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Cortical Color and the Cognitive Sciences

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Abstract

Back when researchers thought about the various forms that color vision could take, the focus was primarily on the retinal mechanisms. Since that time, research on human color vision has shifted from an interest in retinal mechanisms to cortical color processing. This has allowed color research to provide insight into questions that are not limited to early vision but extend to cognition. Direct cortical connections from higher-level areas to lower-level areas have been found throughout the brain. One of the classic questions in cognitive science is whether perception is influenced, and if so to what extent, by cognition and whether a clear distinction can be drawn between perception and cognition. Since perception is seen as providing justification for our beliefs about properties in the external world, these questions also have metaphysical and epistemological significance. The aim of this paper is to highlight some of the areas where research on color perception can shed new light on questions in the cognitive sciences. A further aim of the paper is to raise some questions about color research that are in dire need of further reflection and investigation.

Keywords: Cognitive penetration; Cognitive science; Color consciousness; Color contrast; Cortical color processing; Memory color; Nature of color; Opponent process theory

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1. Introduction

A few decades ago, one of the key debates in anthropology and psychology concerned the categorization of colors in different linguistic communities. Some theorists claimed that color categorization was arbitrary (Whorf, 1956). Others argued that the fact that there are specific reference points in the color continuum, which are used for orientation (called "foci") and are universal, that is, not culture-specific, suggests that color categorization is innate (Berlin & Kay, 1969; Rosch, 1973).

In vision science, much of the research focused on the retinal mechanisms underlying color vision: the different kinds and number of cones contained in the eyes of insects, marine creature, other primates, etc., whether there were cones that extended into the ultraviolet range (Stark, 1987; Stark, Wagner, & Gillespie, 1994), what accounted for color blindness in humans, and whether there were people with four types of cones instead of three (Jameson, 2007). Since that time, research on human color vision has shifted from aiming to attribute conscious color perception to mechanisms of the retina to attributing them to cortical processes. Once conscious color perception such as seeing colored objects, volumes and lights began to be treated as a function of cortical processing, there was a quantum leap in our knowledge of higher-order color processing (Akins, 2001; Kentridge, Heywood, & Weiskrantz, 2007).

The subject of this journal issue is to draw together contributions from different disciplines currently researching human cortical color processing in an effort to shed new light on classical questions in the cognitive sciences and in that way bridge the gap between investigations carried out by researchers coming from different research traditions and different disciplines. The hope is that by doing this we will foster future education, cooperation and collaboration at multiple levels, for example, education between disciplines, experimental collaboration between laboratories, and theoretical collaboration between researchers.

A number of fascinating color conditions have come to light following this shift in research. A grapheme-color synesthete, for example, sees or thinks of letters and digits as having highly specific colors (hue, brightness and saturation). For example, the letter "B" may be perceived as a highly saturated bright periwinkle blue (Sagiv & Ward, 2006; Ward, 2013). A person with cortical achromatopsia is unable to see the colors of the world as a result of damage to the primary visual cortex (Gegenfurtner, 2003; Kentridge, Heywood, & Cowey, 2004). He or she sees the world as being "in black and white." Yet, despite this phenomenology, individuals with achromatopsia are often able to discern shapes and motion on the basis of color information. Individuals with color agnosia, on the other hand, are capable of perceiving color and may be able to match colors to familiar colored objects but they typically have difficulties naming or pointing to colors (Bauer, 2006). These are just a few of the varieties of color perception that arise as a result of cortical color function and dysfunction.

As one might imagine, historically researchers have found different routes into the study of these phenomena. Psychologists have tended to study color synesthesias as just one of a variety of other (non-color) synesthesias. Neurologists, psychology, clinicians and neuropsychologists are the most likely researchers to encounter patients with cortical damage.

Hence, they are the researchers most familiar with achromatopsia or "color blindsight" (Kentridge et al., 2004). The neurophysiologist, who is concerned primarily with neural "wiring" or the informational properties of color processing at a cortical level, may have little to do with human subjects. Hence, such academics might have only a passing interest in, say, color synesthesia but an enormous expertise in the neurophysiology of the color system (for an overview of the neurophysiology of the color system see Hardin, 1988). The same holds true of investigators who are concerned with the conditions of color appearance —how and why the colored world appears as it does to the normal observer (see Hansen, Olkkonen, Walter, & Gegenfurtner, 2006; Witzel, Valkova, Hansen, & Gegenfurtner, 2011 for a more controversial stance on this issue). Philosophers have had more than a passing interest in both the nature and possibilities of color perception in general (Hardin, 1988) as well as consciousness, and unconscious color processing (Akins, 2001; Brogaard, 2011, 2015a; Stoerig & Cowey, 1992).

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2. Retinal and cortical color processing

In philosophy the colors themselves are commonly associated with the spectrum of light reflected by the scene or types of reflections (Byrne & Hilbert, 2003). Color vision as such begins with the three (although some humans have been found to have four) photoreceptors, that is, cones, in the retina (Akins, 2001; Jameson, 2007). What differentiates the cones is their sensitivity to light from a certain region of the spectrum; each cone is, therefore, characterized by the wavelength it absorbs most efficiently: short (S), medium (M), and long (L). Since each of these wavelengths (S), (M), (L), correspond to the hues experienced by humans, viz. blue, green, and yellow, respectively, the three cone types are often identified as blue, green, and yellow. The spectral sensitivity of cones was first measured more than 60 years ago. Since then research has focused on the neural mechanisms of color processing.

The most prevalent of theory of color vision is the *opponent process theory*, which posits two pairs of opponent channels, viz. red and green and yellow and blue (Hurvich & Jameson, 1956). Perception of one member of a pair (say, red) in a certain segment of the visual scene typically precludes perception of the opponent color (blue) in the same segment at the same time. Indeed, although we routinely see binary colors (colors that combine with other colors to produce a new unified color) such as orange or purple we typically do not see yellowish-blue or reddish-green. On the opponent process theory, this is explained by reference to the two opponent channels for color information. While the

S–M (or yellow-minus-blue) channel can give rise to yellow or blue precepts, it cannot give rise to both. Similarly, while the M–L (or red-minus-green) channel can gives rise to red or green precepts, it cannot give rise to both. Yellowish-blue and reddish-green have thus been treated as impossible colors in cognitive science.

Although yellowish-blue or reddish-green appear to be absent from the external world, experiments using image stabilization (a process that leads to loss of border strength[1]) have produced some surprising results. Subjects reported having experiences of what appear to be impossible colors, that is, reddish-green or yellowish-blue (Billock et al., 2001; Crane & Piantanida, 1983). It is tempting to dismiss these results as involving illusory experiences. The conventional view within cognitive science is that the function of the visual system is to produce accurate representations of the external world. Experiments devised to produce illusory experiences, therefore, are seen as a confirmation of the fallibility of the senses. Perhaps, these experiments are no exception: they too can be seen as confirmation of the fallibility of color vision. Taken at face value, however, they seem to indicate that color opponency is, as best, not as rigid or hard-wired as it is considered to be among cognitive scientists (Billock & Tsou, 2010). At worse, they seem to indicate that the opponent process theory is inadequate. Indeed, physiological findings that the detection of boundaries begin at the retina have led some to argue that color vision is better explained by reference to retinal mechanisms than opponent processing taking place in the visual cortex (Brou, Sciascia, Linden, & Lettvin, 1986; see also Hurlbert, Bramwell, Heywood, & Cowey, 1998 whose experiments suggest that the site of the computations of the relative activity of cones within a given type associated with local contrast mechanisms is early in the visual system, most likely retinal.[2]

It is widely acknowledged that the appearance of (at least some) colors such as brown is contingent on their surroundings. This phenomenon, known as *simultaneous color contrast*, has given rise to the term “contrast colors” (Hardin, 1988). For example, a brown object will appear yellow upon masking its surrounding. Simultaneous color contrast is viewed as an effect of color constancy mechanisms, which allow the spectral return from a surface to generate similar color precepts under different illuminants (Palmer, 1999). Color constancy mechanisms are commonly thought to involve either lateral interactions among chromatically sensitive neurons at the retinal stage of the visual system (Jameson & Hurvich, 1989; Land & McCann, 1971) or neural interactions promoting chromatic adaptation, that is, the visual system adjusts its sensitivity to light according to the context in which the light appears (De Valois, 1977; Hurlbert, 1996; Webster & Mollon, 1995). However, both of these explanations have been called into question. For example, Ware and Cowan (1982) found that color constancy mechanisms require both retinal and opponent process mechanisms while Kraft and Brainard (1999) found that color constancy cannot be linked to chromatic adaptation.

The prevalence of color (and other visual) illusions (for a review see Eagleman, 2001) suggests either that the conventional view is correct, in which case it seems that the visual system’s performance is abysmal, or that the conventional view is not correct, in which case it seems that the visual system’s performance is remarkable. One explanation for the prevalence of illusions, which is consistent with the truth of the conventional view, is that color, form, and spatial information processing are processed in independent pathways (Livingstone & Hubel, 1983). However, subsequent research has called into question such strict segregation of signal processing (Sincich & Horton, 2005; for a review of the various processes employed by the visual system see Nassi & Callaway, 2009).

Despite the fact that different features of an image such as color and form are processed by many different neurons in several different cortical areas, in ordinary vision they are bound together. Color research has provided insights into what happens when feature binding fails in conditions such as the melting together of equiluminant colored images or the fragmentation of retinal stabilized images (Billock & Tsou, 2004). It has also provided insights into what happens when signals from the lateral geniculate nucleus (a subcortical area) are sent directly to the specialized areas, bypassing area V1 altogether, as is the case of blindsight patients, who perform above chance level in discrimination or recognition tasks when they are forced to guess despite the fact that they are blind.

There is an impetus to adopt the conventional view (that the function of the visual system is to produce accurate representations of the external world) and view illusions as confirmation of the fallibility of our visual system. The prevalence of color illusions, however, gives rise to skepticism. The visual system is able to assigns constant colors to a scene despite the ongoing changes of both the wavelength of light reflected from surfaces and the illumination. It is also able to produce a single image by combining the two images of a scene associated with each eye—a phenomenon known as stereopsis (Ramachandran & Sriram, 1972). How can a system that seems to be so capable in completing highly complicated tasks as well as our visual system be as fallible as the conventional view suggests?

Such observations have led some to reject the conventional view. Color researchers have used phenomena such as color contrast effects to motivate the claim that they are not illusory or remedial but involve a basic strategy of color vision. On one such view, the function of color vision is to generate color percepts on the basis of how often in past experience a stimulus has exhibited a particular combination of reflectance and illumination (Lotto & Purves, 2000). This approach is based on the common knowledge that there is no one-to-one correlation between the retinal image and external stimuli. Since identical external stimuli are consistent with a variety of retinal images, a single retinal image cannot directly specify the nature of the external source which gives rise to it. Nevertheless, our visual system generates perceptions that generally allow us to successfully navigate the external world. On this view, what matters for successful behavior is not the features of the retinal stimulus but the empirical significance of ambiguous stimuli in the experience of a species understood in terms of the plasticity of the brain over the evolutionary history of a species (Lotto & Purves, 2003).

Color research had also provided insight into questions that are not limited to early vision but extend to cognition. Direct cortical connections from higher-level areas (such as the anterior inferior temporal lobe which involve mechanisms that make use of stored information such as expectations and goals) to lower-level (topographically organized) areas (such as Area 17 which are driven by the inputs associated with the retinal image) have been found throughout the brain (Douglas & Rockland, 1992; Rockland, Saleem, & Tanaka, 1992). One of the classic questions in cognitive science is whether perception is influenced, and if so to what extent, by cognition and whether a clear distinction can be drawn between perception and cognition. Since perception is seen as providing justification for our beliefs about the external world, this question also has epistemological significance.

Color research (Delk & Fillenbaum,1965) has inspired models of cognitive penetration of color perception, one of which implicates visual mental imagery (Macpherson, 2012). Color research features prominently in the research on mental imagery, which involves information in memory that underlies a set of representations that gives rise to percepts in the absence of appropriate sensory inputs (Kosslyn, 1994, 2005). Mental imagery uses the same neural representational machinery used in visual perception (Finke, 1989), and it may even involve visual representations (Fara, 1988) as suggested by findings indicating that mental images can function equivalently to visual percepts in orientation-specific color adaptation known as the McCollough effect (Finke & Schmidt, 1977, 1978).

3. Perceptual pragmatism

The empirical focus in the philosophy of color keeps gaining momentum, with many new empirically based theories entering the scene. However, in the last decade color philosophers appear to have lost sight of the relevance of the neural and experiential realization of color perception. In "Perceptual pragmatism and the naturalized ontology of color" Mazviita Chirimuuta attempts to return to the cognitive sciences as she considers whether they can provide any insights to the philosophical question about the nature of color. The answer is not straightforward for the simple reason that the very concept of color employed by the cognitive sciences "is a fragmented one." Furthermore, as indicated in the previous section, many researchers in the cognitive sciences (not least philosophers) operate with the concept of color that takes it for granted that perceptual systems report on the external world, a model that has been referred to as "the correspondence-detection model" (Akins, 1996, p. 344). The problem with this model, Chirimuuta argues, is that our sensory systems are not primarily concerned with reporting the properties of objects but rather with generating perceptions that allow organisms to successfully navigate the external world, that is, utility. As an example, the responses of thermoreceptors on the skin do not correlate with fixed dermal temperatures but are intended to prevent tissue damage that could occur with rapid cooling or overheating. Similarly, our color perceptions, Chirimuuta argues, do not correlate with fixed spectral properties but are intended to allow us to successfully navigate our environment. She calls this approach to color "pragmatic" to highlight the fact that the important question concerning colors concerns the abilities colors bestow on us, which include to recognize and recall familiar things. On the pragmatist view, an accurate or ideal experience is one that is useful to the perceiver, not one that perfectly represents any properties in the external mind-independent environment. Within the pragmatic framework Chirimuuta defends a position she calls "color adverbialism," which she classifies as a variation on color relationalism. The latter treats colors as relations of a particular kind between perceivers and their environment (Cohen, 2009).

On Chirimuuta's color adverbialism, colors are ways that objects appear to perceivers. We can think of perception as a single act directed from the perceiver toward the perceiver's environment, which is modified in different ways by the color properties of those objects as a result of the interaction. For example, when looking at a ripe tomato, the experience of the tomato is modified in a red way. On this view, color vision is "essentially integrated" with other visual submodalities (e.g., the perception of shape).

With her approach to an empirically informed philosophy of color, Chirimuuta also takes a stance on the question of whether cognition is embodied. Embodiment is broadly understood as the way an organism's sensorimotor faculties enable it to successfully interact with its environment. Embodied cognition is a growing interdisciplinary research program in cognitive science, which emphasizes the influence the environment has on the development of cognitive processes. Chirimuuta rejects the correspondence-detection model, according to which visual systems process sensory input from the external environment and, when successful, generate mental states with contents that correspond perfectly to that environment. She argues that this view of color vision is potentially misleading because perceptual states only provide us with information resulting from the ongoing interaction with our environment.

4. Color realism or color relativism?

A key question about color in the philosophical literature is whether there can be a truly objective account of color. In their contribution "Color relationism and relativism," Alex Byrne and David Hilbert defend a version of color physicalism against objections from color relationalists and color relativists. Color relationalists treat colors as relations between features of objects and perceivers, whereas color relativists treat colors as properties that pick out features in the world only relative to viewers and viewing conditions (for a review, see, e.g., Brogaard, 2015b). Byrne and Hilbert maintain that the plausibility of these positions stands and falls with the soundness of the "argument from perceptual variation." This argument rests on the empirical observation that there can be substantial variation in the color experiences of different perceivers who have normal vision (i.e., they do not suffer from defects such as color blindness). For example, the same surface can appear unique green (i.e., neither bluish nor yellowish) to some but bluish-green and yellowish-green to others. These differences can result from variations in photoreceptor sensitivities, defective photoreceptors, differences in cognitive processes, or variations in external factors (Brogaard, 2015b). Byrne and Hilbert argue that there is good reason to assume that despite variation in color experiences among (normal) perceivers, there can still be objective facts about the colors of objects. This suggests that the argument from perceptual variation is unsound. Although they admit that the argument may have the consequence that we cannot always know whose color experiences are correct, they nevertheless argue that this is not too worrisome, as color variations among perceivers are not radical. For example, they claim that it will still be the case that all perceivers see ripe tomatoes as red.

According to Byrne and Hilbert's color physicalism, colors are kinds of spectral reflectances. Specifically, they are disjunctive properties of reflectances that give rise to certain phenomenal effects in normal human perceivers (in normal viewing conditions) (see also Byrne & Hilbert, 2003). On this view, something is, say, red just in case it has the disjunction of reflectances such that an object's having R will cause it to look red to normal perceivers (in normal viewing conditions). One of the objections they consider is that perceptual variations show that, according to objective reflectance physicalism, nothing looks unique green to normal perceivers (in normal viewing conditions) (see, e.g., Brogaard, 2015b). The reason is that, according to objective reflectance physicalism, something is unique green just in case it has the disjunction of reflectances such that an object's having R will cause it to look unique green to normal perceivers (in normal viewing conditions). Since there is no such disjunction, objective reflectance physicalism entails that nothing is unique green. It follows that all experiences of unique green are illusory. This is problematic for a theory of color that assumes that the role of color vision is to track the colors of things and aims to show that most color experiences are veridical. Byrne and Hilbert argue that this conclusion does not follow from their own account because it takes colors to be primary properties (akin to temperature or length) which have no constitutive connection to normal perceivers much like other primary qualities such as length have no constitutive connection to perceivers.

One worry Byrne and Hilbert's paper brings up is that while they are right that advocates of color relationalism and color relativism tend to rest their case on the argument from perceptual variation, concluding as they do that "the plausibility of relationalism and relativism depends on…the argument from perceptual variation" may be too quick. Granted, most of the current literature against more objective approaches to color put a lot of weight on "argument from perceptual variation." But other considerations such as those brought up in Chirimuuta's contribution may speak for a relationalist or relativist approach to color or related approaches.

One may also worry that a more objective view of colors which take colors to be out there in the mind-independent world rules out particular views about the relation between the phenomenology and content of color perception. The term "phenomenology" of color perception refers to the "subjective feel" of the experience: what it's like to experience, say, redness. The term "content" refers to the color property the experience represents. When we represent a red tomato, for example, the content of our experience consists of a red and roughly round object. One of the questions in the philosophy of mind pertains to the relation, if any, between the phenomenology and the content of color experience. For example, one of the aims is to determine whether the phenomenology of experience depends on its content.

5. The phenomenology and content of color perception

The relation between the phenomenology and content of color perception is the subject matter of Jennifer Matey's contribution to this issue. Her piece is a good example of how philosophical theories of color experience can be informed by the cognitive sciences. She notes that philosophers and cognitive scientists for a long time have treated the phenomenal (or "subjective feel") and intentionality ("what the experience represents") as separate phenomena. According to this view, which she dubs "separatism," sensory experiences do not represent, whereas paradigmatically intentional states such as beliefs, desires, and judgments represent but lack a phenomenal feel. A view that has gained more popularity as of late is the view that there is an intimate connection between phenomenology and intentionality. Some hold that mental states have their intentionality in virtue of their phenomenology. This view is also known as "phenomenal intentionalism." In her paper, Matey presents a challenge to this view that is grounded in empirical investigations of color processing within the cognitive sciences. Owing to color constancy, two targets can be objectively identical and yet the phenomenology associated with them may be quite different when the context in which they are situated differs. So, it would seem that phenomenology cannot determine color content in any objective sense. Matey considers and rejects a number of ways the phenomenal intentionalist could reply to these concerns.

A phenomenal intentionalist could perhaps bypass the worries raised by Matey's contribution by adopting a relativist or relationalist approach to color. Since both of these approaches take the perceiver to be central to color experience, it is natural to think that they could also take the phenomenology of color experience to be the determinant of the experience's content. However, this view may not be plausible, given relationalism. On the version of relationalism defended by Jonathan Cohen (2009), colors are relations among perceivers, features of objects, and viewing conditions. It is unlikely, however, that the phenomenology of color experience can be a determinant of particular perceivers and particular viewing conditions. If you and I can have color experiences with the *same* phenomenal feel to them, then this feel cannot determine aspects of different perceivers. The advocate of phenomenal intentionality thus seems to be better off with a form of color relativism or color adverbialism.

6. Multisensory perception

Another complication related to the discussions about the phenomenology or content of experience is that most of our experiences tend to involve experiences simultaneously associated with multiple modalities. For example, seeing a red tomato, feeling its softness, and smelling its freshness. Such an experience is simultaneously visual, tactile, and olfactory. A classical debate in the cognitive sciences has been that of understanding multisensory or multimodal perception and its relation to cognition. This is an important topic because combining information from multiple sensory modalities enhances our ability to make judgments about our external environment. However, we are only just beginning to get a glimmer of how different modalities work together to produce unified experiences.

An interesting question pertaining to this topic is whether radical forms of multisensory or multimodal processing such as synesthesia may help to inform studies of typical visual processing (Sagiv & Ward, 2006). Synesthesia is a condition involving stimulation in one modality (known as the inducer) eliciting an atypical response (known as the concurrent) in the same or another modality. For example, for some olfactory-color synesthetes certain foods, for example, almonds, can taste like certain colors, e.g., pale blue, whereas for some grapheme-synesthetes certain graphemes have specific synesthetic colors, for example, the letter A is always bright red.

In "Color processing in synesthesia: What synesthesia can and cannot tell us about mechanisms of color processing," Agnieszka B. Janik and Michael J. Banissy take up the question of whether synesthesia should be conceptualized as a perceptual (as opposed to a cognitive) phenomenon. Some theorists have argued, for example, that synesthetic experiences (such as synesthetic colors) are genuine perceptual experiences akin to perceptual experiences we typically have when we are confronted with external stimuli (Ramachandran & Hubbard, 2001). Janik and Banissy review findings indicating that the appearance of inducers has little impact on synesthetic colors and argue that they demonstrate a strong conceptual component in color synesthesia suggesting that synesthetic experiences are not purely perceptual. For example, which color an inducer may elicit depends on whether it is perceived as a letter or as a number (Dixon et al., 2006) while different fonts of the same letter tend to consistently produce the same synesthetic color (Grossenbacher & Lovelace, 2001). The fact that context influences the experience an inducer elicits suggests that the mechanism underlying color synesthesia extend beyond mechanisms of color processing. For example, they appear to involve color imagery and color memory. At the same time, Janik and Banissy present evidence indicating that the perceptual system of synesthetes differs from that of neurotypical subjects. Specifically, color synesthetes tend to have enhanced color processing but reduced motion processing, which raises the question of the extent to which enhanced color processing may also come at a cost for motion in non-synesthetes.

A concern one might have about the hypothesis that color synesthesia differs from regular color processing on the grounds that it involves color imagery and color memory is that it assumes that color processing does not involve these phenomena. Some argue that it is not obvious that color processing is influenced by high-level processes (Raftopoulos, 2001), although the issue is still the subject of fierce debate (see, e.g. Hansen et al., 2006; Siegel, 2012; Witzel et al., 2011). These distinct but related debates about further reveal that a better distinction needs to be drawn between perception and cognition.

7. Cognitive penetration

Another classical debate in cognitive science pertains to the question of the extent to which visual experience is influenced or "penetrated" by cognitive factors such as memory, belief, and familiarity (Pylyshyn, 1999). Some argue that it is not obvious that color processing is influenced by cognitive processes such as long-term memory (Raftopoulos, 2001), although the issue continues to be the subject of fierce debate (see, e.g., Hansen et al., 2006; Siegel, 2012; Witzel et al., 2011).

One piece of evidence in favor of the cognitive penetrability hypothesis, according to which color experience is influenced by cognitive states such as beliefs, comes from studies investigating the effect of memory on color appearance. For example, an early study completed by Delk and Fillenbaum (1965) seems to suggest that our beliefs about the characteristic color of an object may affect the color we experience that object as having. In the study, the experimenters cut out shapes from the same reddish-orange cardboard paper. Some shapes represented objects that are characteristically red, for example, an apple, a heart, a pair of lips, whereas other shapes depicted objects that are not characteristically red, for example, a circle, an oval, a bell, a mushroom. Each cutout was placed one at the time in front of a background whose color could be adjusted from light red to dark red. Subjects were asked the experimenter to adjust the background until they matched it to the color of the cutout. They found that when the cutout represented a shape of a characteristically red object (i.e., an apple), subjects selected a background color that was redder than the color they selected when the cutout did not represent a shape of a characteristically red object (i.e., a mushroom). Based on similar types of observations, a number of researchers have argued that our memory of objects that have characteristic colors cognitively penetrate or otherwise affect the way the colors of objects appear to us (e.g., Delk & Fillenbaum, 1965; Gegenfurtner 2001; Hansen et al., 2006; Levin & Banaj, 2006; Macpherson, 2012; Olkkonen, Hansen, & Gegenfurtner, 2008; Witzel et al. 2011). The methodology of the research establishing that visual experience is cognitively penetrated has recently been challenged by Firestone and Scholl (2015) among others.

In “Is color experience cognitively penetrable?” Berit Brogaard and Dimitria Gatzia provide a number of methodological concerns specifically directed at the research into memory color. They also cite evidence that indicates that color processing is a post-perceptual phenomenon, which takes place outside the visual cortex in regions adjacent to those engaged in other post-perceptual processing such as face perception. Since it is not a genuinely low-level sensory experience, the fact that it may be cognitively penetrable fails to be relevant to the debate about the modularity hypothesis. Finally, they argue that there is a difference between the claim that experience is subject to top-down influences and the claim that it is cognitively penetrated. Only the latter claim is potentially problematic for current philosophical debate about whether visual experience can immediately justify beliefs based on it. To illustrate, suppose now that you believe that the (orange) holiday heart on the office door is red without having any justification. Suppose further that this belief influences and alters your color processing in such a way that you come to experience the heart as red in virtue of having that belief. On one view of justification, this experience can now immediately justify your belief that the holiday heart is red. So, your unjustified belief ends up justifying itself, which is a rather unsatisfactory result (cf. Siegel, 2012).

A question that Brogaard and Gatzia do not consider is whether cognitive penetration is a significant threat to this approach to epistemic justification. It may be held that unlike beliefs, experiences do not have epistemic properties. They cannot be justified or unjustified. But if that is the case, then it follows that the epistemic badness of your belief about the holiday heart cannot transfer to the experience (see Brogaard & Chudnoff, in press).

8. Colors as high-level properties

In “The myth of color sensations, or: How not to see a yellow banana,” Pete Mandik addresses a question related to the hypothesis raised by Brogaard and Dimitria that color properties are much more high-level than it is commonly assumed. Mandik is primarily concerned with arguing against the assumption frequently made in the cognitive sciences, particularly in philosophy, that there are color sensations. For example, when I see a red object, I have a red sensation. The idea that there are color sensations may seem too obvious to question. After all, it would seem that we know that we have color sensations when we engage in introspection. The aim of Mandik’s paper, however, is not to question the claim that it may seem to us from a first-person perspective that we have color sensations. Rather, his primary concern is to examine third-person data that are provided in support of color sensations. Part of the argument against the claim that there are color sensations turns on the observation that color sensations are supposed to be non-conceptual raw conscious feelings, not something that results from conceptual processing and interpretation. For example, a red sensation seems to be a non-conceptual raw conscious feeling: you do not need to have the concept “red” to experience redness, but even if you have the concept, it is still difficult to describe the phenomenology of a red sensation. Mandik, however, argues that scientific evidence suggests that seeing colors occurs much later in the visual process than it would have to occur if there were color sensations.

While there is indeed evidence speaking for a strong conceptual component in color processing, the issue Mandik discusses raises a very interesting question: At which level of visual processing does color consciousness emerges? Individuals with type-2 blindsight, who have lesions to the primary visual cortex, sometimes appear to be able to consciously discern differences in luminance and chroma, despite a radically diminished awareness of brightness and hue (see Brogaard, 2015a for a review). This may indicate that while evidence speaks for a strong conceptual component to hue perception, thus ruling out genuine color sensations, there may nevertheless be color sensations of a more primitive kind.

9. Conclusion

So what is the role of color in the study of cognition? This question falls within a subfield of cognitive science that is still in its infancy. But as the papers in this issue speak to, addressing this question may help us understand how perceptual and cognitive processes give rise to conscious experiences and what these conscious experiences represent, to what extent cognitive processing is insulated from external influences, whether we should approach the adequacy of conscious experiences in terms of objective features such as accuracy conditions or their utility or functional role, and to what extent higher-level cognitive processing influence and shape lower-level perceptual processing.[3]

Notes

1. Border collapse can be produced when two adjacent colors have equal luminance, which is similar but not identical to perceived brightness. Two colors are equiluminant when switching them very rapidly minimizes the appearance of flickering. Border collapse is stronger when eye movement is minimized (see Billock, Gleason, & Tsou, 2001).
2. For a large class of surfaces with random spectral reflectances, ratios are statistically almost constant under changes in illumination. For example, when the light illuminating an entire scene changes, say, from bluish to yellowish daylight, the amount of long-wavelength light reflected from both the target surface and its background will increase, but their ratio will stay the same (see Hurlbert, 1999).
3. Sections of this piece are inspired by and in part based on a conference proposal for, and discussion at, the Cortical Color Workshop and Conference held in Vancouver, August 3–7, 2011, as well as a journal issue proposal co-authored with Kathleen Akins. We thank her for her important contributions. We are also grateful to Wayne Gray for invaluable comments on an earlier version of this paper.

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