EVAN THOMPSON

NOVEL COLOURS*

Could there be genuinely novel colours — that is, visual qualities having a hue that bears a resemblance relation to red, green, yellow, and blue, yet is neither reddish, nor greenish, nor yellowish, nor blueish?[1] And if there could be such colours, what would it be like to see them? How would the colours look?

In his article, "Epiphenomenal Qualia,"[2] Frank Jackson presents a philosophical thought experiment that raises these questions (though Jackson does not himself discuss them). Jackson asks us to imagine a perceiver named Fred who is like us except that he has the ability to see a hue we cannot see. Jackson's question is: "What is the new colour or colours like?"[3] Jackson argues that all the physical information about Fred, including the physiology of his brain and visual system, and his dispositions to behaviour, would not enable us to answer this question. The totality of physical information would still leave out something about Fred's experience, namely, what the extra hue is like from the subjective perspective of Fred. And if at some point we became able to see this extra hue (perhaps by undergoing an operation that made our visual system like Fred's), we would learn something that we did not know as a result of having all the physical information about Fred: We would learn how the extra hue looks and thereby learn just what it was that made Fred's experience different from ours.

Jackson calls his argument "the knowledge argument." In his view, the argument is similar to Thomas Nagel's in his article "What is it Like to Be a Bat?,"[4] but both its point and ultimate conclusion are different. Nagel argues that facts about what conscious experience is like for some creature are essentially connected to the subjective perspective of the creature. The problem that Nagel poses is, how could such facts be revealed in anything objective and physical about the creature? How could the objective characterization indicate what it is like to be the creature (how things are for the creature itself)? (The problem becomes particularly acute in the case of creatures who are significantly different

from us — hence Nagel's example of the bat.) The point of Jackson's argument, however, is not that we would not know what it is like to be Fred even if we knew everything physical about him (though that is also true in Jackson's view); it is rather that there is still something we do not know about Fred's experience — a property that it has — even when we have all the physical information about him: We do not know how the extra hue that Fred sees looks to Fred, and so we do not know all that there is to know about how Fred's experience of seeing the extra hue differs from his experience of seeing red, green, yellow, and blue.[5] Jackson's conclusion is also stronger than Nagel's. Whereas Nagel concludes that we do not understand how physicalism could be true,[6] Jackson concludes that physicalism is false because the complete physical account does not tell us everything that there is to know.

Jackson also presents another thought experiment (or rather "intuition pump" to use Dennett's term) in support of the knowledge argument, one which has attracted most of the philosophical commentary,[7] the example of Fred remaining to my knowledge undiscussed. We are asked to imagine a brilliant scientist named Mary who is confined to a black and white room and is forced to investigate the world through a black and white television. She specializes in visual science and comes to know everything physical that there is to know about visual perception. Jackson claims that upon being released from her room, Mary will learn something she did not know before, namely, how the colours (hues) look. As a result, she will realize that there was something about the colour experiences of other people that all along she did not know in virtue of having all the physical information about them, something she learns only when she comes to have the same kind of experiences.[8] Consequently, the physical account again leaves something out.

The thought experiment is unfortunately poorly described. Mary's vision is supposed to be like ours except she has been confined to an entirely black and white environment. But simply confining Mary in this way will not deprive her of colour experience: She will see colours when she rubs her eyes and when she dreams; she will also see colour afterimages induced as a result of brightness and lightness perception. Perhaps we should suppose that Mary's ability to see hues atrophies as a result of her confinement. But then when Mary is released from her room she will still not be able to see any hues. In either case, Jackson's

experiment as described cannot be performed. To remedy the defects we need to suppose, first, either that Mary's ability to see hues atrophies (and as a result she also loses all memory of hue) or that she is completely colour-blind (monochromatic) from birth; and second, that while completely unconscious she is released from her room and undergoes an operation that enables her to see hues.

Spelling out the thought experiment in this way shows more clearly how it is both related to and different from the example of Fred. Mary is unable to see any hues before her vision is corrected; therefore all of our hues are to her novel hues in the sense that they are new to her when she acquires the ability to see them. But they are not novel hues in the stronger sense mentioned at the beginning of this paper, for they are not novel to us. In the Fred example, however, the hue that Fred sees is a novel hue in this stronger sense, for it is (*ex hypothesi*) a hue that we cannot see. It is this latter sense of novel hue with which I will be concerned here.

Jackson's thought experiments are made to bear considerable weight in the course of his argument. We have already seen that the Mary example is not described as it should be. The situation is in some ways worse with the example of Fred, for the very idea of a novel hue upon which it relies is not developed with the care and attention to detail that is needed. I intend to explore this idea of a novel hue in depth. My intention is not to develop the idea on behalf of any particular theory of consciousness; nor is it to argue for or against physicalism. Rather, by exploring the idea in detail I intend to uncover some of the unstated intuitions that motivate Jackson's arguments, intuitions that are not at all philosophically neutral and uncontroversial. In the end, I will show that the idea of a novel hue when thought out with the care it demands actually undermines a certain way of thinking about the qualitative features of conscious experience (qualia) that is pervasive in contemporary philosophy of mind.

I

My first task is to develop the idea of a novel hue in relation to what we actually know about colour and colour vision. To proceed in this way is important because were we to ignore these details we would be leaving ourselves open to the charge that the concept of a novel hue is incoher-

ent, that it is conceptually impossible for there to be such a hue (and hence for there to be novel colours) because for something to be a hue it must have a location in the hue dimension of our colour space. Indeed, Jackson leaves himself open to precisely this accusation. Since the visual quality that Fred perceives has (*ex hypothesi*) no location in our colour space, what reason do we have for counting it as a hue at all? Perhaps what Fred perceives should rather be counted as, say, a certain sort of shimmer or a distinctive kind of lustre that some objects have, but which we are unable to see.[9]

The idea that our main criterion for something to be a colour is that it have a location in our colour space can be found in Wittgenstein's *Remarks on Colour*. At III-42 he writes:

We will, therefore, have to ask ourselves: What would it be like if people knew colours which our people with normal vision do not know? In general this question will not admit of an unambiguous answer. For it is by no means clear that we *must* say of this sort of abnormal people that they know other *colours* [Wittgenstein's emphasis]. There is, after all, no commonly accepted criterion for what is a colour, unless it is one of our colours.

And yet we could imagine circumstances under which we would say, "These people see other colours in addition to ours."[10]

It should be noted that Wittgenstein does not in this passage assert unequivocally that something is a colour only if it is one of our colours, contrary to the interpretation of some commentators.[11] Rather, he says that there is no other "commonly accepted criterion" for something to be a colour, but then goes on to say that we could imagine circumstances in which we would say that someone sees other colours in addition to ours. The problem, then, is to say what these circumstances would be.

Consider again Jackson's example of the imaginary perceiver named Fred. Although Fred supposedly sees another hue in addition to ours, Jackson provides little to explain why the circumstances are such that we would say it is an extra *hue* that Fred perceives. He notes that people vary in their colour discriminating abilities and then says that Fred "makes every discrimination that anyone has ever made, and moreover he makes one that we cannot even begin to make." Jackson spells out the example in a bit more detail by saying that Fred sorts a batch of ripe tomatoes "into two roughly equal groups and does so with complete consistency." Jackson explains that "all ripe tomatoes do not

look the same colour [hue]" to Fred, that "he has in consequence developed for his own use two words 'red$_1$' and 'red$_2$' to mark the difference," and that "his discriminatory behaviour bears this out: he sorts red$_1$ from red$_2$ tomatoes with the greatest of ease in a variety of viewing circumstances."[12]

It seems clear from these remarks that Jackson is asking us to imagine not simply that Fred's colour vision has greater *sensitivity* than ours, but also that it is of a different *type*. Nevertheless, since Jackson does not make this distinction, the point is worth elaborating.

Variations in colour vision are of two general kinds. First, colour vision can vary in its *sensitivity*. For example, you might be able to discriminate more intermediate hues between red and yellow (or yellow and green, green and blue, blue and red, etc.) than I can; you might be able to discriminate more differences in saturation among various hues than I can; or you might be able to discriminate more differences in lightness than I can.[13] Second, colour vision can vary in its *type* or *dimensionality*. For example, normal human colour vision is said to be *trichromatic* because in hue-matching experiments exactly three lights of independent hue are required to match an arbitrary test light. The visual abilities of a trichromat can therefore be represented in three dimensions. In contrast, the colour vision of most so-called colour deficient perceivers is *dichromatic*; for these perceivers only two lights of independent hue are needed to match an arbitrary test light. The visual abilities of a dichromat can therefore be represented in just two dimensions. The most common type of dichromacy involves failure to discriminate reds from greens (deuteranopia and protanopia); true red-green dichromats perceive only yellows, blues, whites, and blacks. A less common type involves failure to discriminate blues from yellows (tritanopia); true yellow-blue dichromats perceive only reds, greens, whites, and blacks. Thus a dichromat is unable to perceive some of the hues that a trichromat can; in other words, a trichromat perceives additional hues in relation to a dichromat.[14]

What Jackson wishes us to imagine, then, is that we stand in relation to Fred as a dichromat stands in relation to a trichromat. As he says: "We are to Fred as a totally red-green colour-blind person is to us."[15] It follows that the additional quality Fred sees cannot be a *shade* that belongs to one of our hue categories but that we cannot discriminate,

like Hume's missing shade of blue. The ability to see Hume's missing shade would not require (for normal human perceivers) having colour vision of a different type (thought it would for true yellow-blue dichromats); it would simple require having greater sensitivity (discriminatory ability) in the blue region of the colours. Indeed, we gain knowledge of the missing shade by working out how it would have to look on the basis of the shades with which we are familiar. But (*ex hypothesi*) we cannot do this with Fred's red_2, for as Jackson says, to see red_2 requires discriminations that "we cannot even begin to make." Despite the name, then, red_2 cannot be a missing shade of red; it must be an entirely novel hue.

In fact we can be even more precise. It must be remembered that our hue terms are *categorial*: They cover the numerous discriminable colours (specific hue-saturation-lightness values) that belong to a given hue category. (The hue categories have best examples or prototypical members but their boundaries are fuzzy.)[16] In the same way, Jackson's red_2 must be a novel hue category that comprises numerous members corresponding to the specific hue-saturation-lightness values that fall within the category. Hence when Jackson says that Fred "sees two colours where we see one," or "that we should admit that Fred can see . . . at least one more colour than we can," he is being imprecise to put it mildly. Fred can see many more colours than we can because he can see colours that (unlike Hume's missing shade) belong to a hue category none of whose members we can see. (Note, however, that I do *not* say that Fred can see *all* the colours that belong to his novel hue category. Just as we have Hume's missing shade of blue, perhaps there is a missing shade in Fred's novel hue category, that is, a shade in this category that Fred cannot discriminate.)

We can now refine our question about the circumstances in which we would say that Fred sees additional colours. The question now becomes: Does Fred, like us, have colour vision, but unlike us (normal human perceivers) have colour vision of a different type? More precisely, is the dimensionality of his colour vision of a higher order than our own such that he can see not only all our colours but also colours that belong to a hue category none of whose members we can see?

It may seem that in filling in the details of Jackson's example we have

answered Wittgenstein's question about the circumstances in which we would say that someone sees other colours in addition to ours. But matters are not so simple. Recall Wittgenstein's point that "it is by no means clear that we *must* say of this sort of abnormal people that they know other *colours*." We must still face the question of why the extra quality that Fred perceives is to count as a hue rather than some other visual quality that we cannot see. The problem can be refined still further by making use of another of Wittgenstein's remarks:

Can't we imagine people having a geometry of colours different from our normal one? And that, of course, means: can we describe it, can we immediately respond to the request to describe it, that is, do we know *unambiguously* what is being demanded of us?
   The difficulty is obviously this: isn't it precisely the geometry of colours that shows us what we're talking about, i.e., that we are talking about colours?[17]

As a step toward developing this remark of Wittgenstein's, let me first comment on the idea that there is a "geometry" of colours.[18] Although we always perceive colours in some visual context and typically as properties of objects in the world,[19] we can consider colours themselves more abstractly in terms of their location in a space of relations known as colour space. For example, we say that certain hues can be pure or unitary in the sense of not containing any other hues as components.[20] Thus there is a pure yellow, a pure red, a pure green, and a pure blue. (Once again, it should be noted that the terms "yellow," "red," "green," and "blue" do not refer in the first instance to the pure or unitary examples of these hues. Rather, the terms are categorial colour names.) Others, such as orange and purple, are binary in the sense of being composed of two hues: Oranges are reddish yellows and yellowish reds; purples are reddish blues and blueish reds. Certain pairs of hues are antagonistic or opponent because they exclude each other, and so cannot be combined to form a binary hue. Thus there cannot be blueish yellows (or yellowish blues) and reddish greens (or greenish reds). In addition to these hue-relations, colours are related along the dimensions of lightness and saturation. Lightness is the achromatic or white-black dimension along which colours can be scaled.[21] Saturation is the pale-to-vivid dimension that is specified in terms of the proportion of hue relative to a neutral achromatic (grey or

white) point: Saturated colours have a comparatively greater degree of hue in relation to the neutral point; desaturated colours have comparatively less hue content.

There are many geometrical representations of the relations that compose colour space. Perhaps the best known is the colour sphere whose circumference corresponds to the hues at maximum saturation and is formed by joining the two ends of the spectral hues through the non-spectral purples. At the centre of the sphere lies the neutral grey point. Movement away from this point toward the circumference corresponds to progressive saturation; whereas vertical movement toward the top or bottom of the sphere corresponds respectively to an increase or decrease in lightness. Other three-dimensional representations depart from this spherical model in various ways. For example, Ebbinghaus's colour solid is a double cone whereas Munsell's is more like an irregular tree; there are also non-Euclidean models of colour space.[22] These models are based on various sorts of data and have different purposes, and so are not incompatible. What is important for our purposes is simply that the relations among colours can be perspicuously displayed in a geometrical model.

In the previous paragraph, I have been using the term "geometrical" to refer to the spatial representation of how the colours are related. This use is similar to Wittgenstein's but is not the same. Wittgenstein appears to be drawing on this sense as a way of talking about the *logical*, or as he would call them, *grammatical* relations among (propositions about) the colours. But we can approach closer to Wittgenstein's point about the geometry of colour by asking, what is the logical status of the relations that colours bear to each other as displayed in the geometrical representation of colour space? This is a vexing question and I do not wish to attempt a systematic answer to it here. I raise the question because many philosophers hold the reasonable view that certain properties of colours are essential to them whereas others are accidental.[23] And among the properties deemed essential many would include the resemblance relations among the hues; therefore, according to this view, the relations that the hues bear to each other are internal relations.[24]

To take some examples: It is essential to orange that it be a binary hue composed of red and yellow; a hue that did not contain red and

yellow as components could not be orange. (It is thus impossible for there to be a unitary orange.) Attention to these essential properties makes it easy to see why orange resembles red and yellow more closely than it resembles blue and green; it also makes it easy to see that these resemblance relations are essential properties of orange — a hue could not be orange unless it resembled red and yellow more than it resembled blue and green. Analogous remarks could be made about all of the other binary hues, such as turquoise and purple. Turning to the unitary hues, many have argued that the mutual exclusivities or opponencies of red and green, and yellow and blue, are essential to these hues (though confidence in this idea has recently been shaken by psychophysical experiments that in certain highly abnormal viewing conditions seem to induce perceptions of colours described by some observers as reddish-greens and yellowish-blues.[25]) Certain resemblance relations among the unitary hues also appear to be essential. For example, that blue and green more closely resemble each other than either resembles red or yellow seems essential to blue and green; and that red and yellow more closely resemble each other than either resembles blue or green seems essential to red and yellow.

Matters become complicated, however, when we note that not all of the resemblance relations appear to be essential to the colours. First, as C. L. Hardin argues,[26] the *number* of just-noticeable hue differences between two colours does not appear to be essential to the colours: Two colours might for one observer be separated by five just-notice-ably-different hue steps, whereas for another observer they might be separated by seven just-noticeably-different hue steps. It is essential to the two colours that there be some hue-resemblance route between them, but the number of steps on the route does not seem to be essen-tial. Second, although it seems essential (for the unitary hues) that blue and green resemble each other more than either resembles red or yellow, and that red and yellow resemble each other more than either resembles blue or green, the identity of blue does not appear to depend on its resemblance to green (and vice-versa) and the identity of red does not appear to depend on its resemblance to yellow (and vice-versa): True red-green dichromats presumably see yellows but no reds, and blues but no greens; whereas true yellow-blue dichromats pre-sumably see reds but no yellows, and greens but no blues. (Or should

we say that these perceivers are simply unable to appreciate visually some of the internal relations in colour space?) Hardin's suggestion is that essential to the colours are their constituents and the relations that hold among the colours in virtue of those constituents.[27] This view would make the relations that hold among the colours in virtue of features of their hue constituents (like those in the above examples) essential to the colours.

Of course to say that colours are thus internally related (via the internal relations among their hue components) is philosophically infor-mative only to the extent that we have some grasp of what an internal relation is. But it is notoriously difficult to say precisely what is in-volved in the distinction between internal and external relations. It is perhaps not surprising, then, that appeals to colour are often made as a way of conveying what internal relations are supposed to be. Thus in the *Tractatus*, Wittgenstein says that "A property is internal if it is unthinkable that its object should not possess it" and then goes on to give as an example the relation between two colours of the same hue but different lightness: "This shade of blue and that one stand, eo ipso, in the internal relation of lighter to darker. It is unthinkable that *these* two objects should not stand in this relation."[28] Similarly, in his lectures entitled "Form and Content," Moritz Schlick writes that the "relations which hold between the elements of the systems of colours are, obvi-ously, *internal* relations, for it is customary to call a relation internal if it relates two (or more) terms in such a way that the terms cannot possibly exist without the relation existing between them — in other words, if the relation is necessarily implied by the very nature of the terms."[29]

The distinction between internal and external relations to which Wittgenstein and Schlick appeal in these remarks is another difficult topic that I do not wish to pursue here. It suffices for my purposes to observe that if one holds that the relations colours bear to each other are internal, then one holds that propositions about these relations are either necessarily true or necessarily false.[30] Thus the proposition "Orange resembles red and yellow more than it resembles either blue or green" is necessarily true; whereas the proposition "Purple resembles yellow more than it resembles red" is necessarily false. One might also argue that there are necessarily true propositions about the relations

among the *dimensions* of colour space. For example, it is necessarily true that all hues must have some saturation value (since saturation is the proportion of hue content in relation to an achromatic point); and it is necessarily true that all saturated colours must have a hue (achromatic colours have zero saturation values). That all hues must be of some lightness also seems to be necessarily true (how could there be a hue that did not have a lightness?).

It is important to remember that the necessary propositions here are ones about what Wittgenstein calls the "geometry" of colours. In other words, they are not (in the first instance) about colours considered as properties of objects (being coloured); they are about the properties that colours themselves exhibit as displayed in geometrical representations of colour space (see notes 28 and 29). Nevertheless, it is also important to remember that colours are typically perceived as properties of objects; thus the properties of colours as displayed in colour space can be considered as second-order properties of coloured things.

We can now return to the topic of novel colours and to the Wittgensteinian claim that it is the geometry of colours that shows us what we're talking about. We were considering whether there could be a perceiver like Jackson's Fred whose colour space resembled our own except that it contained an entirely novel hue. The first point to be made is that such a colour space would have to have a geometry different from our own colour space. To see why, consider the problem of trying to insert a novel hue into our colour space. The problem here is that colour space is a closed structure, as is immediately apparent from any of its geometrical representations,[31] and so there is no place for a novel hue to be inserted without altering the geometry of the space. As Jonathan Westphal observes:

It is possible . . . to show that the insertion of a fictitious colour into our three dimensional colour space will disrupt the order and prevent us from conceiving some other colour or group of colours in the space, independently of the explanation of this fact in the generative basis of the space. For colours and the similarity colour space are inseparable. The positions of the colours on the hue circuit, for example, are determined by the positions of their intermediaries and vice-versa, and these together determine the geometry of the space.[32]

Westphal's concern is mainly to explicate Wittgenstein's "puzzle proposition" that "there can be a blueish green but not a reddish green."

(It should be noted that reddish-green is not an example of a novel hue in the main sense that we have been considering, that is, a novel *unitary* hue; rather it is a novel *binary* hue.) The point is that if reddish green is to be a possible hue, then some location must be found for it within the colour space. But since the colour space is a closed structure, a new hue such as reddish-green cannot be added to the space without fundamentally disrupting its structure in arbitrary and unprincipled ways. On the other hand, a new hue cannot be located outside colour space, for then it would lie outside the hue dimension, and so could not be a hue. It is a conceptual truth that something is a colour only if it has a location within colour space and there is no room within the closed space for a novel hue.

Westphal is right that a novel hue such as reddish-green cannot be inserted into our *three-dimensional* colour space without altering the space in unprincipled ways. But from this fact it does not follow that our colour space could not contain such a novel binary hue. To see why, recall the experiment that I mentioned above parenthetically that purports to establish perceptions of colours described by some observers as reddish-green and yellowish-blue. As Hardin notes, "if this experiment is valid, no resemblance ordering of *all* experienceable hues is possible in a three-dimensional color space."[33] The possibility of such novel binary hues would therefore imply that our colour space is actually not three-dimensional for all conditions of viewing.[34] Thus a home could be found for reddish-green and yellowish-blue in our colour space without the problem arising of trying to insert them into a closed space of only *three* dimensions.

What now of a full-fledged novel hue, that is, not a novel binary hue like reddish-green and yellowish-blue, but a novel unitary hue that is neither reddish, nor greenish, nor yellowish, nor blueish? It is again a conceptual truth that such a hue must have some location in colour space. But finding a place for a novel unitary hue in colour space requires more than finding a place for a novel binary hue such as reddish-green. To find a place for this latter hue involves establishing a resemblance route between the two already existing unitary hues red and green that does not involve travelling through yellow or blue, or the neutral achromatic point. (It is this requirement that cannot be met in the familiar three-dimensional representation of colour space.) To find

a place for a novel unitary hue, however, would require that we esta-
blish a resemblance route between this hue and at least one of the
already existing unitary hues. In other words, we need to find a re-
semblance route from either red, green, yellow, or blue to a hue that is
neither reddish, nor greenish, nor yellowish, nor blueish. The point can
also be made in terms of hue categories and the geometrical representa-
tion of colour space: We need to find a resemblance route from a
region (volume) of our colour space corresponding to one of our hue
categories to an entirely new region (volume) of colour space corre-
sponding to the novel hue category. But our colour space is certainly
closed with respect to this possibility: The space is completely filled and
so there is no place for a new hue region. Consequently, there is no way
to build a novel hue into the space without fundamentally altering its
geometry (both in the familiar representational sense and in the Witt-
gensteinian sense of logical or grammatical structure).

Considerations of this kind have led some philosophers to conclude
that the concept of a novel hue is simply incoherent. For example,
Bernard Harrison writes: "To be incapable of being placed on the
colour array as we perceive it is simply to be not a colour, and thus not
capable of standing as a term in colour relationships."[35] But this
conclusion is based on a misunderstanding about what is conceptually
required for a quality to be a novel hue. The concept of a novel hue
cannot be that of a new hue inserted into our colour space, for that is
impossible. Nor can it be that of a new hue located outside colour
space, for that is incoherent. The concept of a novel hue must rather be
that of a new hue located in a *novel colour space*, that is, a colour space
that has a fundamentally different geometry from our own. Thus it does
not follow that a quality having no place on the colour array as we
perceive it is not a hue, for the quality might have a home in a different
colour space. Harrison is right to think that our colour space is closed
to the possibility of a novel hue, but he is wrong to think — or at least
has provided no argument to show — that there cannot be different
types of colour space (as indeed there are for people who have colour
vision of different types or dimensionalities).

We still have not fully established the coherence of the idea of a
novel hue, however, for we have yet to establish securely that the
concept of a novel colour space is not itself incoherent. The problem

that arises in this connection is the one suggested by Wittgenstein's remark that it is "the geometry of colours that shows us what we're talking about, i.e., that we are talking about colours." If the relations that the hues bear to each other are, as we have been supposing, internal relations (if propositions about these relations and those that obtain in colour space in virtue of them are necessarily true), then these relations determine what the hues are. And since these relations constitute the geometry of colours, the geometry of colours constitutes what the colours are. Jonathan Westphal has written that "Colour space is Leibnizian. The place holders determine the geometry of the space."[36] On the view we are considering, however, the reverse is also true: The geometry of the space — defined in terms of the (internal) relations among the place holders — determines the place holders. As Harrison puts it: "the relationships which unite colour presentations into an array can only be specified by reference to colour presentations themselves (i.e. to certain contents), while colour presentations in turn can only be specified by reference to the relationships in which they stand to one another."[37] It follows, then, that changing the geometry (the relations) will change the place holders (the colours). But if, as Wittgenstein says, it is the geometry of the space that indicates in the first place that the qualities with which we are concerned are *colours*, then how are we to draw the line between changing the geometry and changing the qualities? Some changes in the geometry are certainly allowable (e.g., those having to do with the number of just-noticeably different hue steps between colours), but if we change the geometry too much our conviction that the *kind* of quality with which we are dealing is colour will be undermined. Perhaps a colour space that had a radically different geometry wouldn't really be a *colour* space. (Cf. the first remark of Wittgenstein's quoted above: "For it is by no means clear that we *must* say of this sort of abnormal people that they know other *colours*.)

The foregoing considerations already indicate how this problem should be approached. First, we have all along insisted that a novel hue must bear a resemblance relation to at least one of our hues. Second, the novel hue must itself be located in some closed space of hue-saturation-lightness relations.[38] These two conditions imply that there must be a resemblance route from our colour space to the novel colour

space. A region in our colour space corresponding to one of our hue categories (red, green, yellow, or blue) must stand at the beginning of the route and a region in the novel colour space corresponding to the novel hue category must stand at the end of the route. For there to be such a resemblance route it is necessary that the hue region in our colour space also be a component region of the novel colour space. By thus containing that region of our colour space as a necessary constituent, the novel colour space will be internally related to it (the proposition that the novel colour space is related to that hue region of our colour space by the relation of containment will be necessarily true).

Must the novel colour space contain our colour space in its entirety? It seems likely that answers will vary depending on the extent to which one holds that the relations the colours bear to one another are internal. If every relation among the colours (in colour space) is internal, then it would seem impossible for our colour space not to be carried over in its entirety into the novel space. We have seen reason to deny, however, that the identity of the colours depends on every relation in which they figure in colour space. Instead we have adopted Hardin's (tentative) proposal that essential to the colours are their constituents and the relations that obtain in virtue of them. On this proposal, then, only these constituents would have to be carried over to the novel space. This proposal has a further interesting implication: If we suppose that opponency is essential to the hues, then any novel hue will require its own opponent complement. It would follow that a novel colour space could not contain just one novel hue; it would have to contain *two* opponently related novel hues. Applied to Fred, this would mean that Fred's colour space would have three pairs of opponently related hues (our two plus his novel pair) and that he might therefore perceive ternary hue combinations in addition to our mere binary hues.[39] The problem with the proposal, however, is that opponency might after all not be essential to the hues (see note 25). If this were the case, then a novel hue would not require an opponent complement. Furthermore, not even all of the relations among the hue constituents of our colours would need to be carried over to the novel space.[40]

These issues are difficult and I do not see how they can be answered short of a fully articulated and well-grounded theory of which features

of the colours are essential and which accidental. In the case of Fred, however, we can say something more definite. Since, as Jackson says, we stand to Fred as a true red-green dichromat stands to us, we can suppose that the hue constituents of our colours must be carried over in their entirety to Fred's novel colour space. Just as our colour space contains the hues and the relations between them of a true red-green dichromat (as well as those of a true yellow-blue dichromat) so Fred's novel colour space contains our hues and the relations between them. In short, whereas we are trichromats and have a colour space of three dimensions, Fred is a *tetrachromat* and has a four dimensional colour-hyperspace.

I have now laid down some conditions for a quality space to count as a colour space, and so have provided an answer to the Wittgensteinian question about what is conceptually required for someone to be said to see a novel hue, though there are certainly many questions that remain. The conditions attempt to preserve the idea that the geometry of colour space is in some sense constitutive of the colours. Yet they allow there to be variations in the geometry within certain limits: Variations are allowed as long as there is some resemblance route from our colour space to the novel colour space. On the other hand, if the envisaged variations in the geometry have the result that there is no longer any such resemblance route, then the conditions necessary to count the space as a colour space are lacking.

It is worth noting that this view meets certain requirements suggested by two other passages in Wittgenstein's *Remarks on Colour.* In these passages, Wittgenstein responds to the question about whether we can imagine people having a different geometry of colour from our own by saying:

— That, of course, means: Can't we imagine people who have colour concepts which are other than ours; and that in turn means: Can't we imagine that people do *not* have our colour concepts and that they *have* concepts which are related to ours in such a way that we would also want to call them "colour concepts"?[41]

I have argued that a novel hue must reside in a novel colour space and that this novel space must contain as a component some region of our colour space corresponding to one of our hue categories. The colour concepts operating in the novel space would consequently cover some of our colours, though they would of course differ from our colour

concepts in various ways. Furthermore, there seems no reason to suppose that these differences could not be revealed behaviourally (e.g., in psychophysical experiments or everyday colour-sorting tasks) and linguistically in the repertoire of colour terms available to the speakers (e.g., our "red," and Fred's "red$_1$" and "red$_2$").

II

What remains to be discussed is the issue of what it would be like to perceive a novel hue. Jackson's claim is that the totality of physical information would still not tell us how the novel hue looks to Fred, and so would be silent about various properties of his perceptual experience, such as how his experience of seeing the novel hue differs from his experience of seeing red, green, yellow, and blue.

The first thing to be said is that, physical knowledge aside, we have already said a great deal about what it would be like to see a novel hue. In the case of Fred, we have determined that he is a tetrachromat and that his colour space is accordingly a four-dimensional hyperspace. Given the similarity of his visual system to ours, we can suppose that this colour space contains a novel opponent hue pair and ternary hue combinations. I see no reason not to count these as facts about what it is like for Fred to see his additional colours. Therefore, Jackson must be speaking loosely when he says that we do not know the "kind of experience" Fred has when he sees red$_1$ and red$_2$. On the contrary, we do indeed know what *kind* of experience he is having in several respects: We know first and most generally that his experience is colour experience. Second, we know that the difference between red$_1$ and red$_2$ is not like the difference between one of the shades of blue we can see and Hume's missing shade; as Jackson himself stipulates, red$_1$ and red$_2$ are not shades of the one colour red. The difference between them must therefore be a categorial difference in hue. Third, as a novel hue in an opponently organized colour space, red$_2$ must have a novel opponent hue complement. Finally, Fred's novel opponent hue pair in combination with our two opponent hue pairs enables Fred to see colours that are ternary combinations of hue.

Jackson might fairly reply that the foregoing misses the point of his argument. Just as someone who is a true red-green dichromat can know

all the analogous facts about normal human colour vision (e.g., that we have an additional opponent hue-pair that enables us to see binary combinations of hue) while still not knowing everything there is to know about how red and green look to us (they presumably look grey to the true red-green dichromat), so in knowing the above facts about the kind of experience Fred enjoys we still do not know everything there is to know about how the additional colours look to Fred.

We can accept this point, yet two things should be noted. First, we have been forced to *exclude* certain things that are legitimately covered by the phrases "what the colours are like for Fred" and "how the colours look to Fred." Thus these phrases do not immediately or unequivocally indicate which features of Fred's colour perception are the ones Jackson takes to be relevant to his argument; and Jackson provides no further description in addition to these phrases. Second, the analogy with colour-deficient perceivers not knowing everything there is to know about how red and green look is made in the context of our present state of knowledge. But if we attempt to extrapolate the analogy to the context Jackson wishes us to imagine in which we have "all the physical information," then matters are not so clear. How can we be sure that Jackson is right in his presumption that we would not know how the colours look? Jackson does not provide *any* substantive argument for his claim; he just says "it *seems* [my emphasis] that no amount of physical information . . . tells us."[42]

The most glaring problem with this assertion, however, is not that it is unargued. It is rather that we simply have no idea *a priori* what would be included in "all the physical information." "Physical" as Jackson uses the term includes the knowledge gained by the physical, chemical, and biological sciences. If we extrapolate to some science fictional future in which we know *everything* physical there is to know, then "physical" will cover the knowledge gained by all future developments in physics, chemistry, and biology; it will include all the knowledge gained by the yet to be invented sciences studying the yet to be discovered levels of organization in the natural world; and it will include a theory of how all the levels are interrelated (including new concepts for relating the levels). That we have in advance no idea what all these developments would entail strikes me as intuitively obvious if anything is. Jackson thus requires us to imagine something that is

actually unimaginable with the result that his thought experiment is at worst defective at its very foundation and at best wildly unconstrained.

It is instructive nonetheless to try to imagine what it would be like to have all the relevant physical information about Fred's colour perception (a task Jackson himself declines to take up).[43] Again we can suppose that we determine that Fred's colour space has a novel opponent hue pair and novel ternary hue combinations. Let us also suppose that Fred is as interested as we are to learn all the facts about his unique colour perception and consequently that he is a willing experimental subject. To exercise our imaginations let us first consider some of the things that Fred can simply *tell us* about his experience: He tells us that one of his novel hues is like red and yellow in that it can be described as "warm," "advancing," and "light," whereas the other is like blue and green in that it can be described as "cool," "receding," and "dark." He tells us that the ternary hues he perceives are also arrayed in various ways along these polarities. He divulges to us the various other affective and emotional associations he has with his novel colours, including some intriguing novel intermodal and synaesthesic associations. Imagine now that we have collected all such phenomenological information about Fred.

Second, consider some of the things that we can establish in standard psychophysical experiments: We determine whether Fred is able to perceive any unitary examples of his novel hues or whether he typically perceives them in combination with another hue (as spectral red for us always has a small amount of yellow). We determine the number of just-noticeably different hue steps between each of Fred's novel hues and red, green, yellow, and blue. We determine the various degrees of saturation and of lightness that his novel hues exhibit. Imagine now that we have collected all such psychophysical information about Fred so that we have a complete psychophysical specification of his novel colour space.

Third, consider some of the things we would know about Fred's physiology: We discover that Fred has a fourth type of receptor photopigment with a distinct spectral absorption profile and we isolate and sequence the gene that specifies it. We discover that signals from cells containing this type of pigment are combined and compared by postreceptoral cells with the other receptor signals thereby generating a third

chromatically opponent channel. Imagine now that we have collected all
such neurophysiological information and that we have a complete
theory that shows us how to relate the psychophysical phenomena to
their neuronal substrates. (Since this is science fiction we can also
imagine that we were able to carry out this research without any harm
or serious discomfort to Fred.)

Fourth, consider some of the things we would know about the
objects that Fred perceives to be categorially different in hue. We
discover, for example, that the tomatoes Fred sorts into two different
groups reflect light differently in the near-ultraviolet. One kind of
tomato has a prominent rise in its surface spectral reflectance curve in
the ultraviolet whereas the other kind does not. Thus Fred's visual
system is sensitive to physical characteristics of the tomatoes to which
our visual system is not. Imagine now that we have collected all such
environmental information about Fred's visual perception.

Finally, remember that what we know about Fred also includes
everything physical about "his behaviour and dispositions to behaviour
. . . and everything about his history and relation to others than can be
given in physical accounts of persons."[44]

The question now before us is: What features of Fred's colour
experience would this kind of account not include? Again it is no help
to say this kind of account would not tell us how the novel colours look
to Fred. The account tells us quite a lot about how the colours look to
Fred — after all, much of what we know Fred told us. And yet still we
wish to insist that something is left out. What might this something be?
How might we describe it?

The idea that inevitably suggests itself at this point is that we do not
know what the "intrinsic properties" of Fred's colours are. We learn
many things as a result of the kind of account sketched above, but we
do not learn the "intrinsic qualitative characters" of Fred's novel hues,
and so we do not know exactly how they differ from our hues. The
problem now is to say just what is meant by the term "intrinsic qualita-
tive character" as applied to the colours.

Although the term "intrinsic" as applied to the qualitative features of
experience has been charged with incoherence by some philosophers,[45]
I think that there is a coherent sense it can be given in this context.
Consider the three-dimensional representations of colour space dis-

cussed above in which each colour is represented by a vector or a distinct point in the space. The size and shape of the colour solid will result from the coordinates we choose and the way they are oriented relative to one another. Yet as colour scientists Judd and Wyszecki observe, "a mere organization of the manifold of colors does not give us any information on the intrinsic properties of the manifold besides the fact that it is three-dimensional."[46] Here the term "intrinsic" is being used, as they go on to say, for "those properties which are independent of the choice of coordinate system and thus independent of any transformation we might use to convert a given color solid into another of different size and shape."[47] In this context, then, intrinsic properties are simply ones that colours have *qua* colours, that is, ones they have regardless of which objects they happen to be the colour. It is the representation of these properties that must be preserved in any geometrical colour space. The example that Judd and Wyszecki give as "the most fundamental intrinsic property of the color space" is the difference between two colours as measured in terms of the number of just-noticeable hue differences between them. This property is clearly a relational one between the colours; it is therefore precisely not intrinsic in the sense typically meant by philosophers, namely, nonrelational.[48]

The term "intrinsic," then, is perfectly respectable when used to characterize properties of the colours *qua* colours.[49] But this sense still does not succeed in pinning down exactly what it is that we are supposed not to know about Fred's novel colours. (The just-noticeable difference relations among Fred's colours, for example, are features of his colour space that we imagined determining using typical psychophysical procedures.) Just what exactly is it that we mean to indicate, then, when we speak of the intrinsic qualitative features of colours?

It is at this precise moment that the term "intrinsic" becomes invoked in its metaphysically dubious sense. Colours are said to have qualitative features that are intrinsic in the sense that they are *purely phenomenal*: They have only a certain qualitative character but no intentional content. These purely phenomenal features are also *nonrelational*: They are features that each colour supposedly has on its own independently of its relations to the other colours (they belong to the colours intrinsically). Finally, the features are supposedly *simple* in the sense that they have no internal structure, and so do not admit of any analysis. We

have, then, the circle of interlocking terms that within the empiricist tradition have always been applied to colour qualities.

It is this empiricist view that the intrinsic qualitative features of colour are not only features the colours have *qua* colours, but are also purely phenomenal, nonrelational, and simple properties accessible from the first-person perspective that, I submit, lies at the root of Jackson's conception of what is missing from our knowledge of Fred when we know everything physical about him. It is not simply that we lack Fred's kind of colour perception and so cannot see the colours as he sees them; it is rather that our inability to see his colours is conceived as an inability to be directly acquainted with certain simple, nonrelational, and purely phenomenal visual presentations. It is this conception that most likely lies behind Jackson's silence about just which features of the colours he means when he says that we do not know "what the new colours are like," for Jackson treats this phrase as if it unproblematically picked out — as though by ostension — some simple and purely phenomenal visual presentation.

Jackson is certainly not alone in holding to this conception of how visual experience is constituted. Appealing to such putative characteristics of colour has in fact become paradigmatic for discussions of the qualitative features of experience (qualia) in most English-speaking philosophy of mind.[50] And since it is rather difficult to say more about what these mysterious intrinsic properties are (they are after all "ineffable" according to the empiricist tradition), almost all claims for their existence involve appeals to intuition rather than argument. Terrence Horgan provides a typical example when in a discussion of the so-called "inverted spectrum" problem he writes: "I take the intrinsic, non-relative nature of qualia to be a self-evident fact, a fact which unavoidably impresses itself upon most of us who actually experience these states. The point is virtually impossible to *argue* for, however, because it depends on an individual's first-person perspective towards his own mental life."[51] Horgan is right that the issue depends on the perspective one takes toward one's experience; the question, however, is whether the perspective that would appeal to nonrelational and purely phenomenal properties is philosophically cogent or whether it results from little more than prejudiced and unargued intuitions.

I do not think it can be demonstrated that there are no such intrinsic

properties, though philosophers in a variety of traditions have attempted to show that the very idea of this kind of property is incoherent. My exploration of novel colours provides further support to this attempt because it shows how the intuition that there are such properties is misinformed and misguided in its treatment of colour. To show the coherence of the very concept upon which Jackson's thought experiment relies, the concept of a novel hue, we had to navigate the complexities of colour space as a system of internally related qualities. To make sense of the very idea of a novel hue we thus had to treat the colours as qualities whose features are not at all intrinsic in the sense of being nonrelational. The properties that colours exhibit depend on the internal relations that to a considerable (though still undetermined) extent compose the structure of colour space. We also had to treat the properties that colours exhibit as complex, not simple.[52] To find a home for a novel hue we had to analyze colours along the dimensions of hue, saturation, and lightness; and we had to analyze the colours into their unitary, binary, and novel ternary hue constituents, as well as their constituent opponent relations. *Thus the conception of the qualitative features of experience upon which Jackson's knowledge argument relies is actually undermined by the very idea of a novel hue that he invokes.*

What about the intuition that colours have features that are purely phenomenal? Although I have placed considerable emphasis on the properties that colours exhibit as displayed in geometrical representations of colour space, that is, on the properties of colours *qua* colours, we do not perceive these properties floating freely as it were. As I indicated at the outset, we always perceive colours as properties of things in some visual context. This fact has two important implications. First, the properties of colour that we have been considering are actually perceived as second-order properties of coloured things. To get a handle on these second-order properties we abstract away from the coloured things that exemplify them and consider the properties directly by locating them in a space of colour relations.[53] *But this space is not itself something perceived.* (Of course representations of it are things perceived.) It is rather the logical structure that constitutes the (second-order) properties embedded in our perceptual experiences of coloured things. Second, when empiricists claim that the fundamental element of this perceptual experience is a *sensation* of colour they are simply

mistaken. The fundamental element of the perceptual experience is the *seeing of a coloured thing*.[54] The point holds even in the most restricted aperture conditions of typical psychophysical experiments on colour and brightness perception, for there we still perceive luminous coloured *areas* at various levels of brightness. Colour and brightness are always perceived as features of some spatially extended area, however small; and the perceptions depend on the amount of light transmitted from the area in relation to other areas in the visual scene as well as on changes in intensity over time.[55] The qualitative features of colour are thus always perceived as contextually situated or embedded in some way, and such situatedness is not accidental to them; rather it constitutes how we experience them. Consequently, the qualitative features always have some intentional content, and so are precisely not purely phenomenal.[56] I submit, then, that the claim made by many contemporary philosophers that the qualitative aspects of our experience include nonrelational and purely phenomenal features is not even phenomenologically cogent.

Should we conclude with Dennett,[57] then, that there really are no such things as qualia? How we answer this question depends on what we mean by "qualia." If qualia are identified as nonrelational and purely phenomenal qualities devoid of any intentional content, then they are the theoretical posits of certain philosophers and the intuitions cited to support them are philosophical intuitions. Such theoretical posits and their supposedly intuitive basis strike me as having virtually nothing to do with how we actually understand our experience in everyday life. By claiming, as I have, that the idea is not even *phenomenologically* cogent, I mean to imply both that it does not accurately portray how our experience is actually constituted and consequently that not even *phenomenologists* need such qualia.[58] If qualia are simply identified as the qualitative features of experience, however, then there are indeed qualia because experience does indeed have qualitative features. The point is rather that we have no notion of what these features could be if they were not constituted by the situations in which we intentionally (in Brentano's sense) experience them.

My own positive view, which I have not had space to argue for in any detail, is that the ability to see novel colours would require novel perceptual systems with novel intentional capacities. Were we to

acquire such capacities, there might be a sense in which we would learn something, even if we knew everything physical that there is to know, but I am unsure how best to characterize such knowledge (if that is what it is), except to say that it would not be a matter of "knowledge *that*" where "that" picks out some simple phenomenal object.

In any case, the methodological moral to be drawn is that we should not pursue our investigations in the philosophy of mind by advancing *a priori* arguments about what science will and will not be able to tell us about our experience and the experiences of other sentient creatures. The only way we will ever know what science can tell us is by doing the science.[59] Doing the science does not mean abandoning the philosophy, but it does mean that our philosophical explorations should not involve unconstrained thought experiments and unargued appeals to intuitions about mysterious properties. Knowledge of the qualitative features of conscious experience, whether scientific or otherwise, can never be had unless we begin from a more accurate and faithful portrayal than that found in Jackson's knowledge argument and many current discussions of qualia.

NOTES

* The ideas explored here have greatly benefited from conversations with Don Dedrick, Dan Dennett, William Seager, Sonia Sedivy, and Francisco Varela.
[1] See C. L. Hardin, "A New Look at Color," *American Philosophical Quarterly* 21 (1984): 125—130; and *Color for Philosophers: Unweaving the Rainbow* (Indianapolis: Hackett Publishing Company, 1988), pp. xx, 145. I discuss novel hues in the context of comparative colour vision in Evan Thompson, Adrian Palacios, and Francisco Varela, "Ways of Coloring: Comparative Color Vision as a Case Study for Cognitive Science," *Behavioral and Brain Sciences* 15, No 1 (1992). This essay provides an empirical context for the more philosophical issues that I am exploring here.
[2] Frank Jackson, "Epiphenomenal Qualia," *Philosophical Quarterly* 32 (1982): 127—136.
[3] *Ibid.*, p. 129. Jackson uses the term "colour" to refer to the visual quality that Fred can see, but that we cannot. As I will show in detail, use of the term in this way is imprecise and invites confusion. The term "hue" is preferable because what Jackson's example actually involves is a perceiver who has the ability to see colours (various hue-saturation-lightness values) that belong to a hue category none of whose members we can see. It is therefore the hue that is in the first instance the novel quality.
[4] Thomas Nagel, "What is it Like to Be a Bat?," *Philosophical Review* 83 (1974): 435—450; reprinted in his *Mortal Questions* (Cambridge: Cambridge University Press, 1979), pp. 165—180.
[5] Jackson, *op. cit.*, p. 132.
[6] Nagel, *op. cit.*, p. 175: "If mental processes are physical processes, then there is

something it is like, intrinsically, to undergo certain physical processes. What it is for such a thing to be the case remains a mystery."

[7] For example, see Paul M. Churchland, "Reduction, Qualia, and the Direct Introspection of Brain States," *Journal of Philosophy* 82 (1985): 8—28. Jackson replies in "What Mary Didn't Know," *Journal of Philosophy* 83 (1986): 291—295. Daniel C. Dennett also ignores Fred and concentrates exclusively on Jackson's second thought experiment in his *Consciousness Explained* (Boston: Little Brown, 1991), pp. 398—401.

[8] Jackson makes clear that the knowledge Mary gains that poses the problem for physicalism is her knowledge about the experiences of other people in his "What Mary Didn't know," *op. cit.*, p. 292.

[9] J. van Brakel, "The Ethnocentricity of Colour," Open Peer Commentary on Thompson, Palacios, and Varela, *op. cit.*, makes this point in relation to our claim that pigeons might perceive novel colours because their colour space might have an additional dimension in which to make chromatic distinctions in relation to our colour space.

[10] Ludwig Wittgenstein, *Remarks on Colour*, ed. G.E.M. Anscombe, trans. Linda L. McAlister and Margarete Schättle (Berkeley and Los Angeles: University of California Press, 1977), p. 22e.

[11] For example, Robert John Ackermann, discussing what he calls Wittgenstein's "careful phenomenology of color," writes: "We could not understand anyone who said that there were five pure colors." *Wittgenstein's City* (Amherst: University of Massachusetts Press, 1989), p. 143.

[12] Jackson, "Epiphenomenal Qualia," *op cit.*, p. 128.

[13] In psychophysics these are specified respectively in terms of the wavelength discrimination, colorimetric purity, and spectral sensitivity functions.

[14] For a general treatment of human colour vision including various colour vision deficiencies see Leo M. Hurvich, *Color Vision* (Boston: Sinnauer Associates, 1981).

[15] Jackson, *op. cit.*, p. 129.

[16] See Brent Berlin and Paul Kay, *Basic Color Terms* (Berkeley and Los Angeles: University of California Press, 1969); Paul Kay and Chad McDaniel, "The Linguistic Significance of the Meaning of Basic Color Terms," *Language* 54 (1978): 610—646; E. R. Heider [Rosch], "Universals in Color Naming and Memory," *Journal of Experimental Psychology* 93 (1972): 439—471.

[17] Wittgenstein, *op. cit.*, III-86, p. 27e.

[18] My main concern here is not Wittgenstein exegesis. It is rather to develop a certain line of argument about colours and their relations, elements of which seem attributable to Wittgenstein.

[19] I ignore here afterimages and other phenomena such as synaesthesia, since they do not affect the point I am making.

[20] This sense of pureness as an attribute of *colour* (hue) should not be confused with pureness as an attribute of *being coloured*. To say that something is coloured purely orange is to say that it is homogeneously orange, which is compatible with the colour (hue) orange being impure in the sense of being composed of red and yellow. We can also say that something is coloured a pure orange, by which we mean that its colour is a good or prototypical example of orange (usually an orange at maximum saturation).

[21] One often finds the term "brightness" used for this dimension. Although there is some disagreement and confusion over the use of these terms, "brightness" most properly refers to the dimension of dim-to-dazzling, whereas "lightness" refers to the grey-scale of black to white. Brightness is perceived as an attribute of colours primarily in the aperture mode of colour appearance, whereas lightness is perceived primarily in the surface mode of colour appearance. See J. Beck, *Surface Color Perception* (Ithaca: Cornell University Press, 1972), pp. 25—29. To add to the confusion, "lightness" is also used in a somewhat different though related sense in computational vision. There it refers to the psychophysical correlate of average relative reflectance. See E. H. Land,

"Recent Advances in Retinex Theory and Some Implications for Cortical Computa-
tions: Color Vision and the Natural Image," *Proceedings of the National Academy of
Sciences U.S.A.* 83 (1983): 5163—5169; and A. Hurlbert, "Formal Connections
Between Lightness Algorithms," *Journal of the Optical Society of America A* 3 (1986):
1684—1693.

[22] For an accessible discussion of various models of colour space see R. W. G. Hunt,
Measuring Color (West Sussex, England: Ellis Horwood Ltd., 1987), Chapter 4. For a
historical treatment of models of colour space see Gerald S. Wasserman, *Color Vision:
An Historical Introduction* (New York: Wiley, 1979). The possible non-Euclidean
nature of colour space is discussed by D. B. Judd and G. Wyszecki, *Color in Business,
Science and Industry*, second edition (New York: Wiley, 1963), pp. 274, 309—310.

[23] For discussion see Hardin, *Color for Philosophers, op. cit.*, pp. 66, 126—127.

[24] For clearly articulated examples of this view see Bernard Harrison, *Form and
Content* (Oxford: Basil Blackwell, 1973); and "Identity, Predication and Color,"
American Philosophical Quarterly 23 (1986): 105—114.

[25] H. Crane and T. P. Piantanida, "On Seeing Reddish Green and Yellowish Blue,"
Science 221 (1983): 1078—1080.

[26] *Color for Philosophers, op. cit.*, p. 126.

[27] Hardin goes on to observe that even this view is flawed, for the opponencies of red
and green, and yellow and blue, might not be essential to them, as the experiment cited
above in note 25 suggests. In Hardin's view, "the characteristics and relationships of
colors depend on their biological substrate, and we delude ourselves if we suppose it
possible systematically to understand the relations colors bear to each other in isolation
from that substrate." *Ibid.*, p. 127. The extent to which the apparent necessities about
colour are grounded in contingencies of biology is yet another difficult topic that for
reasons of space I must set aside here.

[28] Ludwig Wittgenstein, *Tractatus Logico-Philosphicus*, trans. D. F. Pears and B. F.
McGuinness (London: Routledge & Kegan Paul, 1961), 4. 123, p. 27. Similar examples
can be found throughout the *Remarks on Colour*. For example, at I-1, the first passage
of the work, Wittgenstein distinguishes between two "language-games," one which
involves "reporting whether a certain body is lighter or darker than another," and
another which involves stating "the relationship between the lightness of certain shades
of colour." He then says: "The form of the propositions in both language-games is the
same: 'X is lighter than Y'. But in the first it is an external relation and the proposition
is temporal, in the second it is an internal relation and the proposition is timeless."

[29] "Form and Content. An Introduction to Philosophical Thinking," in *Moritz Schlick,
Philosophical Papers (Volume II: 1925—1936)*, eds. Henk L. Mulder and Barbara Van
de Vele-Schlick (Dordrecht: D. Reidel, 1979), pp. 293—294. Schlick goes on to say
that "the relation of similarity between two coloured objects is external, but the relation
of similarity between the particular colours as such is internal." This remark should be
compared to Wittgenstein's statement quoted in the previous note.

[30] See Hardin, "A New Look at Color," *op. cit.*, p. 128.

[31] It might be thought that the Munsell colour space which has the structure of a
branching tree is a counter-example to this claim. One of the virtues of the Munsell
space is that whenever some new pigment is made it can be incorporated into the space
by extending some existing branch. But these extensions are always in one of the
already existing hue families and typically involve creating a more saturated or lighter
or darker shade. In this sense, extending a branch of the tree is like creating one of
Hume's "missing shades of blue." The extensions do not involve adding an entirely new
kind of hue not found in the space.

[32] Jonathan Westphal, *Colour: Some Philosophical Problems from Wittgenstein* (Ox-
ford: Basil Blackwell, 1987), pp. 100—101.

[33] *Color for Philosophers, op. cit.*, p. 126.

348   EVAN THOMPSON

[34] It should be noted that the viewing conditions in the experiment are highly abnormal, and so for normal conditions our colour space might still be three dimensional. The point is that the colour space comprising all the hues we can experience regardless of viewing conditions would not be three-dimensional.
[35] Harrison, *Form and Content, op. cit.*, p. 133.
[36] Jonathan Westphal, *op. cit.*, p. 47.
[37] Harrison, *Form and Content, op. cit.*, p. 127.
[38] These conditions are not original with me; they are Hardin's. See "A New Look at Color," *op. cit.*, p. 128; and *Color for Philosophers*, op. cit., p. 145. I am attempting to push these conditions further in the context of the idea that at least some of the relations among colours are internal relations.
[39] I discuss at length this possibility of ternary hue perception for pigeons whose colour vision is at least tetrachromatic (perhaps even pentachromatic) in Thompson, Palacios, and Varela, *op. cit.* The possibility of ternary hues was to my knowledge first discussed by Hardin, *Color for Philosophers, op. cit.*, p. 146. His discussion was based on imagining a hypothetical tetrachromatic "visual superwoman."
[40] I must confess that I find it very hard to *imagine* how opponency could be inessential to the hues. But the persuasiveness of the (still to my knowledge unreplicated) experiments cited in note 25 is undeniable, and as Hardin notes, "to agree that this is a matter to be settled by experiment is of course to agree that it is conceptually possible that something could look both red and green all over." *Color for Philosophers, op. cit.*, p. 125.
[41] Wittgenstein, *Remarks on Colour*, op. cit., III-154, p. 36e. The other remark is I-66, p. 11e, which differs from the remark quoted above only slightly in wording.
[42] Jackson, *op. cit.*, p. 129.
[43] Here I follow the lead of Dennett who does the same for Jackson's Mary example. See *Consciousness Explained, op. cit.*, pp. 398—401. My point in attempting to spell out the thought experiment, however, is not to show that physicalism is true. It is rather to uncover what is, in my view, the mistaken intuition that motivates certain philosophical views about the qualitative features of experience (qualia).
[44] Jackson, *op. cit.*, p. 129.
[45] Daniel C. Dennett, "Quining Qualia," in *Mind and Cognition*, ed. William G. Lycan (Oxford: Basil Blackwell, 1990), pp. 519—547.
[46] Judd and Wyszecki, *op. cit.*, p. 308.
[47] *Ibid.*
[48] If one were to hold that the difference relation as specified in terms of the number of just-noticeably different hue-steps were essential to the *colours* (though not the *hues* of which the colours are composed), then the relation would be internal to the colours, and so would be intrinsic in the sense of being essential to them (but not in the sense of being nonrelational).
[49] This is the sense in which Harrison, "Identity, Predication and Color," *op. cit.*, seems to use the term: "Moreover, speakers agree for the most part, about the intrinsic properties of colors. They agree, for the most part, about what color samples satisfy identifying descriptions such as 'a dark, purplish red,' 'the color midway between blue and green,' and so on" (p. 108). And on the next page, he says: "we identify turquoise as 'the color midway between blue and green,' or burgundy as a 'dark, purplish red.' Such a characterization identifies a color *intrinsically — qua* color, that is — by characterizing its bare *quale*, without reference to any contingent fact about its empirical circumstances of manifestation (as that boiled lobsters happen to be red, the unclouded sky blue, and so on)" (p. 109).
[50] And so Dennett's characterization of qualia in his article "Quining Qualia," *op. cit.*, cannot be dismissed as a strawman.

[51] Terrence Horgan, "Functionalism, Qualia, and the Inverted Spectra," *Philosophy and Phenomenological Research* 44 (1984): 453—469, p. 459.

[52] For a similar argument see Jonathan Westphal, "The Complexity of Quality," *Philosophy* 59 (1984): 457—471.

[53] Jules Davidoff, "What is a Colour-Space?", Open Peer Commentary on Thompson, Palacios, and Varela, *op. cit.*

[54] This point has been made by many authors. For philosophical criticism of the idea that the sensation is the unit of perception, see Maurice Merleau-Ponty, *Phenomenology of Perception*, trans. Colin Smith (London: Routledge and Kegan Paul, 1962), Chapter 1; Gilbert Ryle, "Sensation," in Gilbert Ryle, *Collected Papers Volume 2.* (London: Hutchinson and Company, Ltd., 1971); David Kelly, *The Evidence of the Senses* (Baton Rouge: Louisiana State University Press, 1986), Chapters 2—3; Jonathan Westphal, *Color: Some Philosophical Problems from Wittgenstein, op. cit.*, Chapter 7. In perception theory, see J. J. Gibson, "Are There Sensory Qualities of Objects?", *Synthese* 19 (1968—69): 408—409, and *The Ecological Approach to Visual Perception* (Boston: Houghten Mifflin, 1979). Jules Davidoff defends the point for colour perception in his *Cognition through Color* (Cambridge, Massachusetts: The MIT Press/ Bradford Books, 1991), pp. 3—4.

[55] See Gregory R. Lockhead, "Psychophysical Scaling: Judgements of Attributes or Objects?", *Behavioral and Brain Sciences*, in press.

[56] Merleau-Ponty, *op. cit.*, pp. 4—5.

[57] Dennett, "Quining Qualia," *op. cit.*

[58] In fact, the phenomenological tradition in philosophy from Husserl to Sartre to Merleau-Ponty is unanimous in its rejection of qualia construed as nonrelational and purely phenomenal qualities. As Merleau-Ponty remarks in his *Phenomenology of Perception, op. cit.*, p. 52: "The pure *quale* would be given to us only if the world were a spectacle and one's own body a mechanism with which some impartial mind made itself acquainted."

[59] See Kathleen Akins, "Science and Our Inner Lives: Birds of Prey, Bats, and the Common Featherless Biped," in M. Bekoff and D. Jamieson, eds., *Interpretation and Explanation in the Study of Animal Behavior* (Boulder, Co: Westview Press, 1990).

Department of Philosophy
Concordia University
Montréal, Québec
H4B 1R6 Canada