**AVOIDING NEUROSCIENCE’S PROBLEMS WITH VISUAL IMAGES:**

**EVIDENCE THAT RETINAS ARE CONSCIOUS**

**Abstract** Neuroscience hasn’t shown how quite similar sensory circuits encode quite different colors and other qualia, nor how the unified pictorial form of images is encoded, nor how these codes yield conscious images. Neuroscience’s fixation here on *cortical codes* may be the culprit. Treating conscious images partly as *retinal substances* may avoid these problems. The evidence for conscious retinal images is that (a) the cortical codes for images are quite problematic, (b) injecting retinas with certain genes turns dichromats into trichromats without cortical help, (c) retinas can discern colors by themselves without cortex, (d) retinal distortions appear in images but cortical distortions don’t, (e) retinal detectors support finely detailed colors, but V4 detectors don’t, due to their big receptive fields, (f) retinal activity has pictorial form, but viable cortical codes for pictorial form don’t exist. So, the colors and unified pictorial form of images arguably arise mainly across arrays of retinal detectors—not from abstract cortical codes. Images may be hidden in retinal activity beyond what EEGs show of it (cf. Strawson’s monism). Also, cortex refines these retinal images but cortical impairment (anesthesia, lesions, etc.) blocks awareness of them, for they’re no longer accessible to the mind’s subject-centered consciousness, resident in cortex. This proposal is largely testable and based in recent evidence. It avoids neuroscience’s elusive, problematic coded images and enigmatic explanations of how they become conscious.

**1. Introduction**

This paper contains two arguments. (a) Neuroscience’s widespread attribution of consciousness to neocortical (or thalamocortical) information processing renders its account of visual images problematic. (b) Treating images partly as retinal substances avoids these problems.

 Neuroscience’s cortical-centered approach stems from its view that conscious images reflect highly integrated information. But this view clashes with evidence reviewed below. For example, lesion studies show that frontal cortex has little effect on images. Also, while posterior cortex and its feedbacks do create some features of images, there’s little evidence that they create the colors and unified pictorial form in images. For example, the codes for the unified pictorial form haven’t been found. Also, while cortical area V4 has color detectors, their large receptive fields support broad color constancy comparisons—not the minute, colored details in images.

 The evidence reviewed below indicates instead that retinal activity is the main neural correlate of the colors and pictorial forms within images—while cortex refines these retinal images with color constancy, depth perception, et cetera. For example, recent studies show that retinal opponent cells can disambiguate cone inputs to enable accurate color perception—and that injecting dichromatic retinas with genes for long-wavelength cones can create trichromatic vision without cortical help. Also, retinal distortions during retinal detachment appear in images, while cortical distortions (e.g., hemispherical splitting) don’t appear.

 In contrast, the common reasons for treating images as cortical are problematic. One such reason is that certain cortical lesions create color blindness. In reply, the lesions may just destroy cortical color-constancy mechanisms, thus blocking retinal colors from appearing higher up in the mind’s unified, subject-centered consciousness created by cortex. Another reason for treating images as cortical is that we’re unaware of images during anesthesia, which disrupts cortical (but not retinal) activity. In reply, retinal images may still exist during anesthesia, but we’re unaware of them because of the total absence of this subject-centered consciousness, where attention, working memory, etc. reside. (In contrast, when we stare blankly ahead without attention, both the images and the mind are present, but the mind is idle.)

 This is some of the evidence reviewed below which supports this paper’s conclusion that while visual images are refined by cortical computations, they’re partly electrochemical substances spread across retinal detector arrays.

**2. Neuroscience’s Problems with Visual Images**

Standard neuroscience and its allied physicalist theories typically construe visual images in terms of information processing (including computational codes) by cortical or thalamocortical networks. But this *neural-network approach* has problems (covered below) in explaining (1) what makes vision conscious, (2) how images get their colors, and (3) how images get their unified pictorial structures. The latter two are the so-called “easy” empirical problems of finding the neural correlates of images. The first is the “hard” metaphysical problem of why these correlates are accompanied by consciousness rather than being nonconscious.

 A recent alternative view in neuroscience offers evidence that the unified form in (3) is instead better explained by attributing images to the information in electromagnetic (EM) fields generated by neural networks in cortex (xxxxx 2013). But this *neural-field approach* hasn’t dealt with issues (1-2).

 Here in §2, this paper scrutinizes these two approaches in terms of the three problems above. It then offers (in §3) a *hybrid approach* that tries to avoid these problems by attributing images to both neural networks and the neural fields they generate. But images are not cortical information. Instead, they’re mainly electrochemical substances spread across retinas (beyond what EEGs, MRIs, etc. detect of them).

**2.1 Why Is Vision Conscious?**

Neuroscience studies both visual processing and its ties to conscious images. The simplest answer to why vision is conscious versus nonconscious is that certain visual activities in brains (whether in neural networks or neural fields) are reducible to visual images. One strong criticism here is the explanatory-gap argument that the soggy grey matter we observe and the technicolor images we privately experience are so radically different that it’s hard to see how they’re identical (e.g., Levine 1983).

 The dominant answers today to why vision is conscious are nonreductive physicalist. Images aren’t reduced to neural networks or fields but are computations embodied in multiple hardwares, whether organic or non-organic. The problems here concern (a) how images and computations are related and (b) how both are related to hardwares.

 (a) It’s unclear how images can literally be *identified with* computations, for images are colored shapes while computations are abstract mathematical relations. (Note that attempts to treat computations as neural interactions versus abstract relations—as in token identity—run afoul of the explanatory gap argument above.) Alternatively, images might be computations in that images are the underlying, intrinsic nature or ground of abstract computations (Russellian monism). However, it’s quite unclear how colors can be the underlying nature of abstractions.

 (b) Computational images are often said to be *realized in* hardwares. But realizing or embodying abstractions in hardwares seems just as obscure as Plato’s claim that his forms are present in material things. It’s also said that images *emerge from* hardware circuits` when they’re organized to process visual information (property dualism). But consciousness thus pops into existence from what lacks consciousness, which seems magical (Strawson 2006).

 So, physicalism has trouble explaining why vision is conscious, for abstract visual images, computations, and soggy neurons are so radically different that both reductive and nonreductive relationships are obscure. Nonphysicalists have problems too. For example, dualists claims that the mental and physical differ radically create problems for their causal relationships. Also, idealist claims that bodies are figments of our minds have trouble explaining why minds depend on brains. This paper is primarily concerned with neuroscience, so these metaphysical problems are just briefly summarized here (xxxxx 2024 gives fuller accounts).

**2.2 How Do the Colors in Images Arise?**

Standard neuroscience has long explained how colors, odors, etc. arise in terms of labeled lines (e.g., Muller 1835, Adrian 1928). Here, these qualia arise from specialized lines with their own peripheral detectors and processing areas.

 A competing view was that (for example) the sweet taste of sucrose arises not from a labeled line for sweetness but from a pattern of activity involving comparisons of different taste receptors (e.g., Erickson 2008). These accounts are now seen as supplementary, not alternatives. For example, we see blue if the long-wavelength labeled line is strongly activated and neurons that compare firing rates of the three color lines inhibit the short and medium wavelength ones.

 The basic problem is that cross-talk in these cross-line comparisons works basically the same for vision, touch, etc.—so how can they account for all the stark differences between sensory qualia? Labeled lines have a similar problem in accounting for the differences between qualia. For these lines arguably use the same basic electrochemical impulses for signaling (Adrain 1928)—and their processing areas aren’t always different (e.g., visual areas can be adapted for touch in blind people).[[1]](#footnote-1)

 An alternative approach is Integrated Information Theory (IIT). It depicts consciousness in terms of the mathematically described causal structures it involves. Tononi (2008) thus attributes different qualia to differently shaped computational spaces. But these putative qualia spaces are so staggeringly complex (Aaronson 2014) that they’re nearly impossible to spell out.

 Nor do neural-field accounts explain how colors arise. For example, Pockett (2000) attributed different qualia to different spatiotemporal patterns in neural EM fields. But if a blue spot’s spatial field patterns determine its color, what is left to specify the spot’s actual spatial contours and location in the overall image?

 So, neither network nor field approaches explain how different colors arise. Also, they usually identify qualia with abstract codes, thus raising the hard problem.

**2.3 How Do the Structures in Images Arise?**

There are two issues here. (a) How do images get their unified structure? (b) How do images get their pictorial structure?

*2.3.1 How Do Images Get Their Unified Structure?*

While our color and moving-shape circuits are separate, we see colors and shapes fused together. What is it about these circuits that unifies consciousness? Arguably, it’s the integrated information processing in cognitive systems that unifies their consciousness (e.g., Coleman 2014). But information processing is just an abstract theoretical construct (a function). So, what is the actual physiological mechanism that carries out this integration of color and shape?

 Fusiform-gyrus cells monitor facial contours to identify individual faces (Le Chang and Tsao, 2017). But such cells just serve to recognize faces, not to actually see them in the first place (damaging these cells can render people unable to recognize faces, yet these people can still see faces). So, what mechanism creates the actual unified pictorial images we see in the first place? Three possible binding mechanisms are (a) synapses in neural networks, (b) synchronous firing in neural networks, and (c) neural EM fields.

 (a) Arguably, *synapses* bind color and shape either. The problem here is that “there are few, if any, direct connections between V4 and V5” which process colors and moving shapes, respectively (Zeki 2003, p. 216). Also, “there is no single cortical area to which all other cortical areas report exclusively, either in the visual or in any other system” (Zeki 1993, p. 296).

 In reply, cortical area V1 (the largest, most detailed visual map) may be the central visual area, for higher areas feedback copiously into it. For example, Lamme (2018, 2020) uses lesion, masking, and other studies (e.g., Raccah 2021) to argue that images arise not from frontal cortex or pre-cortical areas, but from feedback within posterior cortex. In his Reentrant Processing Theory (RPT), feature extraction in retinas is unconscious but perceptual organization in cortical feedback (lateral and vertical) is preattentively conscious (for evidence of preattentive consciousness, see Tsuchiya and Koch, 2008).

 But there’s little evidence that lateral feedback actually binds color and shape circuits. For it’s unclear that interblobs, which detect colored lines, synapse systematically (point by point all across V1) with blobs, which detect colored areas between these lines. Nor is there evidence that systematic blob-interblob synapses come from vertical feedback by higher areas like V4 reaching down into V1. Indeed, higher maps would be hard-pressed to do this for every V1 blob and interblob (again, there’s little evidence that even highly detailed V1 does this). So, there’s scant evidence that color and shape bind synaptically into unified images.

 (b) Alternatively, binding of color and shape arguably comes from networks firing in *synchronized* lockstep to create unified images (e.g., Gray & Singer 1989). For example, in the Global Neural Workspace Theory (GNWT) of Dehaene (2014), consciousness comes from ascending processing triggering a global ignition. Here, selected information is broadcast via recurrent, synchronized activity to the global workspace where images, thoughts, etc. occur. But Thiele & Stoner (2003), and many others found that neuronal firing synchrony doesn’t always correlate with color and shape binding. Koch et al. (2016) add that synchrony can occur without unified consciousness, e.g., during anesthesia and seizures.

 (c) A more viable binding mechanism may be neural *EM fields*. McFadden (e.g., 2013) argues that the discrete consciousness of particles is limited and isolated, but in an EM field they pool their consciousness and information into a conscious EM information field. Synchronized firing of neurons helps indirectly here by aligning their peaks and troughs to form a strong field. (Evidence for binding by fields appears below in §3.3.1.) Fields can thus reach across visual detectors to unite them (so adjacent V1 color and shape cells might unite without synapses).

 This field synchrony better explains the unity of color and shape than neuronal synchrony alone. Color and shape neurons don’t always fire in gamma-frequency synchrony together. But field synchrony is more flexible. It allows different frequencies (gamma, theta, etc.) to occur in phase together by nesting in each other through cross-frequency coupling (xxxx & xxxx, 2023).

 Nonetheless, binding by fields has its own problems. Field accounts attribute this binding to global fields reaching across brains. Yet there’s no evidence that these fields can account for the pictorial form of the images they supposedly bind together. Also, if images and minds are global fields, why don’t intense fields from power lines, MRIs, etc. unite fields between brains, making us telepathic? These issues are avoided by a modified field account below, but it ends up attributing images not merely to global fields across brains but primarily to local fields in retinas.

*2.3.2 How Do Images Get Their Pictorial Structure?*

Neural networks have the virtue of selectively connecting color information point by point across the brain’s visual maps, as pictorial structure requires. But these maps are highly distorted relative to images—nor do these neural networks account for how the colors bind together (as just noted). These network-based accounts haven’t specified the codes for pictorial forms.

 Field-based accounts have troubles too. (a) Nemrodov (2018) used machine learning by computers to decode people’s cortical EM (EEG) patterns and infer what their images look like. But these inferred “images” were crude and coarse—and came from fusiform gyrus, which just interprets images but doesn’t create them. Moreover, for brains to decode their own activity like this, they’d need mechanisms that detect their own activity patterns (like Nembrodov’s EEGs did), then translate the patterns into images (like Nembrodov’s external computer did), and finally turn these translated “images” into conscious images! (b) Fields have trouble selectively connecting color information together point by point into pictures (like networks can partially do). The neural field just pools color information together as a whole into a single consciousness.

**2.4 Summary**

Neuroscience hasn’t explained visual images. It hasn’t explained the colors, structures, or consciousness of images in terms of information processing by neural *networks* or neural *fields*.

 The processing of colors and other qualia by neural networks seems too similar to account for the striking differences between qualia. Nor is it clear which neural EM field patterns could encode colors and how they could be separated from codes for spatial layouts in images.

 Neuroscience also has trouble explaining the unified pictorial structures of images in terms of neural processing by neural networks. The synapses and synchronized firing of these networks evidently don’t explain this unity. But neural fields excel at explaining this unity especially if they’re synchronized (coherent), and their frequencies nest together. But this field account needs to clarify why minds remain separate, while fields reach between brains. Finally, neither neural networks nor neural fields explains how the pictorial form of images is encoded.

 Nor is it clear how all these codes become conscious. The radical differences between abstract codes, soggy neurons, and visual images deeply obscure their various relationships.

 The main source of problems with visual images is thus arguably their overreliance on information processing codes. While brains do process vision behind the scenes, the codes for the colors and structures of images remain empirically elusive, and the relations of these codes to images remain metaphysically enigmatic.

**3. Avoiding Neuroscience’s Problems with Visual Images**

The network and field accounts above might be synthesized to avoid their color and structure problems. The resulting Hybrid Theory (HT) is based on recent evidence and yields testable predictions. HT is a form of neuroelectrical panpsychism. It’s *panpsychist* in that everything consists purely of consciousness, like in Strawson’s (2016) pure panpsychism. HT is *neuroelectrical* in that a strong, continuous EM field localized in ion currents along circuits unifies consciousness in each brain (experimental evidence for this is listed below), but not between brains. Neural networks and fields together create the colors and pictorial form of images. So, images aren’t abstract computations (as often claimed). Instead, they’re substantial electrical activity spread across neural maps in actual colored, pictorial form. Yet images aren’t observed by inspecting people’s brains, for they’re the hidden nature of neuroelectrical activity beyond what sense organs or instruments detect of it.

 HT modifies and synthesizes field accounts of images’ unity and network accounts of images’ colors and pictorial form. But it avoids their computationalism, which treats images as processing codes. Yet computations still play crucial roles in images’ binocular rivalry, color constancy, depth perception, et cetera. Yet this occurs behind the scenes, with “computations” merely being material interactions, not abstract multiply realizable entities.

 In this panpsychism, images reside at all levels of strong electrical activity, from retinas to cortex. However, this paper will argue that retinal detector arrays are the only viable neural correlates of the colors and pictures in images. For example, the cortical codes for both are problematic. Also, retinal detector arrays support finely detailed colors, but V4 detectors don’t. Further, retinas seem to discern colors by themselves without cortical help, and injecting retinas with certain genes turns dichromats into trichromats without cortical help.

 So, attributing images partly to retinas will arguably allow HT to readily explain what network and field theories haven’t—how images get their colored, pictorial form. But Lamme, Tononi, etc. argue that only cortical processing can be conscious, for masking, anesthesia, and other disruptions to cortical processing obliterate images. HT can reply, for example, that retinal images still exist but are just rendered inaccessible to the subject (self) by these disruptions.

**3.1 Why Is Vision Conscious?**

HT tries to avoid the problematic answers to this question via its panpsychism, in which consciousness is the hidden nature of all observable matter-energy. Here, we’re directly aware of our inner consciousness, yet just indirectly aware of the observable, external world through reflected light, instruments, sense organs, et cetera. The external world is thus hidden—its real nature is up for grabs. So, for all we know, *consciousness is the real nature of the world, beyond how the world appears to our senses*. Consciousness can thus be seen as the world’s real, underlying substance—its concrete, fundamental stuff (this resembles Strawson’s well-known monism). Consciousness exists spatially, exerts forces, and is matter-energy’s sole constituent. Physicists can’t object to this simple monism, for they describe everything just by its observable effects—while HT refers to what things are in themselves, apart from these observable effects.

 HT tries to avoid the physicalist problems above in explaining why vision is conscious versus nonconscious. The basic issue was that computations, brains, and minds are so radically different that all their relationships seem obscure. But HT makes no use of abstract computations and their obscure relations to minds and brains via realization, grounding, emergence, et cetera. Nor are minds obscurely reduced to the observable brains of neuroscience, for minds are instead the hidden nature of brain events beyond their observable nature. HT’s monism also avoids the problems in nonphysicalist views. For example, in dualism, causality between radically different minds and brains is obscure. But, in HT, both consist of consciousness. In idealism, bodies are mere figments of minds, which doesn’t explain why minds depend on brains. But, in HT, bodies aren’t figments of our minds, for minds are the hidden reality of certain bodies (xxxxx 2024 gives fuller accounts).

 But HT arguably incurs a problem of its own—panpsychism’s “combination problem” of how simple (micro) experiences in cells, molecules, etc. combine to form larger (macro) experiences, from visual images to thoughts and the subjects who own them. The supposed problem is that micro*subjects* can’t combine to form a macrosubject. But this isn’t a problem if macrosubjects (which consist of memories, thoughts, plans, etc.) instead arise from combining micro*experiences*. HT can explain (using recent experimental evidence) how this latter combination works (this explanation lies beyond the current paper’s scope—see xxxxx 2024).

 So, HT arguably offers a relatively clear, simple solution to this hard problem of why vision is conscious. The argument below is that this synthesis of network and field accounts may also help solve the easy problems of what the neural correlates of images are.

**3.2 How Do Images Get Their Colors?**

HT answers this question in three steps. (a) How do different qualia arise? (b) How do different colors arise? (c) How are existing problems with qualia avoided?

*3.2.1 How Do Different Qualia Arise?*

Existing views haven’t found differences in labeled lines or in field patterns that could help encode different qualia. But there’s growing evidence that different sensory and emotional qualia correlate with different electrically active substances in the cellular membranes found in sensory and limbic circuits. These substances are the membranes’ ion-channel proteins and associated G-protein-coupled receptors (GPCRs). They detect the presence of sensory stimuli or hormones then directly or indirectly generate electrical impulses in sensory and limbic circuits. These EM-charged proteins and their EM fields are thus exceedingly active electrically.

 For example, the three different primary colors correlate with three different OPN1 opsin GPCRs (though color opponent cells play crucial roles in color perception too, as noted below). Also, some different temperatures correlate with different TRP ion channels, and some different tastes correlate with different T1R and T2R GPCRs (<https://www.genecards.org/>). These proteins reside in membrane electrical activity at various levels of the sensory system. There is also evidence that oxytocin and vasopressin receptor proteins correlate with feelings of love (e.g., Busnelli & Chini, 2017). Also, estrogen and testosterone receptors correlate with lust (e.g., Fisher, 1997), endorphin receptors correlate with euphoria (e.g., Sprouse-Blum et al., 2010), and adrenaline receptors correlate with vigilance (e.g., Bayerl & Bosck, 2019). Xxxxx (2019) gives further arguments and citations to support these protein-qualia correlations.

            A full list of the known correlations between proteins and qualia is listed in Table 2 of xxxx & xxxx (2023) at <https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1015967/full>. (Not all these proteins need be linked to qualia, some may be linked to no qualia, or they may be only linked to weak, noisy qualia—arguably only a single protein detector with strong, distinct qualia evolved in each labeled line.) This table is offered as evidence for HT’s claim that qualia are identical to the electrical activities of detector proteins (no competing list of the neural correlates of qualia has yet been published). This table is the empirical basis of the claim that proteins and qualia correlate, while the accompanying metaphysical claim that qualia are the hidden nature of proteins has been defended above on grounds of its avoidance of existing metaphysical problems.

 What exactly is it about the proteins listed in the table that gives them their different qualia? The table focuses here on the proteins’ different masses (m) and rest energies (mc2).[[2]](#footnote-2) The whole range of our qualia resides like a rainbow in the range of these protein rest energies. In nature at large, this rainbow isn’t confined to proteins, but likely repeats across many orders of magnitudes of rest energies in electrically bound masses. What makes this option plausible is that the masses of the different proteins actually correlate well with the different qualia, as the table shows.[[3]](#footnote-3) Also, this approach aligns with HT’s view that qualia are fundamental substances versus abstract computations. Interestingly, this implies that love and other emotions don’t emerge from information processing but are woven into the universe’s fundamental fabric.

*3.2.2 How Do Different Colors Arise?*

In HT, the three primary colors (red, green, blue) are the hidden nature of the three electrically active OPN1 cone proteins, which detect three (long, medium, short) wavelengths of light. For example, we see red if long-wavelength cones are more active than medium-wavelength cones (because, as noted below, color-oppositon cells inhibit the latter’s signals). These three retinal opsin proteins are thus what give color qualia to the labeled lines in HT (cross-line comparisons play a role in modulating these colors, as noted below). This aligns with HT’s panpsychism, where all levels of EM activity are conscious, not just the cortical level.

 Evidence for attributing the primary colors to retinal opsins comes from Rezeanu et al. (2022), who argued that retinal midget ganglion cells can actually disambiguate inputs from the three cones to discern which wavelengths are present. The “circuitry required for hue perception all arises in the retina automatically and it does not require any kind of [cortical] neural plasticity or developmental process.” Also, Mancuso et al. (2009) reported that they injected genes for long-wavelength cones into monkey retinas that had only short and medium-wavelength cones. The retinas rapidly grew long-wavelength cones, enabling the monkeys to discern color trichromatically. The rapid growth indicates that no cortical rewiring was involved, they argued.

            Of course, there are standard objections to attributing colors (and images) to retinas. For example, perceived colors don’t come just from retinal cones, but also from their downstream interactions. This point is addressed below in the account of color opposition cells.

 Another objection is from. Tononi (2004). He argued that colors can’t come from retinal opsins because people who become blind as adults can still have visual imagery and dreams, which presumably arise cortically. But, in reply, there’s no clear evidence that such people wholly lack residual retinal functions, nor is it clear that their imagery involves actual colors. For example, while people with Charles Bonnet Syndrome have visual hallucinations with colors, these people are visually impaired, not blind (Rojas & Gurnani, 2023). Also, while Bértolo (2005) shows that congenitally blind people can draw stick figures from visual dreams, she doesn’t claim that these are in color. While Striem-Amit et al. (2018) argue that blind people can talk about color abstractly, they don’t say that the blind have colored experience. (Additional objections will be addressed below.)

 HT’s account of colors extends from the retinal primary colors above to higher-level mechanisms linked to labeled lines, such as color oppositions and color constancy. When a cone activates bipolar and ganglion cells in retinas, the cone’s conscious color illuminates this labeled line. As the line ascends cell-to-cell into cortex, it resembles a *plastic fiber glowing inside with color*—except that the line’s colors are hidden beyond what EEGs detect of their electrical activity. It’s this electrical activity that unifies consciousness (color) all along the line.

            As labeled lines ascend from cones through higher retinal, thalamic, and cortical cells, a single unified image arises from all the cells’ interconnected electrical activity. Red is seen when the long-wavelength cones are stimulated more than the medium-wavelength cones, for color-opposition cells inhibit the latter’s signals. Similarly, blue is seen if short-wavelength cones are stimulated more. Purple is most likely experienced when adjacent red and blue cones activate the same ganglion cell (e.g., a type 2 “blue-ON” ganglion, Patterson et al. 2019). These converging electrical circuits would blend the red and blue colors into various shades of purple, depending on the relative intensities of the two cones’ activities. This is how primary colors mix to form myriad secondary colors. But, as is well known, green and red lines (for example) don’t mix, for color-opposition cells inhibit activity in one line while enhancing activity in the other. These oppositions can help contrast colored areas and accent edges. All this occurs from retinas to cortex. Color constancy is usually attributed to V4 and its feedbacks into V1 (e.g., Hurlbert, 2003). In HT, these feedbacks adjust how labeled lines oppose and mix in V1, thus achieving constant colors on surfaces that vary in brightnesses (more on this later).

 While the dense electrical activity in color detectors across retinas generates colors, it’s the retina’s EM field that unites these colors to form retinal images. This field is too insubstantial in rest energy relative to the detector proteins to determine the colors in images (cf. the footnotes above), but the field’s continuity is well suited to uniting colors into images. This field extends via ion currents along labeled lines into higher levels to help create more refined images. This visual EM field connects into other circuits to help promote short-term memory and imagination.

            This empirical hypothesis is testable. To start with, the correlations in Table 2 were compiled from numerous studies (see xxxxx 2019 and <https://www.genecards.org/>). They employed fairly standard experimental procedures in which qualia were shown to appear when a certain protein is activated—and to not appear when the protein is deactivated.

            Now the testable prediction is that these existing procedures will ultimately go beyond the dozens of already discovered qualia-protein correlations. They will fully establish that all primary sensory and emotional qualia correlate with electrically active detector proteins. This is a real test of HT because it offers a clear path to falsifying it. For example, the neural correlates of primary odor qualia are a mysterious, impenetrable jungle that might end up not correlating with detector proteins. But the degree to which qualia-protein correlations do continue to hold up will be the degree to which HT’s qualia-protein-correlation hypothesis is confirmed.

 To summarize, in HT, the three primary colors arise in cone opsins. They’re mixed and refined at higher levels by various other cells. Images are thus evolving phenomena residing at various levels—not just cortical ones. HT’s basic general claim above about qualia is that they’re the hidden, underlying nature of electrical activity in detector proteins. The empirical evidence for this testable claim is Table 2, which arguably lists the only viable neural correlates of qualia.

*3.2.3 How Are Existing Problems with Qualia Avoided?* Network-based accounts don’t specify how different labeled lines encode different qualia, while field-based accounts don’t specify how different EM field patterns encode different qualia. HT synthesizes these accounts by arguing that different qualia are different electrified detector proteins in labeled lines, and that EM fields unify these qualia to form overall colors in images. But in HT, colors and images aren’t obscure, elusive codes that the brain mysteriously decodes then translates into conscious form, as in the network and field accounts. Images are instead substances laid out across the electrical activity of detector arrays of neural maps.

**3.3 How Do Images Get Their Structures?**

HT answers this question in three steps. (a) How do images get their unified structures? (b) How do images get their pictorial structures? (c) How are existing problems with structure avoided?

*3.3.1 How Do Images Get Their Unified Structure?*

As argued above, network-based accounts haven’t adequately explained how the separate color and shape circuits bind into a unified form. Neither synaptic connections, synchronized firing, nor integrated information works here. But, as noted earlier, neural fields help explain this unity. Unlike the synchrony of neurons’ activity, field synchrony can involve different frequencies, for they can unite in phase together by higher frequencies nesting within lower ones.[[4]](#footnote-4)

 In HT, the unifying power of a field comes from the amount of its energy flowing through a given area. As this flux density weakens exponentially with distance, the field’s continuity dissipates, and it can no longer unify experiences into a conscious whole. Its unified consciousness thus exists locally where it’s strong and continuous—right along the currents in circuits generating the field—not globally throughout brain tissue, as field theories often claim. Importantly, these EM waves are the *only continuous, unified substance* along neural circuits. This continuity largely occurs across numerous, tightly packed, well-aligned cells with relatively coherent fields. For example, cones, rods, and ganglion cells align and are very densely packed in retinas (up to 200,000, 150,000, and 350,000 per mm2 respectively) which is ideal for unifying their consciousness via fields. While V1 minicolumns aren’t packed so densely, those that detect color and shape are aligned and adjacent, so they can unify consciousness via fields too. But large amounts of brain activity are by comparison quite subliminal.

 HT’s local fields can avoid the telepathy problem facing the global fields of typical field accounts. Fields reaching into the brain from MRIs, for example, are negligible relative to the exceedingly strong local fields created in neural currents at atomic distances. So, in HT, local fields unify experience along brain circuits but not between brains. Our experiences thus remain private—there’s no telepathy.

 Here is a list of the evidence that EM fields unify consciousness. (a) No other mechanism explains the mind’s unity (§2.3.1). (b) Koch et al. (2016) argue that locally activated EEGs track conscious perceptions across brains better than other events, such as neural synchrony or P300 events. This EEG evidence links unified perceptions to local neuroelectrical fields. (c) EM fields alone—not any particles or synapses—propagate signals across slices in hippocampal tissue (Chiang et al., 2019; see below). So, it’s these fields that unify this neural activity. (d) EM waves are the only continuous, unified substance along neural circuits. (e) xxxx & xxxx (2023) lists evidence that oscillating fields help our conscious attention to unify and control cognition.

 HT’s claim that localized EM fields unify visual circuits and detectors to form conscious images can be tested (this “unity test” accompanies the “qualia test” above). The prediction is that blocking the EM field between visual detectors will block images from forming. This can be tested by adapting a proposal in Libet (1993). He suggested that a slab of human sensory cortex—about to be therapeutically removed—could be surgically isolated from surrounding cortex. He predicted that if this isolated slab is artificially stimulated, it will continue contributing to reportable experiences. For experience doesn’t reside in neural connections but in a conscious field arising from cortex as a unified whole (pp. 396, 400).

 Adapting this test to HT would involve drawing on evidence from Chiang et al. (2019) that EM fields—without chemical synapses or gap junctions—propagate impulses (signals) across sliced rat hippocampus tissue in vitro. This occurred when the slice was up to—but not greater than—400 microns. Subramanian (2022) did the same with in vivo rat cortex.

 In HT, the test involves retina, not cortex, for it’s retina that determines the primary colors and pictorial form of images. The test subject would be a rat trained to respond only to photos of three rat holes in a row on the ground. The rat has its left eye covered, and right eye held stationary. A small slab corresponding to only one of the rat holes would be sliced out of the rat’s right retina with medical lasers used for retinal surgery. The prediction is that the rat will *continue responding* to photos of three holes due to the retinal EM field—*but only when the slice is under 400 microns thick*. If verified, this prediction would show that it’s the field in retinas—not cellular structures by themselves—which unify visual detectors to form the mouse’s image. Also, if the rat doesn’t see the three holes when the slice is over 400 microns, this would show that the image resides in the retina (which is sliced), not in cortex (which is intact).

 The next step is to test whether this unified three-holed image persists even when the cortex is sliced, but the field is canceled. This would be done with a voltage clamp, which completely cancels out the propagating field prior to the slice (see Shivacharan et al., 2021 for details). The prediction is that the mouse will not respond to the photo of three mouse holes, for there is no longer a field to unify propagation across the slice. If HT passes this two-step “unity test,” it would show that impulses are propagated across retinal cells by local EM fields in the impulses and that images reside in retinas, not cortex.

 Both the “unity test” and “qualia test” above are good tests of HT because no other existing theories can make these predictions. Standard network-based neuroscience explains qualia and unity in terms of information processing by overall computational circuits. So, it can’t make predictions about colors and their unified, pictorial form in terms of electrical events at the level of cells, proteins, and highly localized EM fields—like HT does in the tests above. Field-based neuroscience explains images in terms of global field patterns. So, it doesn’t explain how localized fields reach into detector cells to create unified images.

 Not only are other empirical theories incompatible with HT’s predictions about qualia and unity, but other metaphysical theories than HT’s are also incompatible with these predictions. Other theories are metaphysically incompatible with HT’s claim that conscious, local EM fields reach as substances into detector cells and unify their qualia together (recall §2.1). For example, reductive physicalism hasn’t explained why visual images are unobservable across neural maps, while HT does offer explanations here. So, if HT’s predictions are verified, this would arguably help verify HT’s “metaphysical” panpsychism.

 The general point is that HT offers a testable neuroelectrical account here of what other theories fail to adequately explain, namely, how all the basic traits of visual images arise—their colors, unity, pictures, and consciousness.

*3.3.2 How Do Images Get Their Pictorial Structure?*

Both network and field accounts have their virtues and flaws here. Networks might partly help to connect color information point by point across neural maps, but they don’t explain how this information binds into unified images. Fields can explain the unity of images, but they’re diffuse and lack the selectivity that networks have in connecting colors point by point. Also, while field accounts use machine learning to translate field patterns into pictorial images, they haven’t shown what brain mechanisms actually detect field patterns and translate them into conscious forms. HT will try to synthesize these two accounts to keep their virtues, but not their flaws.

 In HT, images arise when consciousness is unified by the local EM fields along visual maps. The primary colors and basic pictorial form come from retinas. The overall argument for this view can be summarized as follows. (a) Network and field accounts haven’t adequately explained the codes for colored, unified, pictorial images in terms of cortical computations. In contrast, *arrays of retinal detectors are the only reliable correlates of primary colors, and they attribute colors to every point across images in a pictorial form* (§3.2.2). V4, for example, has color detectors, but its detector arrays lack pictorial form and can’t account for the finely detailed colors of images (§2.3). (b) Retinal opponent cells can disambiguate cone outputs (without cortical help) for accurate color perception (Rezeanu et al. 2022). (c) Injecting retinas with genes for long-wavelength cones can create trichromatic vision without cortical help (Mancuso et al. 2009). (d) Images are shaped like retinas but not cortex. Also, retinal blindspots and warping during retinal detachment are detectable in images, yet the splitting of cortical hemispheres isn’t detectable. (xxxx & xxxx 2023 also list reasons that thalamus may be conscious.)

 HT conflicts here with standard cortical (or thalamocortical) centered accounts of images, such as in RPT and IIT. In RPT, precortical activity isn’t conscious, for it’s hardwired and occurs even during anesthesia (Lamme 2020). Similarly, IIT attributes perceptions to the integrated information of posterior (occipital-parietal-temporal) versus frontal cortex. For artificial electrical stimulation of this “hot zone” of sensory activity produces conscious sensations. Lesions here produce blindness of colors, faces, motion, etc. (while lesions to frontal cortex merely interfere with associated thought processes). In this view, precortical structures such as thalamus and retinas are basically feedforward and lack the highly integrated reverberating feedbacks that consciousness requires (Koch 2019).

 Based on arguments above, HT replies that existing theories such as IIT and RPT don’t adequately explain the colors, unity, or pictorial form of images, so their claims about where visual processing occurs is far from conclusive. Also, retinal arrays are the only neural structures that reliably correlate with colors and resemble images pictorially. Further, HT has ready replies to the following reasons for treating images as cortical versus retinal.

 (a) Arguably, precortical processing is hardwired and occurs even during anesthesia when we’re nonconscious, so precortical processing doesn’t depend on any form of consciousness (Koch, 2019; Lamme, 2020). In reply, HT can argue that retinal images can still be conscious here, but we simply aren’t aware of them because our mind is obliterated by the anesthesia. This aligns with findings by Miller et al. (2024) that during anesthesia, sensory input still activates peripheral sensory areas, but this doesn’t propagate into cortex. In HT, anesthesia disrupts synchronized cortical activities—most importantly, its coherent EM field. This oblierates the mind’s unified, subject-centered consciousness, dissolving its web of memories, emotions, thoughts, attention, and self-awareness. The retinal image still exists but without the mind. In comparison, during a fatigue trance, when we stare blankly without recognizing or thinking, the mind is still present but just resting with attention turned off. During anesthesia, the retinal image still exists, but the mind is entirely wiped out, not just resting.

 (b) Arguably, masking of a visual stimulus by cortical activities can render it unconscious, indicating that conscious images only arise cortically (Lamme 2018). For example, in dichoptic masking, an initial stimulus to one eye is blocked by stimulus to the other eye. The brain integrates these stimuli, often rendering the initial stimulus invisible—likely due to lateral inhibition, as in binocular rivalry. In reply, HT can argue that the feedforward from retinas may still be conscious, but part of it is blocked by these lateral inhibitions. So, it’s inaccessible to the mind’s unified web of conscious activities.

 (c) This same principle may explain why other aspects of retinal images don’t appear in the mind’s unified subject-centered consciousness during binocular rivalry, saccadic suppression, et cetera. For example, in the binocular rivalry, the inhibited image has far lower electrical activity (Tononi & Edelman 2000), so HT would argue that its consciousness is too weak and disunified to appear in images. The same approach may also explain why color blindness results from lesions to V4 (Lebrecht & Tarr, 2008). These lesions may destroy color constancy mechanisms involving V4 and V1, so that retinal colors don’t appear in the mind’s unified, subject-centered consciousness.

 (d) Arguably, V4 detects all hues, yet retinas detect just three (Conway & Tsao 2009), so colored images presumably arise in V4. In reply, in HT, the three primary colors arise in the three cones and are mixed and modulated by cross-fiber comparisons in retinas and higher levels (including cortex) to create the thousands of different hues we can discriminate. V4’s role might be less in creating colors systematically across images than in recognizing colors (it plays a role in the ventral pathway’s object recognition network.

 (e) Arguably, images cannot arise in retinas, for only cortex can globally monitor the luminance (brightness) and wavelength of incoming light so as to attribute constant colors to surfaces with variable luminance (Hurlbert, 2003). In reply, this cortical activity is compatible with HT’s claim that colors arise in cones and are refined higher up, as just noted. While feedbacks from V4 into V1 do play roles in color constancy, these feedbacks could merely adjust activity in V1’s color opponent cells and other cells so as modulate how the hues ascending from cones are mixed to achieve color constancy.

 (f) Arguably, visual images can’t reside in retinas because retinas have blind spots that don’t appear in our images (Tononi, 2004). In reply, HT is compatible with blind spots in retinal images being filled in by cortical areas which lack these blind spots. Cells in these cortical areas could infer and supply missing colors (“filling in”) by drawing on their conscious electrical connections to retinal cells that surround the blind spots. This would involve similar color refining mechanisms to those in color constancy above. Such filling-in processes can also help explain how limited retinal acuity (Boynton et al., 2002) is boosted by V1’s contribution of additional color detectors to the visual field’s center.

*3.3.3* *How Are Existing Problems with Structure Avoided?*

HT is a hybrid account in that it attributes visual images to both visual networks and the fields they generate. Yet HT doesn’t attribute images to the information in networks or fields (which raises deep obscurity in network and field accounts) but to their electrochemical substances.

 Further, recall that networks have problems unifying images, but still might partly help to connect colors and shapes together precisely. In contrast, a global field can unify images but has problems precisely connecting colors and shapes. However, HT’s local fields along circuits can both unify images and connect colors and shapes point by point via the electrical connections between retinal cells. HT also explains conscious unity without the problem that typical field accounts have in explaining why MRI fields don’t make us telepathic. HT’s synthesis thus avoids the problems in network and field accounts, while adopting their virtues.[[5]](#footnote-5)

**4. Summary and Conclusions**

Neuroscience generally attributes consciousness to highly integrated information processing by neocortical (or thalamocortical) *networks* or *fields*. But it hasn’t adequately explained the *colors*, *unity*, *pictorial* form, or *consciousness* of visual images—even though they’re basic phenomena.

 *Network accounts* haven’t adequately shown how networks of labeled lines and cross-line comparisons actually differ enough to account for our starkly different *colors* and other qualia. Nor have these accounts (including GNWT and RFT) shown how the *unity* of color and shape in images arises from synchronized firing by their separate circuits in cortex—or from synaptic connections in cortex, including feedbacks. Nor is it clear how cortical networks encode the *pictorial* form of images—nor even where this occurs. Finally, it’s also unclear how to get from all these codes to actual *conscious* images. For neuroscience and physicalism posit radically different entities—abstract computations, soggy neurons, and conscious images—with well-known problematic relations involving reduction, emergence, realization, grounding, et cetera.

 *Field accounts* compete with these network approaches. Here, images are encoded in oscillating electromagnetic (EM) field patterns reaching globally across cortex. This avoids problematic network accounts of the *unity* of colors and shapes in images, for the continuous oscillating field pools information from various visual circuits into a single consciousness. Recent evidence shows here that EM fields (not synapses) propagate and unify nerve impulses across slices in neural tissue—and that EM fields help guide and unify overall cognition. But unity issues remain. Why don’t global fields unify experiences between nearby brains? And how can diffuse global fields unite finely detailed colors and shapes across images? Concerning images’ *pictorial* form, field accounts don’t fare any better here than network accounts. Machine learning can read EEGs and convert them into pictures, but they’re too crude to account for our images, and they arise from areas that don’t create images but just recognize them. Nor do brains seem to read their own EEGs or convert them into pictures like these machines do. Concerning *colors*, it’s unclear how fields’ spatial patterns encode them or how these codes are disentangled from those for the spatial layouts in images. Finally, field accounts don’t fare any better than network accounts in explaining how to get from all these codes to actual *conscious* images.

 The *hybrid theory* (HT) proposed here synthesizes network and field accounts to adopt their virtues and avoid their problems. Visual images don’t come from just networks or fields but from both. The basis of this synthesis is HT’s neuroelectrical and panpsychist approaches.

 In HT’s *panpsychist* approach, consciousness is the real nature matter-energy beyond its observed appearances. Physicists can’t object, for they describe everything by its observable effects, while HT refers to what things are in themselves apart from these observable effects. HT offers a clear, simple alternative to physicalism’s deep obscurities. Images aren’t reduced to neuroscience’s observable activity, instead they’re the hidden nature of this activity beyond what EEGs detect of it. Nor does HT posit radically different entities with deeply obscure relations (such as emergence, realization, and grounding) like nonreductive physicalism does. There’s just one entity, for abstract computations don’t exist, and images are just the real nature of neural activities beyond their observable appearances.

 In HT’s *neuroelectrical* approach, electrochemical activities account for the unity, colors, and pictorial form of images. The fields that *unify* the colors and shapes in images don’t reach globally across cortex, but just exist locally in ion currents along circuits, where the field is very strong. This explains what global fields don’t, i.e., why images (and entire minds) are unified within each brain but not between brains (telepathically), and how fields connect finely detailed colors and shapes across images. These locally conscious fields fit evidence that the best way to detect images is via locally activated EEGs, which reveal local EM fields. Concerning *colors*, growing evidence indicates that our different qualia come from electrically active detector cells in sensory systems, including the three retinal opsins correlated with the three primary colors. The basic *pictorial* form in images also likely comes from retinas, for only retinal activities resemble images pictorially (similarly, only retinal cones reliably correlate with detailed colors in images). But retinal images are refined at cortical levels for color constancy, depth perception, binocular rivalry, et cetera. While these computations refine color and form, much of this occurs subliminally, behind the scenes (and not as abstract computations but as neuronal interactions).

 Here’s a summary of the evidence that images are largely retinal. (a) There’s little evidence that cortical codes exist for the colors, unity, and pictures in images. (b) Retinas seem to discern colors by themselves without cortex. (c) Injecting retinas with certain genes turns dichromats to trichromats without cortical help. (d) Retinal distortions appear in images while cortical ones don’t (e) Retinal detectors support finely detailed color in images, but V4 color detectors don’t. (f) Retinal activity has pictorial form, but no cortical code for this form exists.

 So, retinal activities are arguably the only viable correlates of images’ unity, colors, and pictorial form. Critics may reply that images must be cortical because certain cortical lesions create color blindness. But these lesions arguably just block retinal colors from appearing in the mind’s subject-centered consciousness created by cortex. Other criticisms can be countered too.

 HT ends up synthesizing network and field accounts of images. Networks’ synapses and synchrony don’t seem to unify the colors and shapes in images, but network interconnections still might partly help to put colors and shapes together precisely. In contrast, a global field is continuous and can thus unify colors and shapes, but it’s diffuse and thus has trouble connecting them together precisely. However, in HT, continuous local fields running right along circuits can both unify colors and shapes, and connect them point by point. HT avoids additional problems in both, especially their computationalism.

 In conclusion, neuroscience’s cortical codes for visual images are empirically elusive and metaphysically enigmatic. HT tries to avoid these problems by synthesizing the standard neural-network accounts with recent EM-field accounts. This yields a neuroelectrical panpsychism in which images aren’t cortical codes but are primarily retinal substances. In HT’s *panpsychism*, the real nature of matter-energy, beyond its observed appearances, is consciousness. This avoids physicalism’s problems by neither reducing images to observable neural activity nor positing any radically different entities. HT’s testable *neuroelectrical* account gives recent evidence that EM activities unify consciousness across retinal neurons and create the colors and pictorial form of images. HT may thus offer potential solutions to the easy problem of what the neural correlates of images are—and the hard problem of why these correlates are conscious versus nonconscious.

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1. Arguably, V4 color detectors do offer ways of distinguishing labeled lines for color from labeled lines for other qualia. However, the receptive fields of V4’s color detectors are far too big to account for the fine colored details comprising images. So, it’s unclear how labeled lines actually differ. [↑](#footnote-ref-1)
2. An alternative is that the proteins’ different molecular structures could create the different primary qualia. But this makes primary qualia emergent. For example, as vision evolved at molecular levels, blue magically popped into existence from molecules that lacked blue. Another alternative is that the different qualia could come from the different resonances of the proteins and their EM fields (both being quantum field substances). These resonances are fundamental instead of emergent because they’re embodied in the fields’ fundamental energy substance, its photons. But this option hasn’t been spelt out yet, so it doesn’t appear in the table. [↑](#footnote-ref-2)
3. In the table, some qualia correlate with more than one mass (which is unsurprising because these qualia likely reside like repeating rainbows in the range of electrically bound masses in nature). On the other hand, there’s no reason that every mass must have a quality—yet each mass that does have a quality must have a different qualia (otherwise, there’s no basis at all for protein-qualia correlations). [↑](#footnote-ref-3)
4. Field synchrony also benefits from another difference that contrasts it from neuronal synchrony. While fans of the latter identify unified consciousness with neuronal synchrony, this identity is refuted by the extreme synchrony during anesthesia, which obliterates consciousness. But HT isn’t refuted here, for its field synchrony just loosely ties unified consciousness to neuronal synchrony, allowing consciousness to disappear during extreme neuronal synchrony. (It disappears because this extreme synchrony floods circuitries, and brain areas can no longer select and coordinate conscious attention, working memory, perception, et cetera.) [↑](#footnote-ref-4)
5. HT ends up differing from other field theories of consciousness in various ways. (a) Everything is conscious in HT, not just EM fields. (b) Consciousness is unified by local EM fields right around neural circuits, not by fields pervading brain tissue. (c) Qualia aren’t encoded in field patterns, instead they are laid out in pictorial form across EM fields and currents. (d) Consciousness isn’t identical to, emergent from, or intrinsic to EM, but is the real nature of EM beyond how it appears EEGs. [↑](#footnote-ref-5)