COLOR AND TRANSPARENCY

VIVIAN MIZRAH*

Chacun a ses lunettes; mais personne ne sait au juste de quelle couleur en sont les verres.
Alfred de Musset, *Fantasio*

Abstract

In this paper I argue that all transparent objects are colorless. This thesis is important for at least three reasons. First, if transparent objects are colorless, there is no need to distinguish between colors which characterize three-dimensional bodies, like transparent colors, and colors which lie on the surface of objects. Second, traditional objections against color physicalism relying on transparent colors are rendered moot. Finally, an improved understanding of the relations between colors, light and transparency is provided.

Introduction

Colors are typically perceived on the surface of objects and any good theory about the nature of colors must account for the fact that colors appear as superficial properties. The main reason why bananas are said to be yellow is not because bananas cause people to feel a yellowish sensation in their eyes or their brain, but because the surface of bananas is perceived to be a particular shade of yellow. The point here is not to *a priori* reject any theory of colors which incorporates sensations or any other subjective element, but rather to stress that color ascription results from the way that colors are located in space. Unlike sounds, odors or tastes, colors are superficial properties and any good theory of color must therefore give an account of the intimate relation between colors and surfaces. Among the diverse numerous philosophical accounts of the nature of colors, physicalist theories of colors offer the most direct explanation of the special relation that colors bear to surfaces. Color physicalism holds that colors are physical properties and that to see the color of an object is to see a physical property. The most popular version of color physicalism is that colors are reflectances or types of reflectances. Reflectance is a dispositional property corresponding to the proportion of the incident light a given surface is disposed to reflect. In identifying colors with reflectance, colors physicalism holds that colors are perceived at the surface of objects, because reflectances are physical properties *of surfaces*. Even though this result may not appear to be remarkable at first, most ontological theories of colors cannot give any comparable explanation of why colors are perceived at the surface of physical bodies. To accommodate their view on the nature of colors, most subjectivists about colors, for example, must embrace a kind a projectivism[1] which holds that colors are not properties of ordinary objects but rather are subjective properties which are mentally projected to the outside world at the surface of physical objects.

Although color physicalism offers a straightforward account for the fact that colors are perceived on the surface of objects, what should it say about the color of transparent objects?

As stressed by Katz in the classical *World of Colour*, colors are multiple and cannot be reduced to superficial colors only. Colors are seen on the surface of objects, but they can also fill a three-dimensional space, like a red Murano articraft or a yellow glass of beer. If superficial colors can be identified with reflectance properties, is there a similar physicalist account for voluminous colors?

Superficial colors are characteristic of opaque objects, whereas voluminous colors are specifically related to transparent objects. For a color to fill a three-dimensional space it must be possible to see behind it. Ordinary superficial colors, in contrast, seem to oppose a resistance to the eye[2] and prevent the vision from penetrating the space behind.[3] To evaluate whether a physicalist account of color can be extended to voluminous colors, we must then investigate the relation between colors and transparency.

For Byrne and Hilbert (2003), to account for both superficial and voluminous colors, color physicalism has to characterize colors in terms of productance rather than reflectance. According to their definition, “productance” extends the concept of reflectance by equating colors with the proportion of the incident light that would “leave”

---

* vivian@mizrahi.ch

[1] See for example Hardin (1993), Boghossian and Velleman (1989).

[2] Katz (1935), p. 8.

[3] Notice that superficial and voluminous colors can be combined according to the degree of the object’s transparency. “Diaphanous” and “translucent” qualify objects which are only partially transparent, and therefore also partially opaque.

an object rather than by the proportion of light that it is disposed to reflect. A glass of rosé wine, for example, selectively transmits a higher proportion of the long wavelengths of the incident white light spectrum. Like that of a ripe tomato, its reddish color can be explained by its distinctive productance property (i.e. the ratio between the light "leaving" the glass and the light falling on it). According to Byrne and Hilbert's proposal, voluminous colors are not "outstanding" colors. Like superficial colors, they are physical properties and can be integrated into a unified version of color physicalism if colors are identified with productance rather than reflectance properties.

Unlike Byrne and Hilbert, I claim that voluminous colors are not *bona fide* colors and that color physicalism should be restricted to reflectance properties. In support of these claims, I will make three points. First, the notion of productance conflates two essentially distinct notions. Second, there is no non-arbitrary way to ascribe a particular color to a transparent object. Third, ascribing colors to transparent objects rests on reflectance properties only.

Productance Physicalism and Transparency

Consider a perfectly white surface which reflects 100% at all wavelengths. According to Byrne and Hilbert's productance physicalism, a perfectly white surface and a perfectly transparent object should be the same color because they have the same productance properties. Remember that productance is defined as the disposition to produce (i.e., reflect, emit or transmit) a specific proportion of incident light. According to Byrne and Hilbert, a white piece of paper and a crystal glass are the same color, because they both integrally reflect or transmit the visible light. But is there a sense in which we can say that a crystal glass is white like a piece of paper? Is this awkward conclusion not the sign that something is wrong with Byrne and Hilbert's theory?

I believe that it is. I will argue that productance physicalism is wrong because it fails to distinguish color from transparency. Subsuming reflectance and transmission properties under the notion of productance conflates two essentially distinct notions.

Byrne and Hilbert's proposal to identify colors with productance faces an initial problem: how to account for perfectly transparent objects which are said to be colorless, like a pane of glass? Consider a perfectly transparent window. If we discard any possible reflection, a perfectly transparent window is invisible.[4] The relation between transparency and invisibility appears to be quite simple: a piece of glass is invisible because it is transparent. Transparency and visibility therefore appear to be opposite notions. In order to see behind or through a body, there must be no visible obstacle. If a body is spatially located between the observer and the background, the background is visible provided only that the intermediate body is not seen. Conversely, in order to be visible the surface of an object must be opaque, and opacity supposes that a surface can absorb or reflect the wavelengths of visible light. Notice that transparency applies to three-dimensional bodies, whereas opacity applies to surfaces. To say that something is transparent is to say that we can see through it, whereas to say that an object is opaque is to say that we cannot see behind its surface. It is also interesting to note that opacity and transparency are complementary and gradual notions. The more transparent an object is, the less opaque its surface. From the level of physical description, this complementarity is quite simple to understand. For a body to be transparent, it must transmit light. Therefore, the higher the light transmission, the higher the transparency. In contrast, for a surface to be opaque, it must absorb or reflect light. Therefore, the lower the light transmission, the higher the opacity.

Transparency and invisibility go hand in hand: the more transparent, the less visible. On the other hand, the concept of color is visual in nature. Unlike shape, for example, which can be visual or tactical, colors are only accessible through sight. According to this analysis, transparency and color are opposite notions in respect to visibility. For an object to be transparent it must be invisible, whereas to be colored an object must be visible. An object's transparency is characterized by its light transmission properties, whereas its color is given by its reflectance properties.

Color productance is wrong because it fails to see that light transmission properties characterize transparency and not colors. By specifying the light transmission properties of an object, we don't do not say anything about its color. We just specify its transparency. To say that a pane of glass transmits 100% of the visible glass is to say that

---

[4] Most ordinary transparent objects are not perfectly transparent. First, most materials contain impurities which make them partially opaque. Second, due to their shape and shiny surfaces, most transparent objects locally reflect some light, like the edges of a pane of glass. Notice that what is perceived in these cases is always the surface of the object, not its volume.

it is perfectly transparent. To say that an object transmit no visible light is to say that it is opaque. There is, in both cases, no way to equate the light transmission properties with any color property.

If Byrne and Hilbert's productance physicalism is rejected and colors are confined to reflectance properties only, what answer can be offered to the challenge raised by voluminous colors? My reply is twofold. First, I will argue that, strictly speaking, voluminous colors do not exist and transparent objects are colorless. According to this view, all charges against reflectance physicalism relying on the existence of voluminous colors must be dropped. Second, I will explore the reasons that make us say that some transparent bodies are colored. I will insist that the supposed voluminous colors are not the properties of transparent objects themselves but the color properties of the surfaces seen through them. As I will explain, transparent bodies are not colored, although they can change the way we perceive colors.

Color Ascription and Transparency

According to Katz and our naïve conception of transparent objects, some objects appear to be both transparent and colored. Take for example a crystal glass filled with beer. If we discard all reflections and impurities which can lessen its transparency, a glass full of beer appears to be both transparent and yellowish. But is that really so? Suppose the transparent beer is located in front of a black wall. What color does is it look? Does the beer still look yellow? If it does not create any discontinuity in the visual field of the observer, the transparent body appears colorless and become invisible provided the specular reflections of its surface and edges can be suppressed. To illustrate this point, suppose for the sake of simplicity, that we take a grey filter and place it on a piece of white cardboard. The filter can be seen as long as its light transmission properties change our color perception of the background. On a white cardboard, the filter can be seen because the cardboard seen behind it appears to be grey (see fig. 1). But if the same grey filter is place on a black cardboard, it becomes invisible and colorless (see fig.2).

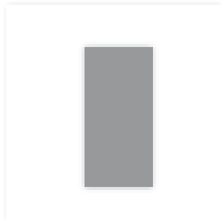

Fig. 1 Grey filter on a white cardboard

Fig. 1 Grey filter on a black cardboard

Because the light transmission properties of the grey filter on a black cardboard does not affect the way we see the underlying surface, we cannot see it. Like a perfectly transparent body, such as a pane of glass, the grey filter on a black cardboard is both invisible and transparent. More generally, color ascription to a transparent object depends on the color of its background. We say that a glass of beer is yellow because that is the way it looks in front of a white piece of cardboard. The way it would appear on a red or blue background would be dramatically different and its appearance would not be described as yellow. To see this, consider again a "reddish" transparent object, like a glass of rosé wine and a "yellowish" transparent object, like a glass of beer. If a "reddish" glass of wine is placed in front of a yellow background it no longer looks reddish but orange. And its color is not different from the color of a glass of beer in front of a red cardboard. Unlike superficial colors, the colors ascribed to transparent objects seem to depend essentially on the color of their background.[5]

Now, why should we say that a glass of beer is yellow rather than orange or green? In other words, why should we determine the color of a transparent object in relation to a white background rather than a yellow or blue one? It's seems that there is no principled way to choose one background at the expense of all the others. To claim, for example, that a beer of glass is yellow would imply that a white background causes a veridical perception of the glass' color, whereas its appearance in front of a blue and a red surface are both illusory.

---

[5] To be more precise, perception of superficial colors is also affected by its surroundings. Simultaneous contrast, for example, refers to the way color perception can change according to the way color of objects affect each other.

In response to the problem caused by the lack of a principled way to select among the background's colors which are supposed to reveal the true color of a transparent body, I will argue that all transparent objects are colorless. According to this approach, there is no way to select the true color of a transparent object, because there is no such property. To give some plausibility to this view, I will clarify its significance from a physicalist perspective and explain why we mistakenly ascribe colors to transparent objects.

Light and Transparency

To understand why transparent object are colorless and to grasp their place in color perception, it is useful to show how they are related to light and lighting conditions. The problem of selecting the "true" color of a transparent echoes the challenge raised by the choice of the illuminant in the determination of the "true" color of a surface. Consider the following case. A banana in daylight usually appears yellow, but the use of a monochromatic light can make it appear red, green, or blue. If a banana can appear red or blue according to the lighting conditions, why is "yellow" usually selected as being the "true" color of bananas, rather than "red" or "blue"? To resist a pluralist view of colors which would endorse the possibility that objects are multiply colored, one strategy would be to distinguish good from bad lighting conditions. According to this view, veridical color perception requires the use of a white light.[6] Whether color appearances can vary according to lighting conditions, only white light enables the colors of things to be truly perceived. To put it differently, all lightings, except white light, are related to illusory color appearances and should therefore not count as cases of veridical color perception. Bananas can be misperceived as red or blue when viewed under particular lighting conditions, but their "true" color appears only under white light.

As stressed by Hardin, any attempt to distinguish veridical from illusory color perceptions by favoring one set of viewing conditions at the expense of the others is questionable. The difficulty raised by Hardin is that there is no non-arbitrary way of choosing between 'kosher' and 'not kosher' viewing conditions.

---

[6] This difficulty is particularly apparent when the various standards of light sources used in psychophysics and industry are considered. See Kuehni (2003), p. 357-360.

> I shall argue that contexts are interest-relative and irreducible to a single context, so there is no unique set of standard conditions under which objects are to be seen in their ‘true’ colors (Hardin 1983, 806).

The fact that white light is favored in order to select which color experiences count as veridical is contingent and arbitrary. Bananas are said to be yellow because human color perception usually take place under daylight or white artificial light. If human color perception would predominantly take place under a monochromatic light source at about 650 nm, bananas would be said to be red rather than yellow.

It can be argued that our lack of an independent standard to choose among the illuminants does not refute the possibility that the “true” colors of objects are being revealed with only one particular illuminant. The fact that we don’t have a definitive reason for choosing a particular illuminant, does not exclude the possibility that true colors are only perceived with white light.[7]

However, the unavailability of an independent standard should make us reconsider the reasons we have for saying that bananas are yellow rather than blue or red. I suggest that the best option is to trust our color perception and accept a pluralist view of colors. If bananas appear yellow in a white light and red in a monochromatic light at about 650 nm, it’s because different lights reveal different colors. As we all know, colors cannot be seen in the dark. This is because colors are dispositional properties whose manifestation depends on light. For a color to be perceived, the conditions of its manifestation must obtain. But those conditions can differ according to the colors at issue. Like solubility which can be manifested in different solvents, such as water or fat, different colors are manifested under different lighting conditions.

According to reflectance physicalism, no light is colored. Lights can actualize color properties, but they do not color things. Long wavelength lights are not red but actualize, and therefore make visible, surface colors which are reddish. Short wavelength lights in contrast actualize bluish surface colors. When using different monochromatic lights, our perception changes, because the colors we are able to perceive are different.[8] More

---

[7] For a similar view see Byrne and Hilbert (2003), p.17.

[8] The use of multi-wavelength lights, like white light, is more complex, because human color perception relies on just three receptor types with broad spectral sensitivity which cannot discriminate between different reflectances producing the same response in each of these three receptor types. However, it can be

generally, perceived color variations due to lighting variations correspond to variations of the surface colors we perceive and not to variations of the lights that are used. This account is backed up by the fact that light is not visible without reflecting surfaces. As rightly pointed by Hilbert,[9] we never perceive beams of light, but only the reflectance properties of the dust particles they illuminate.

Now, why are those remarks about variation in lighting conditions helpful for our understanding of the relation between color and transparency? As I propose to show, transparent objects and light sources are closely related.

As we noticed, change in color perception can be caused by changing the lighting conditions. A yellow banana in daylight can appear red or blue when illuminated with an artificial light. But changing the properties of the light source is not the only way to select and obtain lighting color variations. The use of transparent objects, for example, can produce similar color variations in different ways. First a transparent body can be used like a filter to modify the properties of the illuminant by selectively absorbing some of its wavelengths. By changing the properties of the illuminants, transparent bodies can therefore change the colors we perceive. But transparent bodies can also be located between an observer and a colored surface. In this case, transparent bodies do not directly filter the light emitted by the source, but they partially absorb the light reflected by the colored surfaces. If a white surface for example, reflecting equally all the wavelengths, is viewed through a filter, only the wavelengths which are not absorbed by the filter will reach the eyes of the observer and be perceived. In both cases, the surface color perceived by the observer is the same. Whether it is located at the light source or between a reflective surface and the observer, the transmitting properties of the filter selects in the same way which reflectance properties are perceived by the observer.

---

argued that for all color variation caused by a change in illumination, there is a change in the reflectance properties perceived. Cf. Mizrahi (2006).

[9] Ref Hilbert (1987), p. 162.

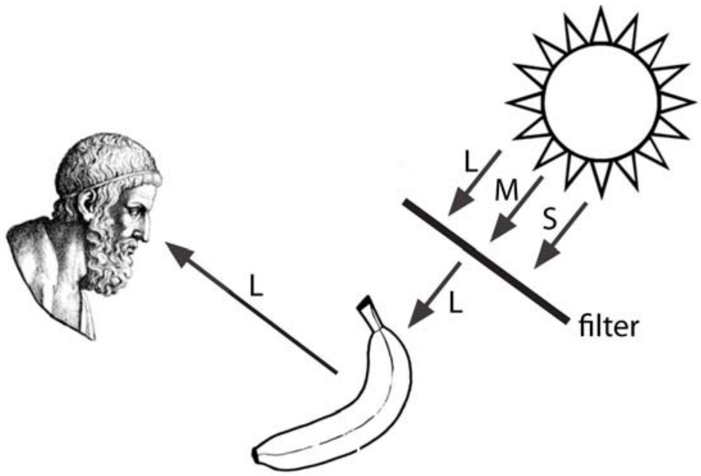

Fig.3 Perception in a long-wavelength light.

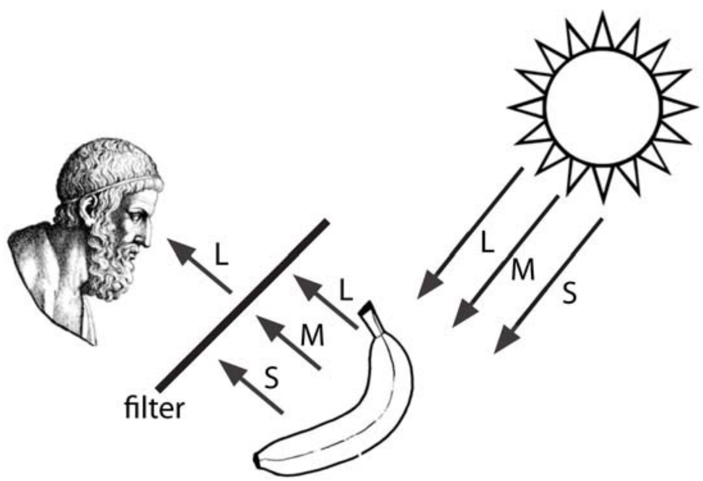

Fig. 4 Perception through a "red" filter

To understand this point, consider the two following cases: a normal trichromat perceiver with naked eyes observes a surface illuminated by a long wavelength light (fig 3), and a normal trichromat perceiver with "red" tinted glasses observes a surface illuminated by a white light (fig 4). Although the circumstances in each case differ greatly, the reddish color of the surface experienced by the subject in both cases is identical with a unique property. In effect, the red tinted glasses used in the second scenario are filters able to block the medium- and short-wavelengths. Wearing such glasses therefore confines chromatic discriminations in the long-wavelength band. The use of a light composed exclusively of long wavelengths would have sensibly the same effect. The absence of short- and medium-wavelengths in the light would prevent color vision from operating in the short- and medium-wavelength band and therefore restrict chromatic perception to the long-wavelength band.

Transparency and color pluralism

The selective role of transparent bodies resonates with the pluralist view on colors recently defended by Allen (2009), Kalderon (2007) and Mizrahi (2006). Color pluralism is the view that objects simultaneously instantiate many different colors. According to this view, the pre-existing and mind-independent colors of a given surface are not all accessible to a given observer at a given time. Their perceptual availability varies according to internal and external conditions. Different visual systems, for instance, can be sensitive to different colors of the same object and some of its colors could perfectly not be detectable by any existing living organism. Colors availability to observers depends in large part on the observational conditions in general and on the light source properties in particular. As we have seen, transparent objects are particularly interesting in this context since they can modify those conditions and change our perceptual access to colors.

By filtering the light, transparent bodies determine which colors are perceptually available for a given observer. Understood in this way, transparent bodies are not intrinsically colored, but only select the colors we can see through them. By selecting which colors are perceptually available, transparent bodies do not add colors to or subtract them from the world. They only change their accessibility to particular observers.

There are, in fact, many situations in which filters are used to reveal physical properties which are not available to the “naked” eye. Consider for example the role of filters in forensic practices. Some evidence at a crime scene, such as fingerprints and body fluids, are often hidden, but can be revealed and made plainly visible with the use of a particular light source and special glasses. The glasses used in such a situation are filters able to block a special band of wavelengths. When wearing these kinds of glasses, the perception of the forensic investigator is limited to a very small part of the visible spectrum. Chromatic discontinuities corresponding to fingerprints or particular smears perceived through those filters are not brought into being by the forensic glasses. They pre-existed the investigation at the crime scene. Color perceptions through transparent bodies are therefore neither illusory, nor erroneous. They are, on the contrary, admitted as evidence in court.

When a transparent body is said to be colored, it is not therefore in virtue of its own colors, but only in relation to its disposition to modify the colors that are perceived. The transparent bodies are usually visible because they cause a chromatic discontinuity in the visual field. According to this analysis, perception of transparent objects resembles perception of deforming lenses in the sense that they both depend on the perception of the surface seen in transparency. To see this, consider a perfectly transparent lens facing the observer. If the lens is flat, it is totally invisible. But if the lens has a certain curvature or is somewhat distorted, its own presence emerges in the visual field of the observer (see fig. 5).

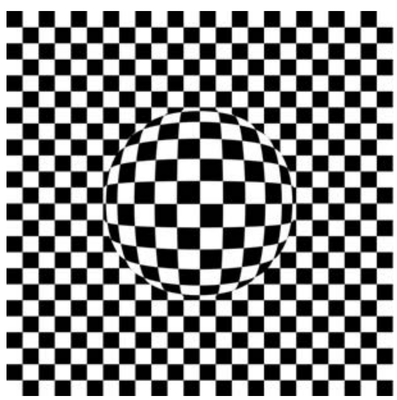

Fig. 5 Convex lens on a checkboard.

The point is that when we perceive a convex lens on a checkboard, for instance, we do not perceive the geometrical properties of the lens itself but rather the geometrical properties of the checkboard distorted by the optical properties of the lens. Instead of chromatic discontinuities as in the case of filters, lenses are only visible through the geometrical discontinuities they create in the visual field.

Conclusion

I have argued that transparent objects are not colored. Like those of opaque objects, their surfaces or edges can sometimes partially reflect light and therefore be partially colored. But colors are superficial properties and, contrary to what have been suggested, colors never fill transparent bodies. This result matters for at least three reasons. First, color variations resulting from the use of transparent objects add interesting data and problems to the general discussion about color ontology. Second, transparent objects have served as counterexamples against physicalist views on colors. This objection evaporates once the role of transparent objects in color perception is clearly understood. Third, a careful examination of transparent bodies shows that they should be conceived as visual media, like air or water, rather as perceptual objects. As eloquently expressed by Heider in "Thing and Medium":

> One cannot get much information about a transparent pane of glass as long as one lets it act as a medium. One can look through it as if it were clear air. Only if one touches it with one's hand (…) can one get information about the pane itself. This is also the case when it is possible to see its edge, or when one sees it from the side and notices a thin glittering line. In all these case it does not act as a pure medium.[10]

Perceptual media have often been neglected in the philosophy of perception.[11] I believe that they deserve more attention in their own right and that much can be learned through a careful examination of their role in color vision and in perception.

References

ALLEN, K.
— 2009, Inter-Species Variation in Colour Perception, "Philosophical Studies", 142:197-220.

BOGHOSSIAN, P. & J.D. VELLEMAN
— 1989, *Color as a Secondary Quality*, "Mind", 98 (January):81-103.

BYRNE, A. & D.R. HILBERT
— 2003, *Color Realism and Color Science*, "Behavioral and Brain Sciences", 26 (1):3-21.

CASATI, R.

[10] F. Heider (1959), p. 49.
[11] Some notable exceptions can be found in Casati (2000), Casati & Dokic (1994), Gibson (1986), Heider (1959).

— 2000, *Une note sur les milieux perceptifs*, in P. Livet (dir.), *De la perception à l'action, contenus perceptifs et perception de l'action*, Paris, Vrin,147-153.

CASATI, R & J. DOKIC
— 1994, *La philosophie du son*, Nîmes, Jacqueline Chambon.

GIBSON, J.J.
— 1986, *The Ecological approach to visual perception*, Hillsdale, NJ: Erlbaum.

HARDIN, C. L.
— 1983, *Colors, normal observers, and standard conditions*, "Journal of Philosophy", 80:806-12.
— 1993, *Color for Philosophers: Unweaving the Rainbow* (expanded edition), Indianapolis: Hackett.

HEIDER, F
— 1959, *Thing and Medium*, "Psychological Issues", I:1-34.

HILBERT, D.R.
— 1987, *Color and Color Perception: A Study in Anthropocentric Realism*, Stanford: Center for the Study of Language and Information.

KALDERON, M.E.
— 2007, *Color Pluralism*, "Philosophical Review", 116(4):563-601.

KATZ, D.
— 1935, *The World of Colour*, London: Kegan.

KUEHNI, R.G.
— 2003, *Color Space and Its Divisions: Color Order from Antiquity to the present*, New York: Wiley.

MIZRAHI, V.
—2006, *Color objectivism and color pluralism*, "Dialectica", 60(3):283-306.