the function of indicating re-

sponse-independent *reflectance* properties, or simply the function of guiding our behavior in a useful way). Since the notion of "the function" of a system is unclear, it is just not at all obvious what could this mean and what could make it the case.[19]

There is a second, much simpler problem for response-dependent representationalism. Briefly, on this view, sensible colors are *relations* to types of neural states and types of perceivers. But this doesn't fit the phenomenology. Sensible colors just don't look like relations. They seem non-relational. Indeed, they seem "simple". Call this the *phenomenological problem*.[20]

So far, we have looked at one version of response-dependent representationalism. But it is not the only version. Colin McGinn (1996) has devised a complicated novel version that is designed to avoid the phenomenological problem. As a bonus, it suggests an answer to the representational problem. Let me explain.

The version of response-dependent representationalism we have so far considered is *reductive:* it *identifies* sensible colors with response-dependent, physical properties of objects (see note 8). McGinn (1999) defends a form of representationalism. But, against reductive representationalism, he insists (1996, 541-542) that, "when we see an object as red we see it as having a *simple*, monadic, local property of the object's surface", distinct from any complex physical property. He is a *non-reductive representationalist*.

Even though he thinks colors are simple, non-relational properties of objects, McGinn also holds that it is just a brute "law of metaphysics" that their instantiation by objects is tied to those objects' effects on perceivers. This is what makes his view qualify as *response-dependent*. In particular, he postulates the following general principle: it is metaphysically necessary that an object has a simple sensible color *C* if and only if, and because, it normally causes the

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[19] For presentations of this "representational problem" for the response-dependent representationalism, see Pautz (2010, 350-355), and Byrne and Hilbert (forthcoming). For a response, see section 3.5 of Jonathan Cohen's contribution to this volume. Cohen's response is that we certainly can represent *in thought and language* fine-grained response-dependent properties. For instance, I can say "consider a property of the form *causing neural state, N1, in Maxwell's population under precise viewing circumstances C1*", and thereby refer to a property of this kind. Cohen then suggests, "if so, then it's open to [response-dependent representationalists] to hold that whatever accounts for the mental representation of such properties [*in thought and language*] can also serve as an account of how states of the *visual system* represent the very same properties". But this is mistaken. The correct account of my ability refer to such a fine-grained response-dependent property *in thought* is that I speak a *language* with a compositional semantics, and this language has symbols like "neural state", "Maxwell's population", "precise viewing circumstances". So I can form a complex predicate out of these terms in order to represent to a fine-grained response-dependent property. Contrary to Cohen, the same compositional, language-based account definitely cannot serve to explain the *perceptual* representation of these properties, for a very simple and decisive reason: the format of perceptual representation is *not* language-like but rather *iconic* (Tye 1995). Even setting this point aside, the suggestion is incredible. What evolutionary advantage would come from the visual system being innately equipped with symbols like "neural state", "my population", "precise viewing circumstances C1", and forming, whenever enjoys a color experience, a complex representation along the lines of "there is an object out there that causes neural state, *N1*, in my population under precise viewing circumstances *C1*". There are other problems with Cohen's response. For instance, he doesn't address the "uniformity problem" mentioned in the text (see also Pautz 2010, 353).

[20] For this problem, see Armstrong (1984, 170), Boghossian and Velleman (1989) and McGinn (1996). One response depends on the "neutrality thesis". For discussion, see McGinn (1999).

experience of that very sensible color, *C*, in some normal perceivers under some normal conditions. Call this [Bicon], because it is bi-conditional claim.

Let's take an example. The ball in our example above has the property: *normally causing experiences of the property of being blue in normal humans (like Maxwell) under normal conditions*. By [Bicon], the fact that the ball has this relational property *grounds* the fact that it actually instantiates the property *being blue*. Nevertheless, according to McGinn, *being blue* is a "simple", non-relational property of the ball that is *distinct from* this relational property that always grounds it. So McGinn thinks that [Bicon] doesn't amount to a *reduction* of *being blue*. Likewise, because the ball is also disposed to normally look greenish to normal twin humans (like Twin Maxwell), it *also* instantiates the simple property *being greenish*, according to [Bicon]. In general, thanks to [Bicon], objects are guaranteed to really possess exactly those simple colors that they normally appear to possess.

McGinn's view provides a unique origin story for color. Given [Bicon], before sentient creatures evolved, objects had no sensible colors, for the simple reason that they did not habitually look to have any colors to any individuals. Then brains evolved that have an intrinsic capacity to enable us to perceptually represent objects as having certain simple sensible colors. That is, brains evolved that in this sense "project" simple colors into objects. Thanks to [Bicon], those objects thereby *acquired those* (and only those) simple sensible colors, in addition to their scientific properties. In other words, [Bicon] guarantees a fortunate match between appearance and reality when it comes to sensible colors.

McGinn's non-reductive response-dependent view avoids the two problems with the reductive version considered above. First and most obviously, it avoids the "phenomenological problem" facing the reductive version. For, on McGinn's non-reductive version, sensible colors *themselves* are simple, non-relational properties of objects just as they appear to be, even if by [Bicon] they are *grounded in* distinct complex, relational properties of those objects.

As we saw, the reductive response-dependent theorist also faces a "representational problem". McGinn faces a question here too: how do we manage to perceptually represent these alleged "simple" sensible colors? McGinn also cannot identify the perceptual representation between subjects and sensible colors with the externally-determined "tracking relation", for a couple of reasons. This goes against internal-dependence. And it requires that sensible colors are "out there" prior to our representation of them, which goes against [Bicon].

However, McGinn's view suggests an alternative answer to the "representational problem". Because he is already an anti-reductionist about sensible colors, he might provide a parallel *non-reductive* account of our ability to perceptually represent those sensible colors. In particular, he might say that this relation is irreducible, just as he thinks sensible colors are. That is, there is *no* true identity of the form: the perceptual representation relation = complex physical relation *R*. (Compare: it is implausible that there is a general *reduction* of the reference relation in physical terms, given that we can refer to such diverse things as chairs, numbers, and uninstantiated kinds.) Nevertheless, he might say that, whenever one bears this relation to some sensible colors, this is *grounded in* one's total internal neural state. Indeed, maybe it is possible in

principle to systematically "decode" what sensible colors an individual perceptually represents from her V4 neural patterns (Brouwer and Heeger 2009, Haynes 2009, Bohon *et al.* 2016). This yields a non-reductive and internalist form of representationalism (Chalmers 2010, Horgan 2015). It might be combined with non-reductive physicalism: experiential facts are *grounded in* physical facts, even if a general reduction is impossible.

It is worth noting another virtue of McGinn's view: it nicely avoids the structural-mismatch problem that we brought against response-independent representationalism (§2). On his view, the sensible colors that we perceptually represent are *simple* properties, which are quite distinct from the types of reflectances shown in Figure 1. So McGinn is free to say that these simple properties generally stand in exactly the resemblance relations they seem to stand in, even if the corresponding reflectances-types do not. For instance, he might say that, when Maxwell says "this shade of blue resembles this shade of purple more than that shade of green", he is correctly reporting that the shades stand in a unique unanalyzable relation of intrinsic qualitative resemblance (see e. g. Allen 2017, 124-125). Since this relation is very "natural" (in the sense of Lewis 1983), McGinn's view also accommodates the point (illustrated in §2 with the story about Larry on a remote island) that, once we experience a finite number of resembling qualities, we can easily determinately grasp this general relation. Then we can apply it to new qualities, and thereby make true or false claims.

McGinn's view also avoids a general problem that Chalmers (2010, 400) raises for all realist views of color. Chalmers suggests that realists are led to *chromatic explosion*. Let's go back to the ball with the reflectance shown in Figure 1. It normally looks one color to Maxwell. It could have looked another color to "Twin Maxwell". Indeed, Chalmers holds that, for any color you choose, the ball *could* normally look that color to a possible perceiver. So, to avoid favoritism or arbitrariness, musn't realists say that, right now, the ball has *all* of those colors? McGinn's view – which Chalmers doesn't consider – avoids this radical chromatic explosion. Given his [Bicon] principle, the ball possesses *only* those simple colors it appears to have to some *actual* normal perceiver under some normal conditions. In general, an object only has enough colors to make the experiences of *actual* perceivers generally veridical, and not more. This is a *limited* color pluralism.

While McGinn's view avoids some problems, it also faces a few new ones. Here I will mention two.

First, the case for [Bicon] is unclear. It is not *a priori*. This is shown by the fact that the *irrealist* representationalist view to be considered in the next section rejects [Bicon], but it cannot be ruled out *a priori* (Tye 2000, 170). The only argument for [Bicon] seems to be that it allows McGinn to agree with our pre-theoretical conviction that objects have the sensible colors they appear to have. But our pre-theoretical convictions have a bad track-record.

Second, simplicity considerations count against [Bicon]. It reports a necessary connection between two highly disparate sorts of properties, namely, *simple*, *occurrent sensible colors* and *complex dispositions of objects* to appear to have those sensible colors. It is not derivable from logic or from any general modal principles. It would have to be accepted as an additional, brute principle – a

special brute "law of metaphysics" (Rosen 2009, 133), or a "grounding dangler".

Third, [Bicon] faces a problem about borderline cases. As Hardin (1988) has emphasized, lighting conditions can radically influence color appearance but there is no precise cutoff between normal and abnormal lighting conditions. Now suppose that you view a color chip in lighting conditions C, where this is a *borderline* case of normal conditions. On McGinn's view, there is a specific simple shade that you determinately perceptually represent, which is somewhat different from the apparent shade of the chip in perfect daylight. Suppose you dub it "blue$_{31}$". Now, by [Bicon], the chip really instantiates blue$_{31}$ iff it looks blue$_{31}$ under normal conditions. Since in this case the right-hand side is indeterminate (since *C* is a *borderline* case of "normal conditions"), it follows from [Bicon] that the left-hand is indeterminate too. That is, there is this specific shade, blue$_{31}$, such that it is *indeterminate* whether the chip instantiates it. Hence [Bicon] requires "vagueness in the world", which many consider to be incoherent (Lewis 1993).

4. Irrealist Representationalism

Irrealism holds that ordinary physical objects don't instantiate sensible colors. All that is out there are particles and waves and fields. It became very popular after the scientific revolution of the 17th century and was defended by Galileo, Newton, Descartes, and Locke. Hardin (1987) and Chalmers (2010) describe the rejection of realism in dramatic terms: they call it a "fall from Eden".

Traditionally, irrealists have said that, although sensible colors do not qualify ordinary physical objects, they do qualify *something*. For instance, if you look at a tomato, the reddish quality *is* instantiated by a round item you experience (called an "idea", a "sense datum", or a "visual field region") located in a kind of private mental arena created by your brain (Boghossian and Velleman 1989). On this view, you only ever experience such very life-like mental images, which you mistakenly believe to be physical objects. But, as I noted at the outset, such "sense data" create serious puzzles.

Representationalism has made possible a new and more defensible form of irrealism. *Irrealist representationalism* holds that, when you view a tomato, you *perceptually represent* the property *being reddish* as co-instantiated with the property *being round*. So it *seems* that these properties are instantiated together before you. But, in fact, the property of being reddish is not instantiated by *anything*. It is not instantiated by a *physical* round thing before you; and it is also not instantiated by a *mental* round thing – there is no such thing. There is no reddish thing there of any kind, even though there seems to be one. So the property *being reddish* is a bit like the property *being a unicorn*: it is an entirely uninstantiated property. When it comes to sensible colors at least, the brain is a kind of "partial virtual reality machine", which projects onto objects some features that they don't really have.[21]

In some respects, irrealist representationalism resembles McGinn's view considered above. It shares with McGinn's view the following two claims.

[21] Recent proponents of irrealist representationalism, or something close to it, include Chalmers 2010, Mackie 1976, Maund 1995, Pautz 2006, and Wright 2003.

First, we perceptually represent objects as having *simple* color properties, which cannot be identified with reflectances or the like. Second, the brain has an intrinsic and innate capacity to enable us to perceptually represent these properties, without any contribution from the world. The difference is this: McGinn wants to accept the commonsense view that objects normally have the very simple color properties that the brain projects onto those objects, so he posits a brute principle, [Bicon], that guarantees this result. By contrast, irrealists reject [Bicon]. They deny that objects really have the simple color properties that the brain projects.

What is the argument for irrealist representationalism? In his influential paper, "Perception and the Fall from Eden", David Chalmers provides a mostly *a priori* defense of this view. As we saw (§2), he uses the conceivability of "altered spectrum cases" to rule out the view of response-independent representationalists that sensible colors are identical with reflectance properties. More generally, he argues that sensible colors cannot be identical with *any* physical properties, because there is an intuitive "epistemic gap" between sensible colors and all physical properties (2010, 399, 415). So, Chalmers concludes, sensible colors must be *simple*, *irreducible* properties. Then, as we noted before (§3), Chalmers argues that, to avoid arbitrariness, realists would need to accept the conclusion of "chromatic explosion": every object has every simple color (p. 400)! (Allen (2017, 71-72 apparently defends this view.) Chalmers says that "this conclusion is even more counterintuitive than the [irrealist] conclusion that all color experiences are illusory". So, he opts for irrealism.

But this complex *a priori* rationale for irrealism faces problems. First of all, as we already noted, Chalmers's conceivability argument against externalist approaches like response-independent representationalism is open to the standard criticism that "conceivability doesn't establish possibility". In other words, response-independent representationalists might agree that "altered spectrum cases" like the case of Maxwell and Twin Maxwell are *conceivable*, but then just deny that they possible. Second, even if representationalists accept the possibility of such cases, realism doesn't require "chromatic explosion". As we saw, McGinn's form of realism, which Chalmers does not consider, puts the brakes on chromatic explosion, and yet it is liberal enough to accommodate the veridicality of our actual color experiences in normal conditions.

However, there is also a more *empirical* argument for irrealist representationalism. This argument has two stages. *First stage:* representationalists can rule out *reductive* theories of sensible colors on the basis of empirical arguments, without having to rely on Chalmers's *a priori* considerations. In particular, sensible colors cannot be identified response-independent *reflectance properties* of objects. For this view is undermined by the structural-mismatch argument and the internal-dependence argument (§2). Sensible colors also cannot be identified with response-dependent properties of objects of the form: *normally causing neural response N in community C*. This view is undermined by the representational problem and the phenomenological problem (§3). So if representationalists want to be realists about sensible color, then their only option is to accept a view like McGinn's on which objects have *simple* sensible properties *over and above* their physical properties. *Second stage:* this type of view can now be argued against on the basis of *simplicity considerations* (§3). McGinn's view requires the [Bicon] principle, which posits a massive unexplained *coincidence*.

In particular, [Bicon] is the conjecture that, if we evolved so that our brain projects certain simple sensible colors onto objects, then *viola* those objects thereby *acquire* those very simple sensible colors. But why should nature be so obliging? There is no overwhelming *a priori* or empirical reason to accept this principle. Of course, it *could* be true. But irrealist representationalist will say that we are obliged to reject it for the same reason we are obliged to reject other needlessly complicated empirical theories.

Another consideration in favor of irrealist representationalism about color experience over the realist forms of representationalism is this. There are especially strong empirical and *a priori* reasons to think various *qualities* we feel in bodily regions (pain qualities, "pins and needles", etc.) cannot be identified with any real, mind-independent physical properties of those bodily regions. There are also especially strong empirical reasons to think that smell properties (discussed in §2) as well as audible properties (e. g. *phoneme-types*) cannot be identified with real physical properties of external items. These are all "projected" qualities. Why should we continue to insist that *sensible colors* are an exception? Why insist that they are really possessed by external items, if these other sensible properties are not (Locke 1869, II.viii.16)? [22]

Finally, there is an evolutionary argument for taking irrealist representationalism seriously. The primary function of the sensory systems is to enhance adaptive fitness - not to represent the way the world really is. There is every reason to expect that this should sometimes involve embellishment or error, depending on an individual's unique ecology. For instance, even if fruits are not intrinsically bright or sweet, it is understandable that we evolved to experience them as bright and sweet.

Irrealism in some form or another is the dominant view among color scientists. For instance, Cosmides and Tooby (1995, xi) maintain that "color is an invention that specialized circuitry computes and then projects onto physically colorless objects".

While irrealism is a popular view among color scientists, it is typically considered to be an outlandish "position of last resort" among philosophers. There is a curious disconnect between philosophy and science. Let us consider some of the philosophical objections to irrealist representationalism, together with possible replies.

Objection. The irrealist representationalist holds that, when you see a tomato, then *redness* is in some sense *ostensibly present to you*, and this is bound up with the character of your experience, even though *it is not instantiated in the world or in your experience.* But this is difficult to understand.[23]

Reply. To see that this is not an objection, consider a different example. Suppose you have the condition known as "Charles Bonnet syndrome which involves vivid hallucinations. You hallucinate an object with a very unusual

[22] For a host of empirical and *a priori* reasons for denying that pain qualities and other sensible properties aren't instantiated in the extracranial world, see Pautz 2010 and Levine forthcoming. For instance, in the domain of speech perception, it often happens that a categorical change in the perceived sensible property (e. g. from /da/ to /ta/) corresponds to no categorical change in the objective stimulus. It is impossible to be a realist about audible qualities; they are projections of the brain.

[23] For this objection, see Campbell (this volume), Levine (forthcoming), and Papineau (2016, sect. 13).

shape. In this case, everyone should admit that, necessarily, in having this experience, you in *some* sense ostensibly presented with an unusual *shape property*, and this is bound up with the character of your experience, even if this property is not instantiated in your environment or in your experience (setting aside exotic objects like "sense data"). This explains why everyone recognizes a sense in which your experience is *non-veridical*. It also explains how your experience gives you the ability to refer to this unusual shape property (a shape property you might have not recently encountered in real life). If this kind of delusory presentation of an uninstantiated property can happen with respect to shape, why can't it happen with respect to color?

Objection. But how could such color illusions *always* happen? How could the brain enable us to perceptually represent properties of a wholly novel sort that have *never* been instantiated in the world? Our standard models for explaining how we represent properties appeal to *tracking* real instances of those properties in the world, but irrealists cannot accept this view. In short, irrealism requires a total mystery when it comes to the "representation relation question" (Tye 2000, 166).

Reply. Irrealist representationalists can make a few points in reply. *First*, we already know from internal-dependence that tracking theories fail in the special case of perceptual representation. For instance, Maxwell and Twin Maxwell experience different sensible colors but track the same reflectance properties. In view of this, the best view of perceptual representation may be the internalist, non-reductive view we considered in connection with McGinn's approach. And that view is consistent with irrealism. On this internalist view, the brain has an intrinsic capacity to represent sensible colors and other sensible properties, *whether or not* they are instantiated in the world.[24]

Second, we already know, independently of the color debate, that the brain is "creative": it is not limited to representing what is there. For instance, it can represent uninstantiated kinds and abstract objects (Chalmers 2010, 417). So why not uninstantiated sensible colors?[25]

Third, the claim of irrealist representationalists that the brain has an intrinsic capacity to represent unreal sensible properties may look mysterious

[24] A clarification: Even if irrealists must hold that the brain alone explains our ability to *perceptually represent* colors, they needn't say that it explains the *existence and character of the colors themselves*. Instead, they might accept a "transcendent" view of color properties on which they exist necessarily and their character is entirely mind-independent (Russell 1912, chap. IX). Compare: the brain doesn't create numbers or the facts about numbers; it only grounds our capacity to represent numbers.

[25] Indeed, on irrealist representationalism, the *central* puzzle about experience becomes: *how can we perceptually represent uninstantiated sensible properties?* To illustrate, consider Frank Jackson's knowledge argument. In her black and white room, Mary learns all the truths about the instantiation of fundamental physical properties in our world. On irrealist representationalism, when she is released, she learns certain truths about non-physical sensible colors, for instance, that there exist these specific qualities, with specific natures or quiddities. But since these properties are uninstantiated, they are not themselves a problem for the physicalist claim that all instantiated properties are grounded in physical properties (Jackson 2004, 431). (Compare: physicalists can believe that there exists the non-physical property *being a unicorn*, and that we are related to it in thought, as long as they say that it is uninstantiated.) So if we accept irrealist representationalism, then we should say that the "sensible properties question" is not the real problem for physicalism. Rather, it is the "representation relation question": how can the brain enable us to *perceptually represent* these peculiar, uninstantiated non-physical properties?

only because we do not know enough about the brain. Maybe, if we had a more systematic understanding of the "neural code", we would understand why one neural state is the basis of representing the color red, while another is the basis of representing the color orange (Brouwer and Heeger 2009, Haynes 2009, Bohon *et al.* 2016).

Objection. Suppose you view a tomato. Then you have a neural representation of sensible redness "bound" in the brain with a neural representation of *roundness*. We just saw that irrealists must accept an internalist theory of how we perceptually represent sensible redness. But previously (§2) we saw that it is very natural to accept an externalist, tracking theory of how we perceptually represent shape. So irrealist representationalists require a non-uniform theory of perceptual representation. Since the perceptual representation of shape is inextricably bound up with the perceptual representation of sensible color, such a non-uniform theory is untenable: if the perceptual representation of sensible color is internally-determined, so too must be the perceptual representation of shape.

Reply. In fact, irrealist representationalists are not committed to a non-uniform theory of perceptual representation. Chalmers (2010, 443) and Horgan (2015) have argued the perceptual representation of spatio-temporal properties is internally-determined, just like the perceptual representation of sensible colors. In fact, one might go further and argue that perceived spatial-temporal relations are no more "out there" than sensible colors. For instance, it seems obvious that the spatial-temporal relations we phenomenally represent are not frame-relative, but relativity theory shows that no such relations are out there.[26]

Objection. Irrealist representationalism requires an implausible across-the-board error theory about all of our talk of colors.

Reply. In fact, irrealist representationalism does not require this. Recall Maxwell viewing the grape, the ball, and the leaf. He judges "the blue color resembles the purple color more than the green color". Remember that response-independent representationalists have trouble accommodating the truth of this judgment (see Figure 1). By contrast, irrealists can hold that this is a perfectly true judgment about the relevant sensible colors, even though they are not instantiated. Compare: there can be truths about resemblances among complex shapes, even if they are not instantiated. Maxwell also judges "the grape is purple, the ball is blue, and the leaf is green". Irrealists can say that he thereby expresses or implicates a truth about how these things habitually look (Boghossian and Velleman 1989; for a somewhat different conciliatory approach, see Chalmers 2006).

4. Conclusion

One general moral to draw from the preceding overview is that representationalism about color experience is a very flexible doctrine. It is compatible

[26] For discussion of the idea that relativity theory and quantum mechanics support irrealism about the spatio-temporal properties we perceptually represent (perceived simultaneity, perceived three-dimensional shape), see Chalmers (2012, 296-297, 333), Boghossian (2011, 56), and Ney (2013, 177-181).

with just about every major view on the metaphysics of sensible colors.[27] The hope of representationalists is that their view can simultaneously accommodate two facts: (i) the phenomenological fact that we ostensibly experience sensible colors "out there" along with shapes and locations, and (ii) the empirical fact that the experience of sensible colors is bound up with neural processing in the head.[28]

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[27] Contemporary *naïve realism* is not as flexible as representationalism. While there are internalist versions of representationalism, naïve realism is essentially externalist and requires a response-independent theory of the sensible properties. So it faces versions of the structural-mismatch problem and the internal-dependence problem from section 2 above. For discussion of this issue, see Allen (2017, pp. 68-73 and chap. 6), Fish (2013, 58-59), Kalderon (2011, 250-256), and Logue (2016).

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