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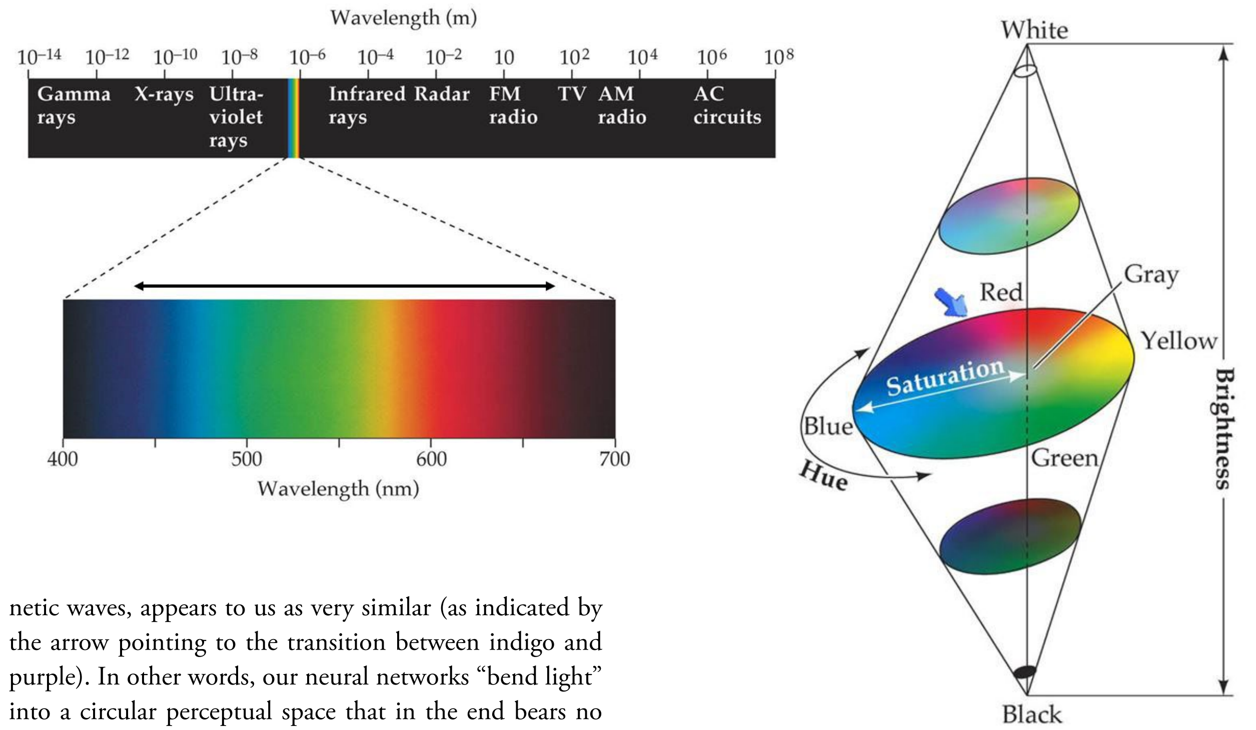
THINGS ARE REALLY NOT LIKE THEY SEEM TO BE, AND NOT AS WE SENSE THEM EITHER...

By Bruno Laeng

A score of philosophers and scientists, ancient and modern, have argued hard and deep to convince us that "things are really not like they seem" and that, in fact, our knowledge of reality is far remote from the world itself. That is, our mind, or – more concretely – our brain, obtains sense data from the world (both our external and internal worlds of objects and bodily feelings), but the perceptions resulting from them are just appearances and we thus live in some sort of "Matrix" or "Wonderland". Living in a Matrix of virtual reality or illusions, i.e. with false beliefs about reality, does not seem too bad after all (despite the existential pain of a Schopenhauer or Buddha) since most of us seem to enjoy it and are not in a rush to leave it. Most importantly, appearances or illusions seem a good thing also from a biological standpoint since some of these virtual realities are pragmatically useful for our survival as individuals and species.

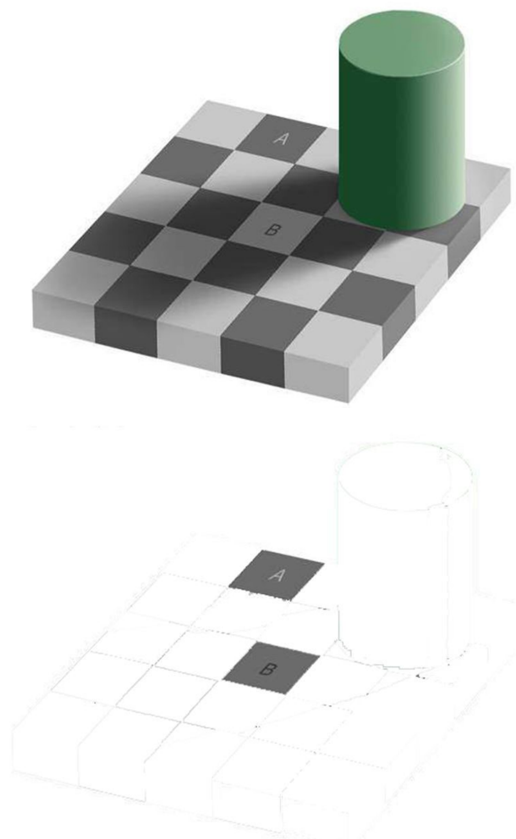
Let's consider colors. According to Galileo Galilei (and Newton), there are no colors out there in the world. Still, we can see, perhaps feel, them – and we like them, too. Yet, if one would remove the sense organs or – more generally – all nervous systems from this world, so would colors (and tastes, smells; perhaps also beauty) be removed from this world, since they only exist in the intercourse between brains and world and both need to exist; so at least Galilei or the neurophysiologist Dale Purves (see Purves and Beau Lotto 2011; Purves, Wojtach and Beau Lotto 2011) would say. What complicates things is that our very sensations would also seem generally unknowable to us since they remain essentially unconscious and they get re-touched and transformed in our perception. In other words, what we sense is not the same as what we actually perceive and are aware of about the world. Our sensations are, according to neuroscience and modern psychology, the output of our biological sensors: They are the initial responses to the outer world. For example, our eye is a complex sensor system made up of millions of photoreceptors and their responses constitute the initial "raw" image (though it is not really an image in the sense of a picture). Some of the retina's photosensitive receptors are tuned to different wavelengths, which makes it possible to distinguish colors, as long as the receptors are wired into a neural network that actively "generates" the colors that we consciously perceive. However, even these initial sensory signals do not seem to mirror or unambiguously scale with physical variables, as a naïve realist about perception would think. For example, according to contemporary physics, one of the main forces within the physical world is electromagnetism and what we experience as light and colors are just a tiny fraction of the electromagnetic continuum, as we can see in Figure 1 below.

In the left part of Figure 1, the rainbow variations correspond to the wavelengths of the light stimulating the eye, so that when the wavelength is shortest we see blueish light (indigo at the limit), and when the wavelength is longest we see reddish light (purple at the limit). Thus, indigo and purple are, physically speaking, the two most different wavelengths that can give origin to color sensations; however, we do not 'perceive' these hues as maximally apart or different from one another. The right side of Figure 1 shows that colors appear to us as changing into one another in a non-linear manner, so that what should appear as most different, if perception respected the scaling of electromagnetic waves, appears to us as very similar (as indicated by the arrow pointing to the transition between indigo and purple). In other words, our neural networks "bend light" into a circular perceptual space that in the end bears no clear resemblance with the original physical variables. In addition, in such a warped perceptual space, we obtain emergent phenomena like color oppositions (e.g., red as opposed to green) that are meaningless in physical terms (in no way is a wavelength at 550 nm the opposite of a wavelength at 650 nm). Thus, when we visually experience the outside world, we are far from seeing the raw sense-data but only a re-touched version of them, which is the product of our brain networks being compelled to "correct" the actual input. Despite the fact that evolution has equipped our nervous systems and those of many animals (consider honeybees) with the ability to use these wavelength differences to visually segregate surfaces also when these may have the same luminance (i.e. same light energy), this happens according to rules that are idiosyncratic to each neural network and literally leads to different ways of world-making.

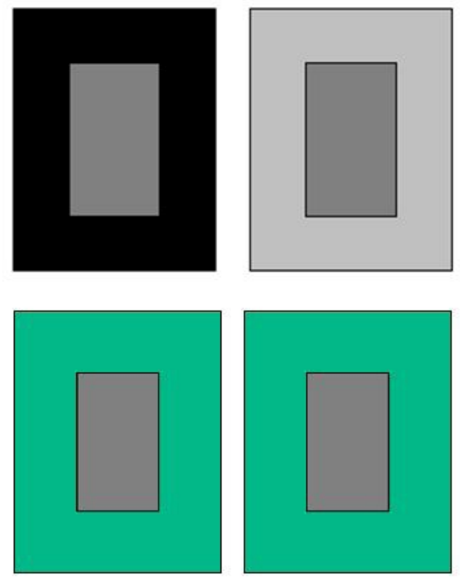


What is most remarkable is that, at least for our human visual experience, where we also have first-person acquaintance with colors, these differences get "flagged" in front of our eyes as different 'colors' that feel qualitatively different. Yet, many scientists take such color experiences or "feels" to be not epiphenomenal, but useful ("adaptive") because they strongly advertise (in just as treacherous a way as commercial ads do). Color experiences advertise food, poison, sexual mates; and – for apes especially – they can be used as symptoms of slight changes in blood circulation and oxygenation (signaling emotional or arousal states), etc. Despite the current philosophical debate that qualia are "non-physical" and that they may even be epiphenomenal to our behavior, it seems clear to many scientists that if the "feels" of these colored experiences would disappear (e.g., as it happens after neural damage or, for example, the disappearance of 'pain' when taking an anesthetic) so would their causal powers on behavior and thought disappear as well. Crucially, this lack of consciousness may be costly and deadly, and the qualitative and conscious feelings serve a biological function. As the contemporary philosopher Frank Jackson points out in his "*Postscript on qualia*" (Jackson 1998; se also Garvey and Jackson 2011) his own previous conclusion, namely that qualia (like colors) are epiphenomenal events, is just very hard to believe. Instead of being a powerless and useless movie of your life, qualia (i.e. how things actually feel to us; the "feel" when, e.g., seeing the red of strawberry or blood) represent states of the world (not of the mind). They thus have a representational function that helps us understand and act in the physical world; this representational function is supported by the brain, which has been shaped by the need to survive.

If one remains skeptical about the fact that our perceptions are continuously re-touched versions of sensory data, psychology is rich with examples of this fundamental fact. A good illustration is provided by Figure 2, originally created by the psychologist E.H. Adelson. It shows (on the left side) what looks like a sort of chessboard; note that two specific squares have been marked A or B and that they clearly appear as black (dark) and white (light) in color, respectively. However, the actual state of things is that they have exactly the same luminance and gray tone, as one can easily appreciate in the image on the right side of Figure 2, where I have erased everything except the A and B squares, which now look identical. In truth, the B squares on the left and right side are identical (same luminance, same shade of gray).



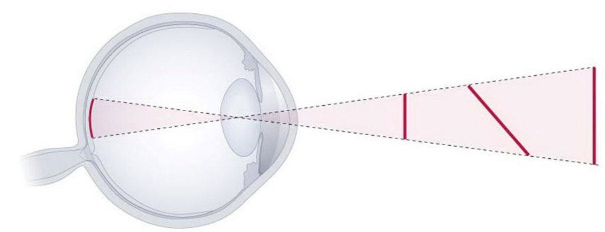
It is important to realize that what happens in Figure 2 is not at all unusual in terms of our ordinary perceptions. The phenomenon that colors (in this case, shades of gray) change dramatically when embedded among others has a name in psychology ('simultaneous contrast') and it has even gotten the status of a "law". The left side of Figure 3 below illustrates the general effect of the same gray tone (the internal rectangles) appearing as lighter when surrounded by a dark frame or darker when surrounded by a light frame. We see them as identical only when the frames around are also identical in color (on the right side of Figure 3). The bottom line of these simple displays is that they demonstrate that we do not perceive what the eye is actually sensing within a particular region of the visual scene but an *interpretation* of it, which takes into account also the neighboring regions of the scene.



Hence, the brain is using the sense data to construct a perceptual world and it is the latter that we experience, and not the original sensations. Why, then, would the brain (i.e. why would it evolve to) trick us into seeing something else than the input itself? It would seem that adjusting the input to see something else than the actual data may be a good (evolutionary) strategy, since it could reduce the chances of encountering unwanted behavioral consequences. In this specific case, the dark frame could likely be interpreted as the presence of shade or reduced light, whereas the light frame would suggest a scene bathed in light, hence in a consistent manner twisting the ways the gray area in the middle looks. If we accept the somewhat astonishing idea that such a "distortion" process takes place all the time, we end up with the realization that our brain (or at least our visual system) is constructing experiences based on "as if" premises, a sort of probabilistic guessing of what is likely to be out there, and what we experience are these probable scenarios. In other words, evolution would have equipped our brains with strategies for making educated guesses about the external world, based on the rate of behavioral success of perception (i.e. avoiding costly results like failing to spot food or dangers, on the risk of death).

However, each individual's perceptual history might lead to developing idiosyncratic strategies, so that different individuals could end up with perception systems (or neural networks) that are biased in different ways. An illustration of the existence of remarkably different perceptual worlds is given by a photograph that went viral on the internet a couple of years ago, commonly referred to as #the dress (Figure 4, below). What is remarkable about this rather unremarkable representation of a female dress is that about half of the viewers see the striped dress in the photo as black and blue (the B&B group) and the others as white and gold (the W&G group). Possibly, individuals in each perceptual group tend to use consistently different visual strategies – without them knowing it or by being unable to control them (in a "Fodorian" modular fashion (Fodor 1987)) – that result in remarkably different ways of generating the colors assigned to the stripes. Thus it would seem that the B&B individuals likely rely on an interpretation of the image as being a photograph taken when the dress was in full light whereas the W&G people rely on an interpretation of the image as being a photograph taken when the dress was in the shade. As we have seen for the examples above in Figure 2 and 3, in the former case the stripes' hues will take a darker tone than when shown in isolation whereas the latter case the stripes' hues will take lighter tones, so as to essentially change colors.

Turning from psychology to philosophy, Bishop George Berkeley warned us several centuries ago that every act of perception is essentially open to interpretation. On the basis of the basic optical properties of the eye – where the lens let the light that's entering the pupil be projected on the back of the eye – he reasoned that such a projection of a line of light (or darkness) could correspond to infinite possible states of the world. Figure 5 below illustrates Berkeley's point. All of the lines in the illustration would generate the same internal projection and, in fact, an infinite set of lines at different distances, slants, and sizes could generate this.



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What we can add to Berkeley's point above, which was sharp, is that perceptual system does not only have to make (quick) decisions about what is out there, but our sense organs will (quickly) adapt to what we think we see and not to the actual 'raw data'. The latest point is a discovery made at the University of Oslo, and in the experimental set-up, optical illusions of brightness constituted the stimuli. In Figure 6 below, we see on the left the original stimulus called 'Asahi' ('sunrise' in Japanese), designed by Akiyoshi Kitaoka, at Ritsumeikan University in Kyoto. On the right side is the Norwegian version of the same stimulus, where the gradients have each been rotated 180° on the plane so as to generate an inside-out version of the original stimulus in a new configuration (nicknamed 'mørketid') (Laeng and Endestad 2012). Although the stimuli are identical in their average luminance and have the same basic visual properties, they look very different in terms of their centers' brightness. That is, 'Asahi' appears to have a very bright center, as if a source of light was shining through from behind the pattern, whereas 'mørketid' appears to have a dark center, indeed darker than the white background of the page. Both the lighter and the darker centers are illusory since nothing is different between them in terms of luminance and, importantly, the two central regions are of the same white as the page itself.

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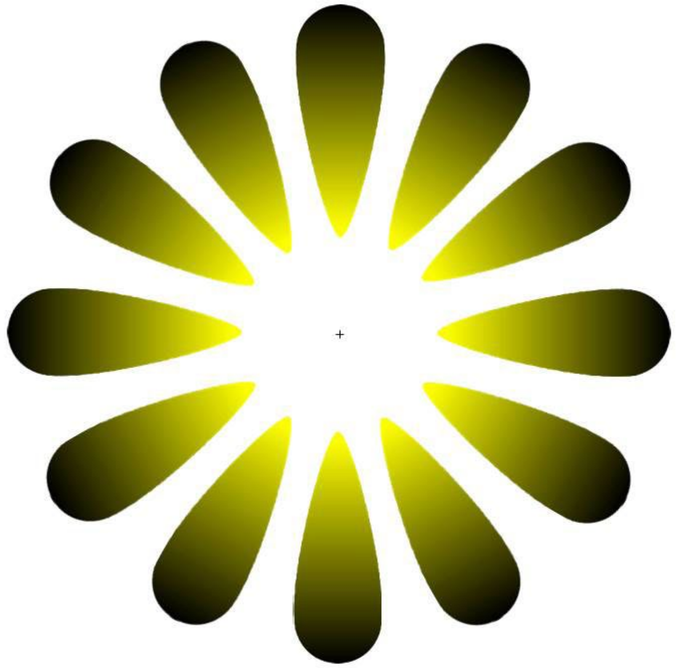
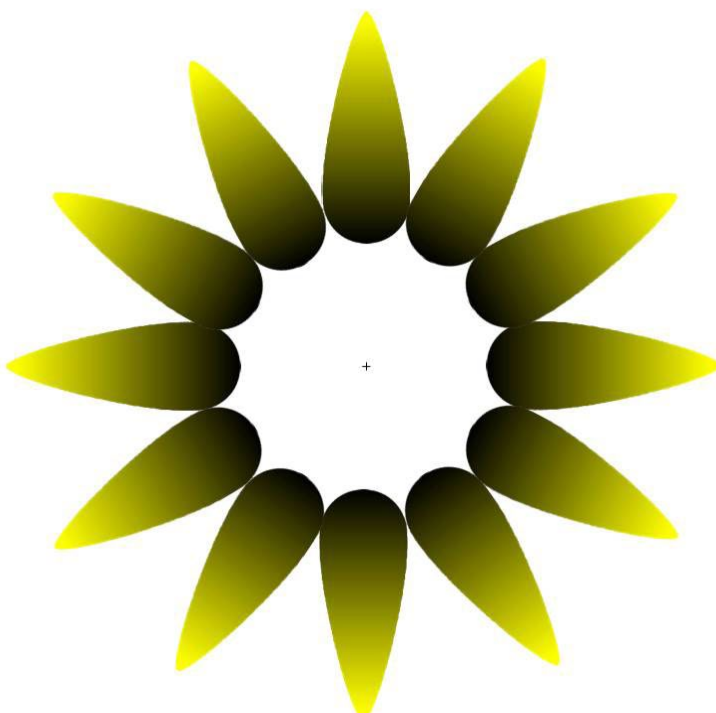
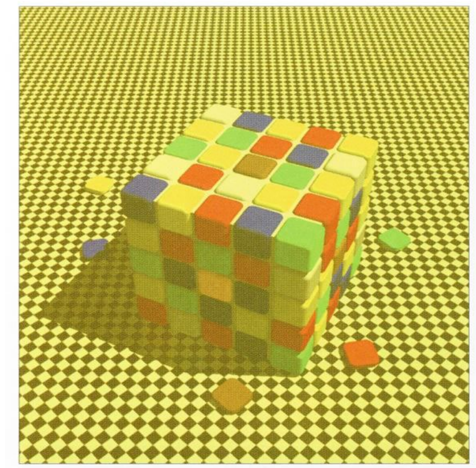


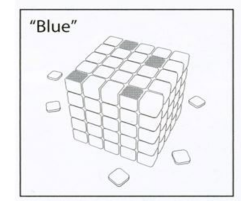


The cognitive laboratory at the department of psychology in Oslo is equipped with an infrared eye-tracker that allows monitoring of the movements of the eyes and the measurement of the size of the pupil. In one experiment participants were to keep their gaze fixed on a central cross shown on a screen for a period of 4 seconds, hence the eye-tracker informed us on which trials the participants obeyed the instruction. Typically, the size of the pupil is adjusted automatically on the basis of the amount of light entering the opening of the eye (smaller when much light is present and larger when the scene is darker). Hence, if the eye adjusts its pupils in the same way an automatic camera does, in proportion to the amount of light energy at any point in time, then the pupils should not react differently to the 'Asahi' or 'mørketid' figures. However, the eye-tracker showed that the pupil constricted to the illusory appearance of light, adjusting to what we think we see instead of the actual light sensed by the eye.

Within current theories in cognitive science (neuroscience), the above findings can be accounted for by a view that takes our brain as functioning as a (Bayesian) statistical machine or a predictive computational system that tends to minimize surprise (see Hohwy 2013). In the specific case of light/dark sensations, biology may have equipped our neural networks with optimal strategies that would tend to reduce unfortunate surprises like glare or sudden loss of visibility. Glare can dazzle and temporarily blind the visual system and it is easy to contemplate the consequences of glare occurring at a particular moment where an individual needs to act or react quickly to something (e.g. in the presence of an aggressor, or a prey, or when moving rapidly within a cluttered environment). For example, we perceive the illusory light in the 'Asahi' figure as generated by a potent light source, which is physically not there, but – if it were – would likely dazzle us. Most remarkably, our perceptual mechanisms generate an interpretation of the world that is closer to what is predicted to likely happen in the "near future," more than to the sensations in the present (Changizi 2009). We also seem to be ready to counteract such predicted states of the world by preparing our optical sensors, the eyes, to react accordingly by adjusting the size of the pupils in time.

To conclude, it seems like Galileo Galilei was right in saying that there are no colors out there in the world. There is nothing blue in the sky, for example, in the sense that if all people should disappear from the face of earth, colors would be removed from this world and the sky would "cease" to be blue, since its blueness requires our brains. As this last illustration by Dale Purves shows (taken from Purves and Beau Lotto 2011), the top blue color of the squares in the "Rubik" cube below are added by our brains and is not present in our sensations: What we perceive as blue squares are actually achromatic patches. When looking at the "blue" cells by themselves, it is clear that they are only made of gray pixels, and, when viewing the whole picture, blue is substituted for the colorless sensory information. QED: Things are really not like they seem to be, but not as we sense them either…





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