Where are the colors we see?

Part I

[A]
Where are the colors we see? Surprisingly, this simple question has no clear answer. Research in physics, biology, and the neurosciences has produced no definitive answer. And why not? Probably, because the answer is elsewhere and is not recorded within these three disciplines. How so? Because color formation is concurrent with becoming conscious of color. To describe the process that generates color and where it unfolds, we need to include the observer's entry into consciousness, a subjective transition experienced by an individual being.

Color research has many questions that remain without a clear answer. Where does color form? How does it form? When does it form? What is color? Why does color appear? This is not a vague 'why' to be answered by hypothesized survival advantages, but is about the function of color in vision.

As soon as research includes the process of becoming conscious, answers can be found and, in the next ten minutes, you will find that these five questions have answers. This can be achieved when one central fact of color vision is recognized. I call It 'the unified principle of color'.

[B]
The unified principle embodies a shift in attitude. Our expectation of an objective material-based answer has to be relinquished in order to allow for the understanding that colors we see are generated in the act of perception, but not as a bio-physical response to stimuli, rather, as a creative act performed by the subject that perceives color. The unified principle of color is anchored in the creative potential of a living being.

[C]
To begin, I present a few basic facts about the interaction between light and the eye.

What we see as light is the energy to which our eyes are attuned. This energy vibrates in a range of roughly 400 to 700 trillion hertz, or, times per second. The retina of our eyes has cone-shaped cells that respond to these tiny wavelengths measured in nanometers, or billionths of a meter.

There are three types of cone cells each with different sensitivities. The L-cones are most sensitive to the longer wavelengths of light. The M-cones are most sensitive to the middle range of wavelengths, and the S-cones are sensitive to the shorter wavelengths. I will refer to these three as 'cone sets'. What we see when they are stimulated is light. It can be brighter or dimmer, but has no color. An image a cone set forms from incoming light is necessarily black and white. All wavelengths of light are colorless. They are just darker or brighter.

This point needs emphasizing. Light registers in the eye as brightness. This may sound strange at first because light is spoken of as having red wavelengths, green wavelengths and other colors.

What is not often said is that this is merely a manner of speaking and not a factual description. There are no colors in light of any wavelength and, at times, we see an object as green or any other color when the wavelengths that are supposed to produce that color are totally absent. Speaking of wavelengths as color is no more than a handy shortcut and it works more often than not.

[D]
From studies in vision, such as Edwin Land's research in color science, it appears that, separately, each cone set forms a view of what is before it, and the three views are later integrated to become the image we see. When all three cone sets register the same relationships between what is brighter and darker, the three views can combine into a single black and white image. This happens when the light received contains the full range of wavelengths. This is described in greater detail in the book: *The Unified Principle of Color.*

A very different situation arises when light reaching the eye is not the full visible range of wavelengths. When some wavelengths in the spectrum are missing or not equally bright, this creates a problem for vision. For example, if the shorter wavelengths of the spectrum are missing or weaker, the S-cones sensitive to these shorter wavelengths will register little or no light and, in the view of the S-cones, the object seen will appear dark or black. At the same time, the L and M cones, sensitive to the longer wavelengths, will register what is seen as bright. This means that the different cone sets register contradictory views of what is seen. This creates a visual impasse because we cannot make sense of three different views of the same scene at one time. How do three different renditions of what is looked at become one single visible image?

Since vision is a fact, and since the topic of this talk is color, you surely already guess that the answer will involve color. However, before presenting a description of how color formation takes place, I will make a detour and jump ahead into what happens when we do see color.

[E]
When we see something that is colored, what is the response of the three retinal cone sets?

Consider the situation where light passing through a prism produces the spectral colors. The beam of light coming out of the prism is spread out into different colors and this spread means that every color we see is made up of part only of the full spectrum. None of the colors we see contain the full-spectrum light. Let's think more about this.

Take for instance the red part of the colors. It is on the side where the longer wavelengths that stimulate the L and M cones while the shorter wavelengths that stimulate the S-cones are absent. This means that the three cone sets register different brightness values for what is see and because of this are unable to combine into a single unified image. Sight is not possible unless two of the cone sets stop functioning and allow one single black and white view to form. And yet, almost miraculously, the contradictions between the different views disappears when instead of seeing the light as brighter and dimmer, we look and see the color red. When we see

red, the different brightness values registering in the three cones consort to produce the single image. Red resolves the conflict of luminosities present when seeing is restricted to registering light as stronger or weaker, i.e., as bright, dim or absent. In fact, every color we see is the transformation of a particular set of luminosity contradictions into a single, visible image and in this way enables sight. We might even imagine color to function as a corrective that realigns the imbalance resulting from light that is not full-spectrum.

In this, the function of color comes clear for it enables sight. At this point, we might imagine that we have found a way to make the contradiction disappear. Can we conclude that color unifies the three views of the cone sets and, with this, the problem of the contradictory views is resolved? Not so fast! There is no color in light, only brightness, so where would color come from? How could it suddenly appear and enter into what we see? We still don't know how light, whether dim or bright, turns into color. The age-old enigma of color remains – for another couple of minutes!

What we have learnt from this is that color vision allows for 'symbiosis' of three, otherwise, incompatible views and brings unity to contradictory views. This goads us onwards, for there must surely be a way to move from the three conflicting black and white views to a single view through the implementation of color. This is the challenge. How, when, and where does color suddenly appear and enter the personal experience of the observer becoming perceiver?

Part II

[F]
It seems obvious that the transformation from brightness to color takes place but we never witness it. We experience the result, yet the process itself is hidden. We do not observe it because it is not a physical process and happens out of reach of both our physical senses and our thought processes. It takes place as a transformation within consciousness that is animated by intent. In today's understanding this statement may sound strange and I therefore take a few minutes to open the topic wider.

Sight is not a causal sequence that proceeds on its own when eyes are open. Without the intent to see, no image would appear, as can happen, for example, in cases of autism. Seeing is a privilege that is enabled by an observer embodying the intent of looking in order to see. Because the intent to see is not a conscious act, we tend to ignore its presence.

The experience of color requires both intent and a living being that anchors the presence of that intent.

A being that is alive, when confronted with three contradictory cone-set views, experiences a visual impasse. The presence of the intent to see challenges that impasse. Intent has a kind of momentum and carries forward the quest for vision, calling for a way to overcome the obstruction. The movement to a solution comes because, with intent, the end directs the means. This is described more fully in the book, *Making Sense*. Intelligence and creativity

inherent in a living being respond to this call by elaborating a solution. Of course, there is another element to the story because the universe is a silent accomplice. It offers the potential for resolution which the living being finds and employs to achieve the intended goal of seeing.

[G]
The implementation of intent is something mysterious, although central to life and all we experience.

The intent to see brings effects that go well beyond what can be described by a chain of material causes. In the case of color vision, it engenders a change in attitude on the part of the observer. Instead of stubbornly reproducing the same visual impasse, a new way of seeing is elaborated. Brightness differences that were in conflict when seen as light and dark (black and white) are now seen in new way. Instead of contesting one another, the differences become co-constructors in a new mode of seeing; what was oppositional becomes complementary. On a more encompassing level, a higher level maybe, a new refined quality is born. I like to compare it with laughter, a response that emerges from the attitude we hold while seeing or hearing something. If we do not enter the particular attitude that makes it funny, the same event would not evoke humor. In a similar way, color emerges from a particular attitude that enables its presence to emerge. Releasing the view that interprets what is seen as conflict opens the mind to the reception of color, and this allows for a panoply of experiences that are not accessible when brightness alone is seen.

This changing attitude is something we don't often take time to consider. We can listen to an instrument playing a sequence of different notes but there is a more encompassing level of listening, a higher level maybe, when we hear those notes as melody; and so it is, too, when we see relationships as color.

But where exactly does this transformation take place? It happens in the perceptive experience of the observer intending to see. In English, the word *mind* refers to the potential for understanding and so, we can say the transformation manifests in the mind of the perceiver.

Strange but true is the fact that the same physical elements that are present when a visual image could not form, are also present after the transition to color. Nothing is added, nothing is removed. Incompatible levels of illumination are present beforehand and they continue to be present afterwards. Nothing has changed and yet, all is transformed. The impossible visual situation of conflicting black and white views has receded and instead, colored objects appear. Without any change in the physical situation, the persistent presence of intent gives rise to a whole new way of seeing and with it, the perceiver gives birth to a novel, unified, visual experience – the manifestation of color.

[H]
The conclusion to be drawn here is that a perceiver generates the colors it sees. By what means is this accomplished? By creating what is not there! This requires creative imagination. Color comes out of a world referred in mystic traditions as the *Imaginal,* described by Henry Corbin as

the *Mundus imaginalis*. It references a source of information that is neither drawn from the physical world nor from the mental world. Color comes to us like meaning in symbols and architypes, meaning that emerges through the interconnection of all and not from a specific process we can observe. But, with this, we are moving out of the present subject. I will now return and respond to the questions that were listed at the outset.

Where are the colors we see? Color does not have a physical presence. The creative imagination of a living being generates the colors that appear. They are thrust into the perceiver's consciousness by the presence of the intent to see. Color holds the potential to resolve contradictory views but, being merely potential, it is not present. To bring this possibility to manifest requires a creative act performed by an intelligent, living being – a human being or, perhaps, a butterfly. That individual being draws upon this potential, realizing the transition to color vision.

So, then, where are the colors we see? They are in the mind – a word that references the seat of intelligibility. Color perception requires recognition of the presence of conflict as well as the impetus that enables a creative solution. This is possible for a living being because both requirements are rooted in the intent to see. This particular intent is not an independent, self-contained function but is nested in wider circles of intent that have a wider embrace, such as the will to know.

As to the questions when and why color forms, it is clear that color enters at the moment it is seen, and it serves to enable visibility where visibility is denied. This is the most basic answer and there are surely other answers that go well beyond what I touch upon here, for color enables further qualities of being, beauty for instance, and much more than this. I have merely given rudimentary answers. They serve as first remarks that, I hope, will be of help to those searching more deeply.

15 October, 2024
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