Jack and Jill and Fred and Emily are all fictional characters who have had starring roles in spectrum inversion thought experiments in the past half century. Fred is the oldest, introduced in a 1962 article in Mind by DM Taylor on the incommunicability of content. I'm proud to say I introduced Jack and Jill in an article on intersubjective inversion in 1985. All three have been much discussed by Sydney Shoemaker, in articles dating from 1975 to 1996. Emily is Shoemaker's nonsexist version of Fred, introduced in 1996, though given the manipulations required to secure a full intrasubjective spectrum inversion, I don't think it does gender justice any service to make the protagonist a female.

I believe we need to re-examine these old arguments: that they don't demonstrate what they long been taken to demonstrate. Here's a recent sample of what they are taken to show:

> It is a central fact about experience that it has a complex structure. ... Take color experiences as an example. For every distinction between color experiences, there is a corresponding distinction in processing. The different phenomenal colors that we experience forms a complex three-dimensional space, varying in hue, saturation, and intensity.... The three-dimensional structure of phenomenal color space ... corresponds directly to the three dimensional structure of visual awareness. (Chalmers 2010, 21)

This principle has its limits. It allows us to recover structural properties of experience from information-processing properties, but not all properties of experience are structural properties. There are properties of experience, such as the intrinsic nature of a sensation of red, that cannot be fully captured in a structural description. The very intelligibility of inverted spectrum scenarios, where experiences of red and green are inverted but all structural properties remain the same, show that structural properties constrain experience without exhausting it. (Chalmers 2010, 22)

The last sentence expresses a widespread view, but I believe it is incorrect. I will argue that the intelligibility of inverted spectrum scenarios does not demonstrate the existence of properties of experience distinct from the structural properties of experience.

To put the point in a more standard way: the intelligibility of the various sort of inverted spectrum scenarios has long been taken to show that there exist certain properties of experience--qualia--that are distinct from all the functional and intentional properties of experience. The moral of it in the classic articles that "qualia cannot be functionally defined". Now of course there is a sense of that proposition with which everyone can agree: since qualia are not words, they cannot be functionally defined, or defined in any way, any more than rocks or rivers can be defined. But the intent is clear: that qualia are a class of properties of experience that are distinct from any possibile functional properties of experience. We need them to make distinctions between experiences that outrun the ones we can make using functional characterizations. In particular, we need them to characterize the relations between the experiences of two subjects, when one of the subjects is spectrum inverted relative to the other. If the two subjects are two distinct people, we have "intersubjective" inversion. If they are one person, but at two distinct times, we have "intrasubjective" inversion.
Chalmers uses the term "structural properties" of experience, meaning the properties of the relations in which they stand, and the standard "functional roles" or "causal roles" would indeed be included in that set. But other relations of experience, such as relations of phenomenal similarity, and the resemblances amongst the colors, might not be recognizable as functional or causal roles, though they certainly help provide the structure described in the structure of appearance. So the "structural" formulation is useful.

Chalmers also usefully identifies a characteristic common to many of the thought experiments popular in philosophy of mind: that they move from epistemic premises, or premises about the conceivability of this or that, to ontological conclusions. The arguments are taken to demonstrate the existence of a kind of property distinct from functional and intentional properties. The spectrum inversion arguments do indeed have this form. Chalmers himself thinks the conceivability arguments justify the claim that qualitative properties of experiences are ontologically fundamental features of the world over and above the features characterized by physical science (Chalmers 2010, 121). They might themselves be fundamental properties, like mass or charge, he says.

I am highly skeptical of this argument form. I doubt that we can safely derive ontological conclusions from premises that describe what we can or cannot conceive. Since some versions of the spectrum inversion argument clearly proceed in that fashion, it is incumbent upon me to show where they go wrong.

Of the various spectrum inversion scenarios, I think the intrasubjective variety is the one most easily imagined. Hilary Putnam describes its beginnings as follows:

...imagine your spectrum becomes inverted at a particular time in your life and you remember what it was like before that. There is no epistemological problem about “verification.” You wake up one morning and the sky looks red, and your red sweater appears to have turned blue, and all the faces are an awful color, as on a color negative. (Hilary Putnam, *Reason Truth and History*, 1981)

Putnam's mention of "epistemological problems" flags a feature of mid twentieth century treatments of the inverted spectrum. Intersubjective inversion was a common target of both verificationists and (later) ordinary language philosophers, who described it as unverifiable, hence without meaning; or as language gone on a holiday, hence without meaning. (Even the great Frege, in his essay "The Thought", considered the question "does my companion see the green leaf as red, or does he see the red berry as green?" but declared it to be "unanswerable, indeed really nonsensical." He says "when the word 'red' does not state of property of things but is supposed to characterize sense-impressions belonging to my consciousness, it is only applicable within the sphere of my consciousness"). Putnam used intra-subjective inversion in his lectures in the 70's and 80's, because it avoids all these issues. Even Frege might wake up one morning and find that today the leaves of the trees look red, and the former red berry now looks green.

Sydney Shoemaker has, in a series of essays (1975, 1982, 1990, 1996a, 1996b) provided the most precise and compelling description of intrasubjective inversion. The first of those essays was
prompted by the Block and Fodor 1972 article I discussed last time, and indeed formulates the problem as they did: does the conceivability of spectrum inversion demonstrate that there are kinds of psychological states whose "type identity criteria" cannot be functionally defined? Shoemaker agrees that the mere possibility of spectrum inversion demonstrates that a particular quale cannot be functionally defined; but holds that what it is for a psychological state to have some qualitative character or other can be characterized functionally. So, against Block, and later Chalmers, Shoemaker argues that "absent qualia" are impossible.

Now to show that a spectrum inversion scenario demonstrates the existence of qualitative properties of experience that are distinct from functional properties, one must design the scenario so that the normal peripient and inverted peripient manifest identical functional properties. Yet, intuition suggests, there is a qualitative difference between their experiences of one and the same object. That qualitative difference cannot be characterized in functional terms. Ergo there seem to be kinds of psychological states whose type identity criteria are not functional. Or, to use more recent lingo: there are properties of experience--qualitative properties--that are distinct from any possible functional property. In Chalmers' terms: these qualitative properties are distinct from any possible structural property of experience.

The requirement that the normal and inverted percepts are functionally identical to one another puts some significant constraints on the structure of color perception. Wherever the normal peripient finds color x relatively more similar to color y than to color z, the inverted peripient must find the inverse of x relatively more similar to the inverse of y than to the inverse of z. Otherwise the judgements and discriminations manifested by the two subjects will differ. They would then have different functional organizations, and most likely would be behaviorally distinguishable. The normal peripient might find a particular set of color chips easy to discriminate from one another, while the inverted peripient would find it difficult.

It bears emphasis that this constraint on the structure of color perception is not found in every use of the spectrum inversion scenario. If one is using it to draw some epistemological conclusion, for example, there may be no need to preserve functional isomorphism between normal and inverted percepts. But within recent philosophy of mind the main use has been metaphysical: to demonstrate the existence of properties that are distinct from functional properties. And for that project the premises describing functional isomorphism are mandatory, not optional.

I will repeat some of the short hand that makes the structure description simpler.

1. The "color quality space" for a subject S is defined by the resemblances and relative similarities that S experiences among perceived colors.

2. A "spectrum inversion" requires a function that maps every perceived color to an inverse, such that some perceived colors have inverses that are distinct from themselves.

4. The color quality space is invertible if and only if the mapping of colors onto inverses yields a structure isomorphic with the original.

Here's what I mean by "the color quality space". Give a human with normal color vision a set of color chips of all sorts of different color, and the following task: arrange these chips so that more similar colors are always closer to one another than samples that are less similar. With enough samples, and enough time, we'll eventually get a three dimensional arrangement. That
arrangement is a "uniform color scaling" or, colloquially, the "color quality space". One axis of it goes from white to black. Any color chips at the same point on that axis are all of the same "lightness" or "brightness". On any such plane you'll find the familiar "hue circle". Around the circumference you'll find the familiar hues. At the center of the hue circle is an achromatic patch (a gray) which matches all the color samples on that plane in lightness. Distance from that central achromatic axis gives the "saturation" of the color. If this three dimensional arrangement is truly uniform, then any two samples that are at the same distance from one another in it are also equally similar to one another.

The color chips in that example are what I'll call "stimuli" for color: they are objects that look to be, or appear as, colored. Remember that our quarry is colors as experienced, or colors as they appear, and for this project it is necessary to distinguish the experiences of colors from the stimuli that occasion those experiences. The "stimulus class" for a given color for a subject S is simply the set of objects that for that subject fairly reliably look to be that color. We can be more or less stringent about how reliable this connection must be. It doesn't hurt to define it intersubjectively, and as perfectly reliable. So: the stimulus class for a color predicate P in a language community L is the set of objects x such that if x is visible to a normally sighted member S of that language community, and S is queried 'is that P?' then S will invariably respond 'yes'." So the stimulus class for 'red' is the set of objects that, if visible to a normal trichromat in that community, will invariably be called "red". Around here it includes stop signs, blood, ripe tomatoes, etc. You can think of this class as the class of paradigmatically red things.

The idea of mapping a color to an "inverse" was introduced by Syndney Shoemaker in his 1975 article "Functionalism and Qualia". The differences between colors and their inverses might be small or large. If for example a small rotation of the "color wheel" could suffice as a spectrum inversion, then pure (or unique) red is mapped to a slightly yellowish red; unique yellow is mapped to a slightly greenish yellow, and so on. If however one thinks (as most do) that all the pure or unique hues have to be mapped either to themselves or to other unique hues, then inversion is a rather more radical transformation. Hues might each be mapped to their complement, so the inverse of red is green, the inverse of yellow is blue, the inverse of orange is a bluish-green, and so on.

The invertibility of the color solid became an intricate part of the debate. Sydney Shoemaker pointed out in 1975 (in "Functionalism and Qualia") that the need to preserve functional equivalence puts some significant constraints on the structure of similarities among the colors. He says that if inversion is possible then it must be the case that

(3) the mapping preserves, for any normally sighted person, all of the 'distance' and 'betweenness' relationships between the colors (so that if shades a, b, and c are mapped onto shades d, e, and f, respectively, then a normally sighted person will make the same judgments of comparative similarity about a in relation to b and c as about d in relation to e and f) ... (Shoemaker 1975, 258)

For example if orange is as similar to red as it is to yellow, then the inverse of orange must be as similar to the inverse of red as it is to the inverse of yellow. If they fail to bear those resemblances to one another, then spectrum inversion would yield changes in judgements and discrimination behaviors. It wouldn't even retain behavioral equivalence, much less functional
isomorphism. So for spectrum inversion to be possible, a color and its inverse must stand in the same pattern of relationships of resemblance to all the other colors.

II

Shoemaker's innovation in the description of intrasubjective inversion is to imagine it proceeding in a series of partial inversions. In each partial inversion the relative similarities between some stimuli would change dramatically, with both reportable and observable effects. So along with the reports of the subject involved, we could have behavioral evidence that a partial inversion has occurred. This is true for all the partial inversions required. But at the end of the series of partial inversions, the color quality space has entirely inverted. At that point the perception of every color has been replaced with the perception of its inverse. So, per hypothesis, all the resemblances and relative similarities the subject originally found among chromatic stimuli will be restored; behaviorally the subject is now indistinguishable from his or her old self. Yet the qualitative character of the perceptions of many stimuli now differs from what it was.

Fred is a bit easier to describe (Shoemaker 1982, 362 ff):
1. Suppose Fred's color quality space is invertible.
2. One morning Fred wakes up and discovers that he has undergone the first of what will be a series of partial spectrum inversions: the chromatic appearances of things that have one particular shade of color, and those that appear to be the inverse of that color, have traded places.

Suppose for example that the color is red and its inverse is green. Stop signs are (presumably) in the stimulus class for red, and healthy foliage is in the stimulus grass for green. After the partial inversion, to Fred stop signs look green, and a healthy lawn looks red. But suppose that just that one pair of stimulus classes swap appearances; everything else appears chromatically the way it did the day before.

3. Each such partial inversion would change the discriminability and relative similarity relations that Fred finds to obtain among stimuli. Call the color C and its inverse I. Objects that used to appear as quite similar to those in the stimulus class for C now seem quite dissimilar from them, and relatively much more similar to those in the stimulus class for I. Fred would also likely report that the appearances of some objects have changed, and he would at least initially be likely to apply the predicate for the color C to objects in the stimulus class for I (as that is how those objects now appear to him).
4. Therefore, each partial inversion would change the structure of Fred's color quality space, and it would change it in ways that would be behaviorally and introspectively detectable.

That's how partial intrasubjective inversion disposes of any worries that the changes in question are unverifiable or a product of the misuse of language.

[The Farnworth hue order test]
Suppose that after each inversion Fred "accomodates" to the change. Eventually he will unreflectively and reliably apply the color predicate for C to objects in the stimulus class for C, and that for I to objects in the stimulus class for I. The series of partial inversions comes to an end when every color that has an inverse distinct from itself has swapped stimulus classes with its inverse. At that point, the structure of Fred's color space is once again identical to what it was before the series of inversions began. And Fred's color discriminations, judgements of relative similarity, and use of color predicates will be indistinguishable from that of his old self. Therefore, at the end of the series Fred is behaviorally and functionally isomorphic to what he was before it began.

After the series of partial inversions is complete, Fred is functionally isomorphic to his old self. Yet the qualitative character of Fred's experiences of many different objects has changed. Stop signs and healthy foliage have not changed in appearance since the first partial inversion; and they both look different to him than they did before the series of inversions began. Therefore, the qualitative properties of experience are distinct from their functional properties. Or, as it was put back then, the qualitative character of experience cannot be "functionally defined".

Technically, one other change is needed within Fred to have a complete intrasubjective inversion. As it is, he could remember the old normal appearances of objects, and he could remember that objects to which he now unhestatingly applies the predicate "green", such as stop signs, used to look red. Furthermore, his diachronic similarity judgements have changed. Before the inversion, objects in a given stimulus class maintained similar appearances across time--the stop sign today looks the same as it did yesterday, and the day before that, and the day before that, etc. The inversion ruptures such diachronic similarities, so that many objects in many stimulus classes once had, and are remembered to have had, a very different appearance. To make Fred functionally isomorphic to his old self, both such functional aberrations must be eliminated. Fred must lose all episodic memory of the series of inversions and of accomodating to them. Furthermore all memories of the colors of objects prior to the color swap must be adjusted so that it will seem to Fred as if objects have always had more or less the colors they have now. (This last change is sometimes called "amnesia", but Fred was not amnestic before the spectrum inversion, and so he should not have a memory loss now. Instead we need a global "search and replace" through all memories of objects and events prior to the end of the series of inversions, replacing their contents systematically without destorying the memories themselves. At the end of this process, Fred must seem to remember objects always looking to him the way they do now (after the inversion has been completed.)
In later work Shoemaker (1990, 1996) takes the argument to show not only that qualitative properties of experience are distinct from functional properties, but also that they are distinct from intentional properties. Emily embodies this change. The intentional properties of experience are described by describing what those experiences represent or how they represent the world to be. The distinction is mentioned in Shoemaker 1982 between "intentional" and "qualitative" senses of the phrase "looks the same". Before the inversion Fred will say the stop sign looks red, and after he has accommodated to the partial inversion Fred will say the stop sign looks red. There is a sense--the intentional sense--in which the sign "looks the same" before and after the inversion. At both times the object is judged to have the color that everyone in the language community calls "red". But in the "qualitative" sense of the phrase, the sign looks different from the way it used to look.

The intentional properties of experience go far beyond those necessary to explain our use of color words; Shoemaker also accommodates what he calls "sense-individuated intentional properties". Reference-individuated intentional properties are distinct just in case the two representations have distinct extensions. Sense-individuated intentional properties may differ between representations that have identical extensions if they differ in the way they pick out those extensions (Shoemaker 1996a, 103). Chromatic experiences in quality spaces of different structure may manage to refer to an identical stimulus class as their extension, but the way that quality is represented--its similarity and difference relations to other chromatic qualities--is distinct. The quality space represents a particular as standing in an intricate pattern of relations of resemblance and difference to other colors; and if the structure of those relations differ, then arguably the ways in which the quality space picks out a class of stimuli will differ as well. The "intentionalist" position which Shoemaker is intent on refuting is that all of the qualitative differences between experiences can be described as differences in such sense-individuated intentional properties:

if creatures differ in quality spaces in the way imagined then the senses of their color experiences will differ, even when they are experiences of what in fact are the same colors. So, it may be held, we can say that experiences are the same just in case they share the same sense-individuated intentional properties...and that there is no need to invoke some set of properties over and above these--qualia or "phenomenal" properties--in virtue of which experiences are similar or different." (Shoemaker 1996, 108)

The thought experiment that Shoemaker uses to show that we do "need to invoke some set of properties over and above" the sense-individuated intentional ones requires a few minor changes from the saga of Fred. The protagonist in this drama is now Emily.

One proposition that is now overt (but only implicit in 1982) is that even after the inversion the chromatic appearances of some objects do not change. Emily's color quality space is symmetric with respect to a plane (it is a reflection symmetry) and the appearances as of yellow and as of blue lie on that plane. So the inverse of blue is itself, and the same for yellow.

Second, and more importantly, the process of "accommodation" to each partial inversion is more thoroughly described. Just like Fred, she adapts her use of the relevant color predicates, so that eventually she will say "red" when something looks green to her, and "green" if it looks red. (Shoemaker 1996, 111) But we assume as well that eventually all of her chromatic intentional properties accommodate to the change. After each partial inversion, all of the linguistic and non-
linguistic ways in which she represents the colors of objects in the relevant pair of stimulus classes eventually accomodates so as to be "of" the new extensions.

One premise in the argument needs some clarifying: the sense in which each partial inversion changes the *structure* of the quality space. Shoemaker describes the partial inversion in somewhat alarming terms:

> Each change involves a change in the structure of the quality space in which two shades "change places", each coming to appear the way the other did previously, the appearance of all of the other shades remaining unchanged, this being followed by an "accomodation" in which the intentional content of the experiences adjust to the change. Two different shades are involved in each change. After the final change, all shades have changed their appearance, the original structure of the quality space has been restored, and for every shade S the S-produced experiences have (in normal circumstances) the intentional content of being-as-of-S. (Shoemaker 1996, 111)

Now in what sense do the shades "change places", and in what sense does the appearance of a shade "change"? I think we must understand "shade" here extensionally, as referring to the set of objects that, normally and paradigmatically, appear to be that particular color.

For consider: qua shade, red does not change its appearance when Emily suffers her first partial inversion. What changes is that the things that formerly looked green now look red. But even to understand this we have to understand "look red" to mean: presenting exactly the same appearance that red things did the day before. Otherwise the very description of the partial inversion becomes incomprehensible.

A key part of the structure of the color quality space is that red appears as a component of many different binary colors, such as orange and purple. If the appearance of red itself, qua shade of color, changed in the partial inversion to that of green, then all these binary hues must be affected as well. Orange and purple would have to come to appear somewhat greenish, and not somewhat reddish. But clearly Shoemaker insists that each partial inversion affects the appearance of only two shades, namely that of a particular fully determinate color, and that of its inverse.

This is why I think it is handy to talk of "stimulus classes": the set of objects that present that particular shade, or that serve as stimuli for the experience as of that particular shade. To understand a partial inversion as a "change in structure", these stimulus classes must be included as part of that structure. Recall that this is perfectly legitimate in functionalism: among the relations one uses to define a particular mental term are relations to "stimulus inputs". And indeed what changes places in the structure of the color quality space is the attachment of particular stimulus classes to the appearance as of a particular hue. The very same objects that yesterday looked green today look red. Redness qua appearance has not changed at all; what has changed is simply the set of object that present. Shoemaker himself distinguishes between "R-produced" experiences, and experiences "as of R". R-produced experiences are those whose stimulus is some member of the stimulus class for red; experiences as of R are those in which one experiences the appearance as of red.

someone reports, after the microsurgeons have been at work on her, that nearly everything looks the way it did before, but that the shades of color within a very small range have "switched places" with their complemenaries, each shade now looking the way its complementary used to look. This would be a change
in the structure of the subject's quality space, and would be reflected in behaviorally detectable changes in
the subject's discriminatory abilities" (Shoemaker 1996, 143)

Initially, Emily's experience as of red was caused by, and represented, a property of objects in the
stimulus class R, which includes such things as ripe tomatoes, stop signs, blood, and so on. A
different set of objects G causes experiences as of green. After the inversion, the set of
objects R causes experiences as of green, and the set G yields experiences as of red. But it is as
if Emily has moved to Inverted Earth: eventually, says the intentionalist, the experiences as of
green, which are now produced by R, will come to represent, and be as of, the color of objects in
stimulus class R. Intentional content hence eventually inverts.

But the qualitative character of Emily's experiences as of stop signs or healthy lawns changes just
once, on the night of the relevant partial inversion. So, says Shoemaker, the qualitative character
of her R-produced experiences is still just what it was immediately after the partial inversion.
Shoemaker says "her current R-experiences might be phenomenally just like her R-produced
experiences right after the operation, and likewise that her current G-produced experiences might
be phenomenally just like her G-produced experiences right after the operation." (Shoemaker
1996, 111-112). So even if the intentional content eventually inverts, the G-ish qualitative
color character does not thereby become R-ish. Therefore:

"an adequate description of the case must invoke a notion of qualitative, or phenomenal, similarity that is
distinct from (even if normally coextensive with) the relation of "intentional similarity", and with this it
must invoke qualia in addition to intentional properties of experience." (Shoemaker 1996, 112)

We need to invoke a set of properties over and above, and distinct from, both the functional and
the intentional properties of experience. The new properties are qualia. The conclusion is clearly
metaphysical, the premises epistemic. In that respect I think the argument illustrate the
Chalmeresque move in all its glory: from conceivability to an existence claim.

IV

The crux of this argument--just like that of the argument from intersubjective inversion I
described in the fall--is the relation that must obtain between the appearance as of a color, and
the appearance as of the inverse of that color, if the color quality space is to be invertible. I think
I can show you that Shoemaker commits a very subtle of the mistake diagnosed last time: of
confusing structural isomorphism, or indeed structural indiscernibility, with structural identity.

Shoemaker is clear and forthright about the fact that an invertible color quality space will possess
a certain kind of symmetry. If a partial inversion can swap red with green, but preserve
functional isomorphism, then red must stand in the same pattern of relations of resemblance to all
the colors as does green. Those two points stand in patterns of relation to all the rest that are
indeed isomorphic to one another. Shoemaker says:

If behaviorally undetectable spectrum inversion is a possibility, then different color qualia may be in a
certain sense functionally indistinguishable. They will occupy different locations in a "space" of qualia, but
because of the symmetrical nature of that space it will be impossible to give a functional description that
applies to the one but not to the other--rather in the way that if one is describing in spatial terms a spatially
symmetrical array of objects, then any description one gives of an object will apply as well to its
symmetrical counterpart. If this is so, then color qualia will be "ineffable" in a way that goes byeond the
irreducibility to particular physical properties that goes with multiple realizability. (Shoemaker 1996, 263, middle of section IV)

Yes, the two color qualia occupy different locations in a color space that, if it is invertible, is symmetrical. And yes, we can allow that there is a sense in which those two qualia (of a color and its inverse) are "functionally indistinguishable". But there is a large step from that claim to the claim that they are functionally identical. Even if we allow that the space is symmetric and that green is the inverse of red, we do not thereby demonstrate that red and green have identical functional properties.

The simplest way to see this is to note that while they stand in the same pattern of relations to other relata, they do not bear identical relations to identical relata. Their relational properties are of the same form--their structure diagrams are congruent--but they are not identical. The color appearance and its inverse are what I'll call an "automorphic pair" (thank you Marcus), but they are not identical.

In fact the structural descriptions of the two members of an automorphic pair are not even coextensive. Consider: suppose we detail the relations of resemblance amongst all the appearances as of color. We discover that that structure possesses at least one symmetry: there is a mapping from colours onto inverses, some of which are distinct from the colors themselves, which yields an automorphism of the original structure. It follows that if we know that green is the inverse of red, we know that green is distinct from red. It is, after all, at a different place within that structure. Yes, the pattern of relations that it bears to all the colors is isomorphic to the pattern manifested by its inverse red. Per hypothesis this is one of those pairs in which the color is mapped to an inverse distinct from itself. If there are no such pairs, then our symmetry group is just Einheit, identity, and nothing changes when an inversion occurs.

It can be shown formally that if we have an invertible solid, and a symmetry other than identity, then the structure descriptions of colors and inverses distinct from those colors (a) are in a sense isomorphic, but (b) are not logically equivalent, and (c) are not co-extensive. Their extensions must differ if anything happens on the night when the first partial inversion occurs.

Shoemaker says (in the above quote) that "any description one gives of an object will apply as well to its symmetrical counterpart". The sense in which this is true is that the structure as a whole is invertible. There are two distinct assignments of stimulus classes to the structure which are automorphic to one another. The same structure description applies to the color quality space as a whole and to its inverted form.

But this does not imply that a structure description of a particular quale is also simultaneously satisfied by the inverse of that quale. That is, there is no time at which, for any subject, the same structural description would be true of both the appearance as of a color and the appearance of its inverse. Once you've given the structure description for one of those, you thereby also imply a distinct, and non-coextensive, structure description for its distinct inverse.

I suggest the problem demonstrated here, and the sense in which a color and its inverse are "functionally indistinguishable", is purely epistemic. It boils down to the fact that, if the color solid is invertible, (and supposing for the sake of simplicity that it has only one inversion distinct
from itself) then even given all the behavioral, verbal, and introspective evidence, we might not know which of the two structure descriptions is satisfied by the stimulus classes at hand. There are two distinct ways in which all the facts might satisfy the same Ramsey sentence. And we don't know which of those two is actual.

But consider what we would need to rectify this failing of ours. We don't need anything added to be able to distinguish between a color and its inverse: the structure description does that for us. Technically, the Ramsey correlates for the color and its inverse are distinct expressions, which can be shown to have distinct extensions. We don't need the assistance of an omniscient being (like God, or Ernie Sosa) to help us with that problem. But what we do need--and all that we need--is for that omniscient being to whisper into one person's ear one assignment of an appearance to a stimulus. "Psst: that one appears red, not green!" With that one assignment the entire structure is given an univocal interpretation, and all of the structure descriptions for all of the chromatic appearances lock into place, with a unique stimulus class for each.

Here's what might be a helpful analogy for understanding the difference between automorphism and Einheit (or identity). Consider the humble H\textsubscript{2}O molecule. It has two little hydrogen atoms stuck at the equator of the oxygen atom, at an angle of 120 degrees from one another. Zoom down to the picometer scale, and orient the molecule correctly, and the big oxygen atom will look like Mickey Mouse's head, with the two little hydrogen atoms resembling his cute little ears. Now this molecule has four symmetries: a rotational axis (right up through the center of Mickey's head); two reflection planes (one of which goes through the middle of both of his ears, and the other of which devides him in half, between his two ears); and last, of course, Einheit, identity. Now the reflection symmetries are a bit strange because they could change the spin of some of the more fundamental particles making up Mickey. Take something spinning clockwise: in a reflection, ie taking it "through the looking glass", with the reflection plane parallel to the axis of rotation, the results will be something spinning counterclockwise.

But consider the rotational symmetry. We twirl Mickey 180 degrees around, so that the ear that was to the left is now to the right. Mickey's new orientation is isomorphic with his old one: all his parts stand in exactly the same pattern of relations to all his other parts after his inversion as they did before his inversion. Both normal and inverted Mickey satisfy exactly the same structure description. And most likely Mickey is his new orientation is qualitatively identical to Mickey in his old one. If we assume that any proton is qualitatively identical to any other one, and similarly for neutrons and electrons, then we would have this result. Fundamental particles can't get dings or scratches on them in their long careers.

But for all that the new orientation of Mickey is not identical to his old one. The proton making up the hydrogen nucleus in his left ear might have condensed from quarks right here, in what eventually became the state of Connecticut. Whereas the one in his right ear might have condensed from quarks 13 billion years ago somewhere in the Oort cloud, and been fortuitously transported here on an asteroid 4 billion years ago, when Earth was condensing from stellar dust. In brief, his right ear is not from around here. The two orientations are not identical. This automorphism is not identity. But we can't know which of the two possible orientations Mickey currently satisfies. I think our situation with spectrum inversion, if it were possible, would be exactly analogous.
So how exactly does the distinction between automorphism and identity bear on the inference to the conclusion that we must posit qualia as a set of properties of experience over and above the functional and sense-individuated intentional properties of experience?

The critical intermediary conclusion of the argument is that functional and intentional resources do not allow us to characterize what changes in Emily: in what way she is different post-inversion than she was pre-inversion. Recall how Shoemaker puts it:

an adequate description of the case must invoke a notion of qualitative, or phenomenal, similarity that is distinct from (even if normally coextensive with) the relation of "intentional similarity", and with this it must invoke qualia in addition to intentional properties of experience. (Shoemaker 1996, 112)

Now this indeed would follow if Emily were functionally and intentionally identical to her old self. Things that once looked green now look red. Suppose her experiences post-inversion (and following "accomodation") represent the same extensions, and have identical contents, as what they had pre-inversion. Suppose her experiences have exactly the same functional properties now as they did before the series of partial inversions began. Then if we are to characterize what has changed in her experience as a change in its properties, we must invoke some kind of property that is distinct from intentional and functional properties.

This move is blocked if automorphism is distinct from identity. I am denying the inference from "Emily is functionally isomorphic to her old self" to "Emily is functionally identical to her old self." She displays, not an identity of functional properties, but rather an automorphism. In other words, there is a distinction in the functional properties of Emily pre and post-inversion. One is a non-identical isomorph (or automorph) of the other. Yes, her experiences as of color post-inversion stand in a pattern of relations that is isomorphic to her experiences as of color pre-inversion. But for many experiences of particular colors, it is not the case that it stands in identical relations to identical relata pre-inversion and post-inversion. Such a difference is clearly a difference in functional (or at least structural) properties, and I submit that it characterizes precisely what has changed in Emily. She is now an automorph of her old self.

In any case, if we have structural resources to characterize the difference between Emily pre-inversion and Emily post-inversion, then the inference to the claim that we must invoke qualia as a set of properties over and above functional ones is unwarranted. So, as promised, I believe this shows that the conceivability of spectrum inversion does not suffice to demonstrate the existence of properties of experience over and above the structural ones.

Here's another way to make the point. Recall that Shoemaker says

After the final change, all shades have changed their appearance, the original structure of the quality space has been restored, and for every shade S the S-produced experiences have (in normal circumstances) the intentional content of being-as-of-S. (Shoemaker 1996, 111)

Shoemaker doesn't mean that "all" the shades have changed their appearance, but rather that at the end of the process all those whose inverses are distinct from themselves have changed. (Emily's experience of blue is unchanged throughout.) The end of the series of partial inversions...
does not restore the quality space to its original structure. Instead, it is transformed into an automorph of its original structure. These indeed are isomorphic to one another, and it may be epistemically impossible for us (humans) to determine which of the two is satisfied right now. But recall Mickey Mouse with his left ear composed of Connecticut quarks, and Mickey Mouse with his right ear composed of Connecticut quarks. Those two structures are also isomorphic to one another, it may be may be epistemically impossible for us (humans) to determine which of the two is satisfied by Mickey right now. Nevertheless the two configurations are not identical to one another.

The issue is confusing because something does get restored to its original configuration: namely the total set of Emily's color discriminations and relative similarity judgements. Each partial inversion would yield anomalous behavior in various color discrimination tests. The simplest is perhaps the "Farnsworth Hue Order" test. This was used by Berlin and Kay to ensure that their informants had normal trichromatic discrimination even if they happened to speak a language that has only one or two basic color words. In each test a set of twenty color samples (each a die painted a certain hue) are shaken up and dumped onto a table; the informant is asked to arrange them in a line in such a way that samples close to one another are always relatively more similar to one another than are samples further apart. Any trichromatic adult can do this after some experimentation; one might end up with a series that starts with blue, runs through red, yellow, and green, and ends with a bluish green.

After a partial inversion Emily will produce anomalous results on this test. She will put the red sample at one end of the order, and the green sample in the middle, between purple and orange. But then as additional partial inversions take place, she will swap the positions of more and more of the color die. For example, orange will swap places with a greenish yellow. Purple will swap places with a greenish blue. When the last partial inversion is completed Emily will again produce a normal ordering in the Farnsworth Hue Order test. It might start with blue, run through green, yellow, and red, and end with a greenish blue. No die is out of place. But her experiences of all the colors other than blue and yellow have been "inverted".

Emily might have identical behavioral dispositions after the inversion as she did before it. But it is a staple of functionalist lore that different functional organizations can yield identical behaviors and identical behavioral dispositions. If the color quality space is invertible then it would be easy to produce two (or more) that do so. Nevertheless they can be distinguished functionally.

VI

To close let me try to put the conclusion in a slightly more positive way. I am apt to be asked, incredulously, "Do you mean to say that the difference between the experience as of red and the experience as of green consists in a difference of purely structural properties?" The answer is "yes", and here's the beginning of a defence of that answer.

Whatever else qualia are, they are, according to their proponents, something that suffices to determine the relations of qualitative similarity and difference that hold among those experiences. It is, says Shoemaker, because experience as of red has the qualitative properties
that it does that it has the similarities that it does to experiences of oranges and of purples, and the
differences to experiences of greens, blues, and yellows.

Now the intentionalist proposes that the resemblances among the colors of objects are
determined by how those colors are represented. Chromatic experience represents objects to
have various properties, and the resemblances and differences among those properties are to be
unpacked by unpacking the representational content of the experiences.

Suppose the intentionalist puts forth a bold hypothesis: that the content of a particular
experience as of color is just a Ramsey correlate of the sort I've been discussing. At the very
least the content has to determine the relations of qualitative similarity and difference between
experiences as of this particular color and those of others: the Ramsey correlate does that. It
would entail relations of discriminability and relative similarity among various classes of stimuli
as well: that objects that are red are very easy to discriminate from those that are green, but not
from those that are reddish orange. The Ramsey correlate does that too.

It might be objected that the structural difference between the Ramsey correlate for red and that
for green is too small--they are members of an automorphic pair after all--to account for the
salient experiential between red and green. But suppose we had a color quality space that was
invertible, and that green was the inverse for red. I submit that the differences between the
Ramsey correlates for those colors is in fact the perfect representation of what the difference
between red and green would be. They would be members of an automorphic pair. The earlier
spectrum inverse arguments that assume that automorphic structural properties are identical
structural properties are simply mistaken. There is a qualitative difference to be sure, but it is not
one that outruns the differences in structure.

Consider other domains in which we employ representational systems that might manifest the
kind of symmetry that allows for inversion scenarios. Our representation of space might allow a
perfectly symmetrical universe, such that all the spatial relations between where we are right now
and everything else in the universe do not suffice to determine whether we are at point A, or at
the inverse of point A. Even more interesting: our representation of chiral properties (left vs
right, clockwise v. counterclockwise, etc) might be such that a planet far, far away might satisfy
the total relational structure in two distinct ways, and nothing the inhabitants tell us in their
transmissions suffice to tell us how to translate their chiral terms into ours. Neither of these
symmetric representational systems should tempt us to posit new kinds of properties. There were
indeed arguments that the difference between "incongruent counterparts"--between left and
right--provide some grounds for the metaphysical posit of absolute space, but I think it is clear
that those arguments do not work. These potentially symmetric representational systems yield at
best epistemic puzzles: there will be scenarios that provide two distinct options, and even with
full knowledge of all the relational facts we cannot tell, we cannot know, which one is satisfied.
I suggest that spectrum inversion is a scenario that can yield that sort of epistemic problem, but
nothing more than that. Just as the Ozma problem doesn't licence the posit of absolute space, so
the spectrum inversion problem doesn't licence the posit of qualitative properties of experience
distinct from structural ones.