PRO TO PRO
CONTINUING EDUCATION

PRODUCT SPOTLIGHT – WILEY X CAPTIVATE LENSES

WILEY X LENS TECHNOLOGY REDEFINING COLOR WITH CAPTIVATE

By Deborah Kotob, ABOM

[1 CE CREDIT]

THIS COURSE IS SUPPORTED BY AN EDUCATIONAL GRANT FROM WILEY X

LEARNING OBJECTIVES:

Upon completion of this program, the participant should be able to:

1. Learn about Captivate polarized lenses with filters to attenuate color signal overlap in the retina, increasing color vividness and discrimination, sharpness, contrast and detail.
2. Learn how our brain interprets color from retinal signals.
3. Learn how color signals are redefined with selective filtering of specific wavelengths of light.

TO EARN CONTINUING EDUCATION CREDIT:

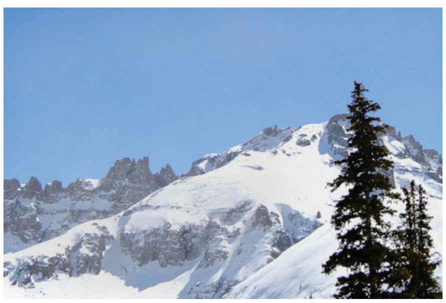
This course has been approved for one (1) hour of Ophthalmic Level II continuing education credit by the ABO. To earn ABO please review the questions and take the test.

Note: As of January 2020, no tests will be graded manually. Please call (800) 825-4696 for more information.

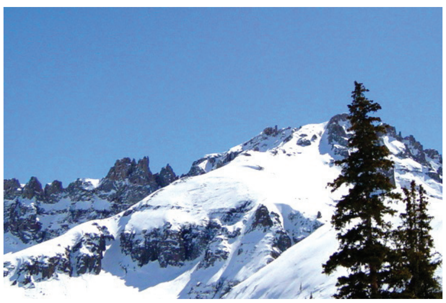
BRAIN ILLUSTRATION: PIXABAY/ELISA RIVA

In this course, we will learn about Captivate polarized color-enhancing sun lens technology from Wiley X. We all know that polarized lenses enhance contrast and detail by blocking reflected glare, but now we will learn how polarized sun lenses are better with color and contrast-enhancing filters. Color-enhancing filters make details and colors POP! We will learn how a polarized sun lens with a Captivate color-enhancing filter eliminates overlapping low chromaticity (hue and colorfulness) wavelengths from transmitting to the retina to improve the high chromaticity response, meaning that the brain receives a more precise color signal for enhanced contrast and better color discrimination. We will also look at the effect of short wavelengths of blue light on visual haze due to retinal defocus and scatter along with its potentially damaging effect on the retina. On the other side, we will discuss beneficial blue light's positive effects on our health and circadian rhythm effects.

WOW! There is no better feeling for an optician than dispensing glasses/sunglasses that elicit a WOW response from the customer. Even better is that these happy customers share their excitement about the incredible vision they experience in their new eyewear with friends and family. If we are lucky, they even share on social media. Captivate color-enhanced polarized lenses from Wiley X is such a product. So how do these color-enhanced polarized lenses improve the wearer experience? Captivate color-enhanced (CE) polarized lens technology uses proprietary patented color filtering science to attenuate wavelengths of light associated with color confusion and blue light-induced haze. Captivate polarized lens technology from Wiley X meets the ANSI Z87.1 for high mass impact, high-velocity impact and optical clarity as well as the European EN 166 safety standard. Bonus, they now have the additional benefit of color and contrast enhancement. The scientific premise for Captivate technology is that the human eye is unable to see the entire visible light spectrum clearly, because it has difficulty distinguishing light at the boundaries where pure color peak response curves merge/overlap and produce color confusion at the blue/green and green/red junctures. Captivate lenses filter out the confusing light at these boundaries, which helps increase clarity and color definition with vibrant contrast and vivid detail.



Without Captivate CE Tech



With Captivate CE Tech

Organic dyes used in Captivate CE lenses selectively block blue wavelengths of light and attenuate specific yellow wavelengths to produce a visual experience with more vivid colors, better depth perception, enhanced clarity and high definition. Captivate lens technology provides all of this, and they are polarized to provide polarized glare protection. Captivate lenses have 100 percent UV/HEV protection. Although a proprietary technology, Wiley X shares that they engineered Captivate lenses to allow beneficial blue light (long wavelength blue light) to transmit through the lens while blocking the harmful and defocused short-wavelength blue light. Beneficial blue light is essential for maintaining our Circadian rhythm. Our circadian clock controls our biological clock/rhythm to keep a normal 24 hour sleep/wake cycle and produce the happy alert brain chemicals that improve alertness, mood and memory.

The circadian rhythm and beneficial blue light connection (Fig. 1):

We have specialized non-seeing photoreceptor cells in our retina called intrinsically photoreceptive retinal ganglion cells that set our 24 hour circadian clock. These cells contain melanopsin that is sensitive to beneficial blue wavelengths of light, making these long blue wavelengths essential for maintaining normal circadian rhythm. The importance of maintaining a healthy circadian rhythm cannot be overstated as this internal clock controls our 24 hour sleep/wake cycle and other daily rhythms such as hunger, mental alertness and mood, stress, heart function and immunity.

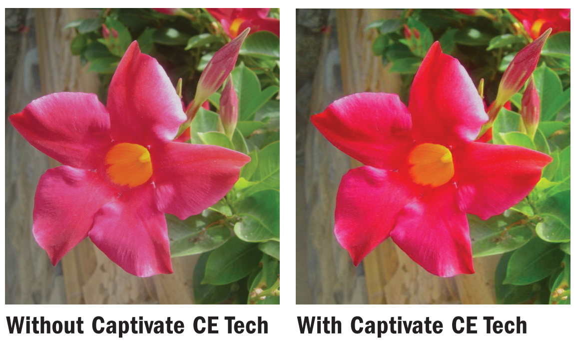
We need beneficial blue light, those long blue wavelengths between 460 nm to roughly 490 nm during daylight hours to produce the serotonin hormone and other essential brain chemicals that wake us in the morning and keep us alert and happy throughout the day.

Conversely, eliminating potentially harmful, scattered and defocused short-wavelength blue rays from sunlight has many positive benefits, including enhanced color vision, sharper detail and enhanced depth perception all while protecting the retina from potential damage that has been linked to ocular disorders such as age-related macular degeneration. Captivate lenses allow beneficial blue light to transmit through the lens while high-energy visible (HEV) blue light from 400 to 430 nm is blocked. Excess exposure to solar (sun) HEV blue light is linked to a higher risk of retinal damage. This photochemical damage from sun exposure to blue light is related to an increased risk of age-related macular degeneration, the number one cause of blindness in persons over the age of 50 in the U.S.

About color vision: First, we need to understand that we see with our brains. Our brain processes and translates electrochemical signals generated by the retina into visual perception. Later in this course, we will learn how we can help the brain's perception of color by selectively filtering blue and yellow wavelengths. The signals created by retinal photoreceptor cells travel through a network of retinal neurons and are further refined by retinal ganglion cells as part of the visual cycle.

What role do our eyes play? Our eyes (cornea and crystalline lens) refract and focus

FIG.1 Our biological clock aka circadian clock is set by our intrinsically photosensitive retinal ganglion cells, which contain melanopsin that is sensitive to beneficial long blue wavelengths of visible light.



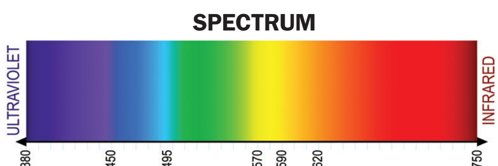


FIG.2 Visible light spectrum—the wavelengths from the electromagnetic spectrum which we perceive. Visible wavelengths correspond to light waves that specialized cone photoreceptor cells in our retina convert into electrochemical color signals for the brain.

light on the light-sensitive photoreceptor cells of the retina. When visible light (Fig. 2) strikes photoreceptor cells in the retina, it initiates the visual cycle, the transduction of light into electrochemical signals. The initial color signals produced are the result of Trichromatic theory (Fig. 6), where our three color-sensitive cone photoreceptors absorb the light according to their unique peak wavelength sensitivities. Next, the retinal ganglion cells refine the electrochemical signals according to the opponent theory (Fig. 7), and these signals are transported from the retina to the brain via the optic nerve that I picture as light's super-highway to the brain. The light information travels from the retina to the brain via the optic nerves of our right and left retinas. Ultimately, the light signals reach the visual cortex of the brain's occipital lobe.

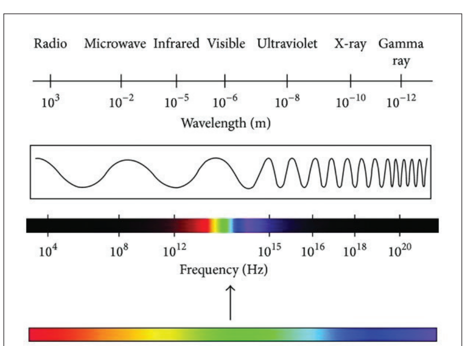


FIG. 3 The electromagnetic spectrum—The shorter the wavelength, the higher the frequency and energy. Every wavelength of light from the visible light spectrum is associated with a color hue. Other wavelengths of the electromagnetic (EM) spectrum, such as UV and infrared light is invisible to the human eye.

The brain requires clear signals from the retina to process and produce clear visual perception accurately. Eliminating color confusion with wavelength-specific filters that remove overlapping wavelengths at the transition point between high chromaticity and overlapping areas results in the brain receiving more precise color signals. Color signals are the product of our cone photoreceptor cells in our retina, where the combined response of the unique pigment opsins of the (S) short-blue, (M) medium-green or (L) long-wavelength red cone receptors are responsible for the many hues (colors) that the brain perceives.

To have sight, we first need light. Visible light is electromagnetic (EM) radiation that falls between ultraviolet radiation and infrared radiation on the electromagnetic spectrum (Fig. 3). Visible light must then interact with objects in our environment where it is either absorbed by an object, transmitted through transparent objects or reflected from objects. It is the light reflecting from objects that travels to the eye and forms an image on our retina. The reflected light first strikes the transparent cornea, the first refractive (focusing) structure of the eye; it then travels through the pupil, the opening of the iris; then, the crystalline lens further refracts it before forming an image on the retina. Once struck by light, our retinal photoreceptor cells initiate the visual cycle, transducing light into electrochemical signals, which are transported to the brain via the optic nerve.

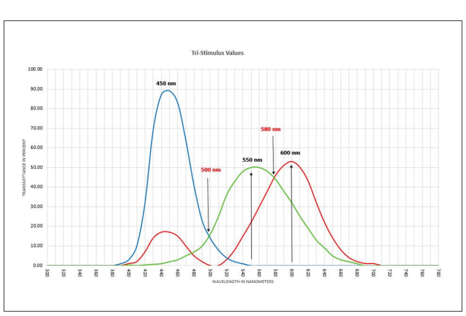


FIG. 4 Trichromatic cone photoreceptor response curves

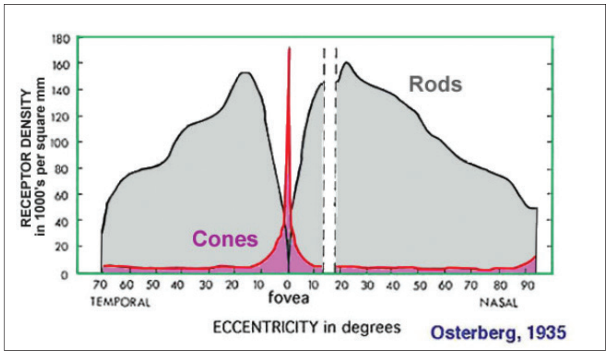


FIG. 5 The fovea is located in the macula in the central retina, the area that produces the highest resolution vision, including color vision. The fovea is devoid of rod receptors but densely packed with color-sensitive cones. (100,000 cones with a visual angle ~15 degrees and devoid of rod photoreceptor cells.)

Photopic daylight vision for color vision: There are two types of photoreceptor cells called rods and cones with one rod and three classes of cone cells. Under photopic conditions such as daylight, illumination levels, our trichromatic (long, medium and short-wavelength) cone photoreceptor cells, commonly referred to as RGB (red, green, blue), are active (Fig. 4). The red cones (peak sensitivity ~610 nm) are most sensitive to long wavelengths, green cones (peak sensitivity ~550 nm) are the most sensitive to medium wavelengths, and blue cones (peak sensitivity ~450 nm) are the most sensitive to short wavelengths of visible light. Rods are most active in the dark, but they do not produce color signals, only black white and shades of grey. We use our cone photoreceptors for daytime photopic vision and sharp central vision.

When light under photopic conditions reflects off an object in our environment and reaches our retina, it will excite all three types of cone photoreceptors to different extents. A red apple will excite the L (red) cones the most, M (green) cones to a lesser extent and S (blue cones) to an even lesser degree. Color perception is the collective response of the three absorption spectra of the S, M and L cones combined with the neuronal interactions between the retina and the rest of the brain. We see with our brain, and the retina is an extension of our brain.

Vision depends on the level of illumination. In high illumination levels, our cone photoreceptor cells are active, and we can see full color. This is referred to as photopic vision. In dark conditions, we use scotopic vision, and the rod photoreceptor cells are active. Rod photoreceptor cells don't produce color signals. We use Mesopic vision (both rods and cones) during twilight and in low light conditions where there is enough light present to activate cones, but illumination is also low enough to enable some rods. In this course, we address color vision, and so we will be discussing photopic vision.

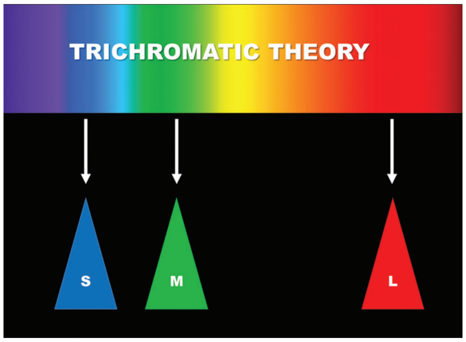


FIG. 6 Trichromatic theory—peak cone sensitivity of S, M and L Wavelengths

Color brightness: How bright color appears to the human eye can be described by the **luminosity function**. Luminosity function describes how sensitive the human eye is to different wavelengths of light. In photopic conditions, the L cones are most sensitive to red at ~610 nm, the M cones to green at ~550 and S-cones to blue at ~450 nm.

There are two theories that describe the role of the retinal photoreceptor cells and their neurons in producing electrochemical light signals that the brain translates into color vision. Both theories are needed to explain our human color vision. The trichromatic theory (Fig. 6) explains the role of the photoreceptors, and the opponent theory explains the additional neural retina processing that occurs based on how the photoreceptor color cells are interconnected (Fig. 7).

The trichromatic theory comes from color matching and color mixing studies carried out by Young and Helmholtz. They conducted experiments with individuals where the relative intensity of one, two or three light sources of different wavelengths was adjusted so that the resulting mixture field matched an adjacent test field composed of a single wavelength. Individuals with normal color vision needed three different wavelengths (i.e., primaries) to match any other wavelength in the visible spectrum. This finding led to the hypothesis that normal color vision relies on the activity of three types of receptors, each with a different peak sensitivity. Consistent with the trichromatic theory, we now know that the aggregate balance of activity in S (short-wavelength), M (medium wavelength) and L (long wavelength) cones that determine our perception of color as shown in Fig. 6.

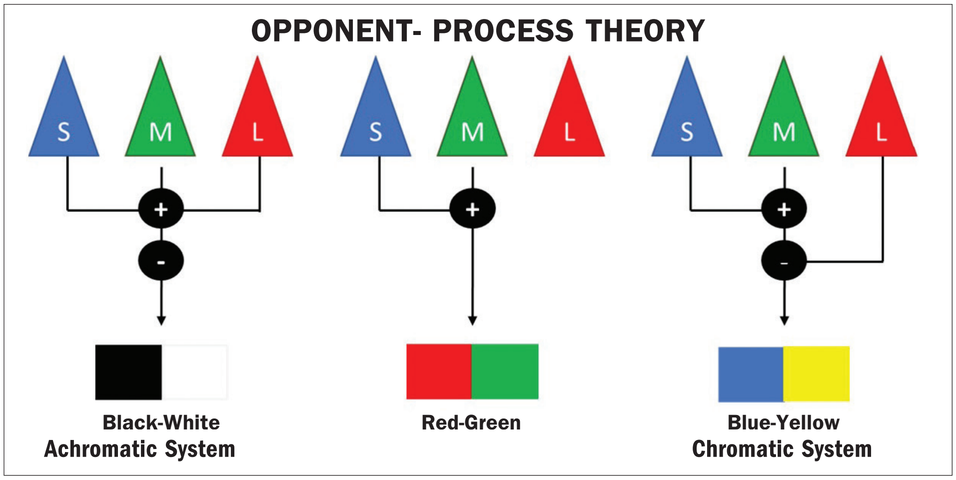


FIG. 7 Opponent process theory

The opponent-process theory was developed by Ewald Hering (1920/1964). The theory is that S, M and L cones photoreceptors have neural connections that come together to form three opposing color pairs: blue/yellow, red/green and black/white (Fig. 7). Activation of one of the pair inhibits activity in the other. Interestingly, the two colors of each pair cannot be seen at the same location, meaning that we don't see "bluish yellow" or "reddish green." This theory also helps explain some types of color vision deficiency. For example, people with dichromatic deficiencies can match a test field using only two primaries. Depending on the deficiency, they will confuse either red and green, or blue and yellow.

The opponent-process theory explains how we see yellow though there is no yellow cone receptor. It results from the excitatory and inhibitory connections between the three cone types. Specifically, the simultaneous stimulation of red (L cones) and green (M cones) and blue (S cones) is summed, and if blue signal dominates, then its opponent yellow is inhibited. If on the other hand, the blue signal is weaker than yellow, then the blue signal is inhibited, and we perceive yellow. White light is comprised of three color cone signals in equal amounts.

The optic nerve carries signals from the retina to the brain (Fig. 8) where the signals

from the right hemisphere of each eye cross over to the right, while the signals from the left hemisphere of each eye cross over to the left (at the optic chasm) and are ultimately delivered to the occipital lobe, the visual processing center of the brain and the location of the visual cortex. The actual color we perceive is the net result of complex visual processing calculations comparing the responses between the different receptors from each visual field (right and left for each eye).

Tuning wavelengths in color-enhancing lenses: The properties of color perceived by the human visual system are hue, saturation and brightness. Spectral colors can be correlated with wavelength, but the same color can be the result of a combined response from multiple wavelengths. The three-cone photoreceptors S, M and L receptors, each contain unique photopigment opsins. Excitation of the receptor occurs in response to varying levels of illumination thresholds across a range of wavelength frequencies. It is the combined responses of the three cone color receptor cells that determine its tristimulus value. The tristimulus value is a wavelength versus intensity contour plot that identifies the eye's overall color sensitivity. The range of discernable colors is defined by the response of the three types of cone photoreceptors. Interestingly, despite only having three color receptors, some theorized that our eyes see over 10 million different colors. Captivate lens technology employs notch or band filters to eliminate color confusion for a distinct separation of signals received by the brain. Eliminating color confusion allows the brain to process a more precise signal for clearer color perception and enhanced contrast. Captivate uses a spectral control filter to improve chromatic contrast and enhance the visual perception of color. Unlike other color-enhanced sunglasses that are tailored for specific activities at different illumination levels, such as boating, golf and tennis, Captivate provides overall enhancement of color in all color/mirror combinations to improve color vision regardless of the activity.

ELIMINATING COLOR CONFUSION ALLOWS THE BRAIN TO PROCESS A MORE PRECISE SIGNAL FOR CLEARER COLOR PERCEPTION AND ENHANCED CONTRAST. CAPTIVATE USES A SPECTRAL CONTROL FILTER TO IMPROVE CHROMATIC CONTRAST AND ENHANCE THE VISUAL PERCEPTION OF COLOR.

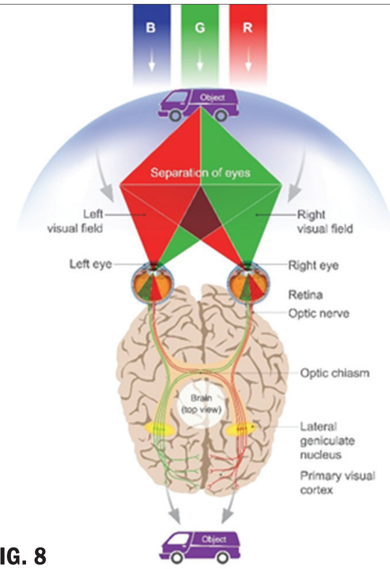


FIG. 8

How does reducing specific blue wavelengths enhance color vision? Our eyes generally have difficulty with blue light, both for myopic focusing of blue light inside the eye and from its increased tendency to scatter in the environment and inside the eye. Both the defocus and the resulting haze reduce color and contrast sensitivity. Captivate color enhancement lenses block HEV blue light from 400 to 430 nm and attenuate 500 and 580 nm wavelengths to maximize the contrast between blue/green and green/red color boundaries. An aspect of blue light to consider is that wavelengths of high-energy visible light or HEV light, are known to be absorbed by the macular pigment in the retina and the outer segments of the photoreceptor cells making these essential cells vulnerable to damage that has been proposed to increase the risk of age-related macular degeneration. Beneficial blue wavelengths of light around 460 to 485 nm influence our daily circadian rhythms and therefore, should be allowed to reach the eye because its absence is associated with seasonal affective disorder and other chemical imbalances in the brain that affect mood, glucose intolerance and sleep/wake cycle. Disruption is linked to sleep disorders, obesity, diabetes, cardiovascular problems and mental health conditions such as depression and bipolar disorder.

IN SUMMARY

Wiley X states that its mission is to provide superior impact protection and optical clarity in their eyewear and sunglasses. They now add to the benefits of their polarized lenses with Captivate technology that helps us maintain a healthy circadian rhythm with the transmission of beneficial blue light while attenuating potentially harmful blue light rays. Furthermore, Captivate technology filters specific blue and yellow wavelengths that interfere with our clear vision and color definition. An essential benefit of blocking HEV blue wavelengths is retinal protection from HEV induced photochemical damage. Irreversible retinal damage occurs when the retina experiences excess exposure to sunlight, aka solar HEV blue light. An excess of HEV blue light overwhelms the eye's natural defense mechanism and ability to protect the retina from this high-energy light. Recommend color-enhancing polarized lenses to your customers and enjoy their enthusiastic response when they experience the world through color enhanced high-definition Captivate polarized lenses! ■

To earn ABO credit, please review the questions and take the test. As of January 2020, no tests will be graded manually. Please call (800) 825-4696 for more information.