



Article

Need an Emotional Recharge? Want to Feel Refreshed?

How tinted lenses affect us

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People are fascinated by colors – whether in art, nature, fashion or, of course, the sciences. While there's no doubt that colors can elicit certain emotions and associations, where exactly is the line between our gut feeling and actual science? There have already been studies¹ on this subject. Now, ZEISS Sunlens² has commissioned two more for four specific colors. They confirm that tinted lenses have a demonstrable effect on our physiology and psychology, i.e. on our body and mind.

Working together with the ZEISS Vision Science Lab in Tübingen, ZEISS Sunlens has developed a new portfolio called ZEISS BioChrom³ featuring four special colors for tinted lenses⁴. These lenses not only offer UV protection but also positively impact our mood, performance and sense of well-being. This is important because market research from ZEISS has shown that consumers increasingly ask for products that complement a healthy lifestyle, resonate emotionally and increase performance.

Traditionally, a lot of colors have been associated with a specific function – even if these vary from one culture to the next. Whoever intends to avoid making too much of a fashion statement with their sunglasses and wants realistic color perception opts for brown or gray lenses. These are the two tints usually recommended at an eye care professional's (ECP) office. Pilots, meanwhile, seem to always go for green lenses. The emperor Nero supposedly watched gladiator fights while looking through a transparent green stone since it was purportedly better for your eyes. A green found in nature, such as that of a forest in springtime, was said to have restorative qualities. In the first half of the 19th century, green and blue lenses were worn in the parlor – the wearers thought these would make them feel refreshed. Gamers who spend hours

¹ ZEISS Vision Care (2019). ZEISS BioChrom White Paper

² Headquartered in Varese, Italy, ZEISS Sunlens is responsible for developing and producing (non-prescription) sunglass lenses together with customers and partners, such as major brands (including POC, Nike and Victoria Beckham). Unlike prescription lenses, which are tinted during or after manufacture, large numbers of sunglass lenses are already being made in Italy from tinted plastic for the particular customer.

³ ZEISS BioChrom is only available for non-prescription sunglass lenses. ZEISS BioChrom is a new dimension for tinted eyeglass lenses. Their features go beyond the traditional features of sunglass lenses like glare or UV protection.

⁴ For consumers, the ZEISS BioChrom lenses are only available if a sunglass manufacturer uses them in production.



playing online opt for lenses with a yellow tint. These lenses supposedly increase concentration while also protecting against potentially damaging blue light. And what about someone who wears rose-colored glasses: is this person really more optimistic? Could there be something to all this? One thing is certain: just how colors affect us varies enormously from person to person and depends on the particular situation. But the fact of the matter is that studies have confirmed real effects.

Color – More than just a visual process

When talking about the science of color perception, then it's important to understand how color signals are processed. One especially crucial factor for color perception is the fact that color signals are processed in the brain as part of a network-like structure – and not just in the visual cortex, but also other regions, including those primarily responsible for memories and emotions. This explains why colors are far more than just visual information and evoke emotional and physiological reactions. But which color elicits a particular response?

To get to the bottom of this question, ZEISS first performed an in-depth review of existing research studies and then commissioned two more: one at the ZEISS Vision Science Lab in Tübingen, Germany, and one at the Behavior and BrainLab of IULM University in Milan, Italy. Various measuring methods (EEG, pupillometry, eye tracking, skin conductance and heart rate measurements) were used to investigate what specific neurological, physiological and psychological effects the four ZEISS BioChrom lens tints can have on us.

A refreshing blue

A lot of us have heard that blue (i.e. shortwave) light impacts our sleep/wake cycle.⁵ Blue has an activating effect. It makes us think of refreshing water or a clear blue sky. And there's scientific evidence to back this up. A previous study showed that test subjects were better able to concentrate at night when exposed to blue light (as compared to white or red light).⁶ They also felt less tired. During the ZEISS study in Milan, researchers found that test subjects with ZEISS BioChrom blue-tinted lenses became physiologically active more quickly when transitioning out of a quiet phase, and that their ability to concentrate improved. This was determined based on measured reaction times, which were significantly better than with test subjects who did not wear ZEISS BioChrom blue-tinted lenses. That's why ZEISS BioChrom blue stands for "Refresh."

⁵ Brainard, G. C., Hanifin, J. P., Greeson, J. M., Byrne, B., Glickman, G., Gerner, E., & Rollag, M. D. (2001). Action spectrum for melatonin regulation in humans: evidence for a novel circadian photoreceptor. *Journal of Neuroscience*, 21(16), 6405-6412. // Cajochen, C., Munch, M., Kobińska, S., Krauchi, K., Steiner, R., Oelhafen, P., ... & Wirz-Justice, A. (2005). High sensitivity of human melatonin, alertness, thermoregulation, and heart rate to short wavelength light. *The journal of clinical endocrinology & metabolism*, 90(3), 1311-1316. // Vandewalle, G., Schmidt, C., Albouy, G., Sterpenich, V., Darsaud, A., Rauchs, G., ... & Maquet, P. (2007). Brain responses to violet, blue, and green monochromatic light exposures in humans: prominent role of blue light and the brainstem. *PLoS one*, 2(11), e1247.

⁶ Lockley, S. W., Evans, E. E., Scheer, F. A., Brainard, G. C., Czeisler, C. A., & Aeschbach, D. (2006). Short-wavelength sensitivity for the direct effects of light on alertness, vigilance, and the waking electroencephalogram in humans. *Sleep*, 29(2), 161-168.



A calming green

Various studies have shown that green is perceived as calming and relaxing.⁷ One recent trend is called "forest bathing": people immerse themselves in the gentle green of the trees in order to take a rejuvenating break from the stresses of daily life. Creativity is also associated with green. One study showed that those test subjects exposed to green prior to a creative task performed better on a creativity test than the control group.⁸ Since the participants weren't aware what the goal of the study was, it was possible to show that green affects creative performance unconsciously. Using EEG measurements, other studies have demonstrated that migraine patients handle green light best, perceiving it as the least painful. For 20 percent of the test subjects, green light even reduced pain intensity.⁹ All in all, green has been scientifically proven to have a calming, generally positive effect on the body and mind. The green ZEISS BioChrom lenses can also achieve these types of effects and thus stands for "Relax."

Yellow for greater concentration

The warm, bright color yellow is associated with concentration, attentiveness and joy.¹⁰ While not alarming like red, it does cause people to focus. Yellow light increases our contrast sensitivity¹¹ and can lead to improved reaction times.¹² Studies have documented how yellow helps test subjects stay focused: particularly under challenging conditions (deafness or a reading disability), a yellow filter placed over the text can increase reading speed and reading ability.¹³ The ZEISS study in Milan also demonstrated that ZEISS BioChrom yellow-tinted eyeglass lenses have a positive effect on a person's attention level and ability to concentrate as compared to the control group. This was measured using different tools, including an EEG and eye tracking, in a driving simulation test. The study participants had to identify potential dangers. The results support the theory that ZEISS BioChrom yellow-tinted lenses assist us with staying focused while completing

⁷ Norman, R. D., & Scott, W. A. (1952). Color and affect: a review and semantic evaluation. *The Journal of General Psychology*, 46(2), 185-223. // Nakshian, J. S. (1964). The effects of red and green surroundings on behavior. *The Journal of General Psychology*, 70(1), 143-161.

⁸ Lichtenfeld, S., Elliot, A. J., Maier, M. A., & Pekrun, R. (2012). Fertile green: Green facilitates creative performance. *Personality and Social Psychology Bulletin*, 38(6), 784-797.

⁹ Nosedá, R., Bernstein, C. A., Nir, R. R., Lee, A. J., Fulton, A. B., Bertisch, S. M., ... & Doran, B. L. (2016). Migraine photophobia originating in cone-driven retinal pathways. *Brain*, 139(7), 1971-1986.

¹⁰ Kohmura, Y., Murakami, S., & Aoki, K. (2013). Effect of yellow-tinted lenses on visual attributes related to sports activities. *Journal of human kinetics*, 36(1), 27-36.

¹¹ Wolffsohn et.al. (2000). Contrast is enhanced by yellow lenses because of selective reduction of short-wavelength light. *Optom Vis Sci*, 77 (2), 73-81

¹² Lacherez, P., Saeri, A. K., Wood, J. M., Atchison, D. A., & Horswill, M. S. (2013). A yellow filter improves response times to low-contrast targets and traffic hazards. *Optometry and vision science*, 90(3), 242-248.

¹³ Study applies only for deaf children: Hollingsworth, R. S., Ludlow, A. K., Wilkins, A. J., Calver, R. I., & Allen, P. M. (2015). Visual performance and the use of colored filters in children who are deaf. *Optometry and Vision Science*, 92(6), 690-699. / Study applies for kids with dyslexia: Ray NJ, Fowler S, Stein JF. Yellow filters can improve magnocellular function: motion sensitivity, convergence, accommodation, and reading. *Ann N Y Acad Sci*. 2005 Apr;1039:283-93.] Ray NJ, Fowler S, Stein JF. Yellow filters can improve magnocellular function: motion sensitivity, convergence, accommodation, and reading. *Ann N Y Acad Sci*. 2005 Apr;1039:283-93.



a task. The feeling that this color helps improve our ability to concentrate has been scientifically verified. That's why ZEISS BioChrom Yellow stands for "Focus."

Emotionally charged red

Red is the color of love but also of rage. No matter the context, it's the color of strong emotions. The matador in the ring waves a red muleta not because of the bull, which cannot see the color red, but to excite the audience. Physiological tests have shown that the color red causes the strongest emotional activation, followed by green, yellow and blue.¹⁴ There is also a correlation between wearing red jerseys in competitive sports and a higher chance of winning.¹⁵ Thanks to the ZEISS study conducted in Tübingen, it was possible to prove that red has an activating effect on test subjects exposed to emotional stimuli. Moreover, the EEG measurements showed that the brain activities increased in one region in particular, which indicates neural emotion processing and the activation of motivational systems in the brain. Compared with all three other colors, red's impact proved the strongest.¹⁶ So which color is best-suited to a challenging situation that demands considerable motivation and action? Red, of course! That's why ZEISS BioChrom Red stands for "Boost."

Always the right option for you

Anyone looking on the Internet for information on tinted lenses to achieve certain outcomes is flooded with various offers. So what makes ZEISS eyeglass lenses so special? These tinted lenses were developed in close cooperation with the ZEISS Vision Science Lab in Tübingen and the Product Management area at ZEISS Sunlens. First, the scientific approach taken to explore this topic, especially the two studies conducted for the tints on offer, is a true first. Moreover, the wavelength range for the four colors is specially defined based on existing studies. Finally, ZEISS BioChrom lenses also offer UV protection – even though, depending on the wearer, the lenses are not always be worn outside. Moreover, as is the case with all ZEISS products, the lenses are subject to extensive quality testing.

When, how long and at what tint intensity the ZEISS BioChrom lenses should be worn is up to the particular wearer.¹⁷ The effect ultimately depends on a wide range of situational and personal factors. ZEISS has provided scientific evidence that there is significant impact on a person's body and mind. Every wearer has to find out on their own which color works for them and how it helps them achieve their personal goals. These lenses were first presented to a large audience at this year's MIDO, an eyewear show in Milan, and the feedback was extremely positive. So it looks like that these lenses will be used in lots of exciting ways in the future.

¹⁴ Jacobs, K.W. (1972). The effect of the four psychological primary colors on GSR, heartrate, and respiration rate. Master's Thesis 3911. Eastern Illinois University: Illinois, USA.

¹⁵ Hill, R. A., & Barton, R. A. (2005). Psychology: red enhances human performance in contests. *Nature*, 435(7040), 293.

¹⁶ Schilling, T., Sipatchin, A., Chuang, L., Wahl, S. (2019). Looking Through "Rose-Tinted" Glasses: The Influence of Tint on Visual Affective Processing. *Frontiers in Human Neuroscience*, 13(187).

¹⁷ Please note: only the lowest tint intensity level is suitable for driving.



Additional Information Color Perception

When light hits our eyes, then various photoreceptors in the retina get to work, emitting specific signals based on the wavelength and intensity of the light. These signals are directed along the visual path to the brain, where they are processed. This sounds straightforward, but the processing and impact of colors is far more intricate. Colors are intertwined with our biological and physiological systems and have been shown to affect our biorhythm¹⁸ as well as our mood.¹⁹ Color signals aren't just processed in the region of the brain responsible for visual information but also where emotions play a role, to take just one example.

Different light wavelengths are perceived as colors, starting with violet (the shortest wavelength) and extending to blue, green, yellow, orange and red. The photoreceptors in the retina are divided into rods (responsible for brightness and contrast) and cones (responsible for color perception). There are three types of cones that are sensitive to red, blue or yellow. All other colors and color nuances are combined cognitively from these three colors to create color composites. This process is shaped in part by how we are socialized. We learn to name the color categories within our cultural milieu, and hence our cultural background also determines how we understand colors and what we associate with them.

Additional Information Study Design

ZEISS Vision Science Lab at Eberhard Karls University in Tübingen: The test subjects (n = 31, 12 male / 19 female, average age: 25.9) were asked to look at 96 images from the "International Affective Picture System" for six seconds each, once with and once without ZEISS BioChrom lenses (with maximum intensity for all four tints). These images are used frequently in research to test emotions and concentration. There are positive (e.g. puppies), neutral (e.g. an everyday object like a pot) and negative images (e.g. a weapon). While looking at the images, the test subjects' brain activity (in selected regions of the brain) was measured with an EEG. In addition, heart rate and galvanic skin response were also measured to identify emotional activation.

"Behavior and BrainLab," Research Center for Neuromarketing and Consumer Behavior at IULM University in Milan, Italy: In Milan, the four ZEISS BioChrom tints and their impact on the study participants (n = 64 / 32 male / 32 female, age range between 30 – 50) were tested using different methods. The participants were divided into a test and a control group (with and without ZEISS BioChrom lenses with medium tint intensity) and then performed tests selected specifically for the particular tints. This way, it was possible to measure the physiological, neurological and physiological effects of each color separately. The neurophysiological effects were determined by using eye tracking, pupillometry, galvanic skin response measurements and EEG.

¹⁸ Berson, D. M., Dunn, F. A., & Takao, M. (2002). Phototransduction by retinal ganglion cells that set the circadian clock. *Science*, 295(5557), 1070-1073.

¹⁹ Suttle, C. M., Lawrenson, J. G., & Conway, M. L. (2018). Efficacy of colored overlays and lenses for treating reading difficulty: an overview of systematic reviews. *Clinical and Experimental Optometry*, 101(4), 514-520.



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For its customers, ZEISS develops, produces and distributes highly innovative solutions for industrial metrology and quality assurance, microscopy solutions for the life sciences and materials research, and medical technology solutions for diagnostics and treatment in ophthalmology and microsurgery. The name ZEISS is also synonymous with the world's leading lithography optics, which are used by the chip industry to manufacture semiconductor components. There is global demand for trendsetting ZEISS brand products such as eyeglass lenses, camera lenses and binoculars.

With a portfolio aligned with future growth areas like digitalization, healthcare and Smart Production and a strong brand, ZEISS is shaping the future far beyond the optics and optoelectronics industries. The company's significant, sustainable investments in research and development lay the foundation for the success and continued expansion of ZEISS' technology and market leadership.

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