10 facts about: How damaging is blue light to the eyes?

First, there are two types of blue light: the natural blue light of the sun and the artificial blue light emitted by LED lamps, energy-saving lights as well as smartphone and computer displays. There is an ongoing scientific discussion as whether, and how, blue light causes damage to the eyes. In this short article, we'll tell you what you need to know about blue light, the necessity for our normal vision, any potential eye damage, and even the positive effects of blue light.

1. What is blue light?

Some portion of the electromagnetic (EM) spectrum is generating signals and perception in the human visual system. This part is called “light”, the non-visible bands of the EM spectrum are often referred to as “radiation”, e.g. UV radiation or IR radiation. The visible spectrum encompasses the band of approx. 380 nm (blue - violet) to approx. 780 nm (red). The blue light is the part of the light spectrum with the shortest wavelengths between 380 nm and 500 nm. The blue light is adjacent, and partly overlapping with the UV radiation spectrum, that is characterized by even shorter wavelength (100 nm – 400 nm).

2. Do we need blue light for normal vision?

Blue light is of paramount importance for a normal and rich color vision and high contrast vision. The human retina consists of three color receptors for the colors blue, red and green, and only the full functionality of all three cone-type receptors ensures normal color vision. Another kind of photoreceptors in the eye are allowing for vision at low light conditions in dark environments. These rod-type receptors are dominantly sensitive also in the blue and blue-green spectrum. Since the rod-type receptors are also dominant in the retinal periphery they therefore allow for peripheral vision and motion perception.

3. Can blue light cause damage to the eyes?

Research in life-science disciplines has created an undisputable body of evidence of health hazards and biological cell damage from UV exposure. This is true for skin and also for ocular tissues. Wavelength of EM radiation is connected to its photon energy by physical laws. The shorter the wavelength the higher the inherent energy. The photon energy is the culprit of possible damage to cells and molecules. Since the blue light is next to the UV spectrum, and the blue light holds the highest photon energy of all visible light spectrum, a legitimate question addresses the potential of cells being damaged from blue light exposure. In contrast to UV-related research – for blue light there is still substantial research ongoing, and conclusive evidence to be delivered.

While scientific studies show that blue light can trigger metabolic processes that can, through photo-oxidative stress to cells, lead to long-term degradation of cell integrity and eventually support premature cell death. However – the observed damage cues for the ocular, namely the retinal structures are multiparametric hazards. And because the consequences are of long-term time scale / decades than years – a proper discrimination of the causality is hard to show.

4. At what dose does blue light begin causing damage to the eye?

The relatively high levels of energy inherent in the comparatively short wavelengths of blue light have been shown to impact metabolic processes in retinal cells. It is entirely plausible that excessive exposure to blue light can cause damage to the retina. However, scientists are currently unable to say what dose and what light sources have significant damage-causing potential. So far available scientific results only imply that artificial blue light from typical architectural LED lighting, or displays is far below any known thresholds to create health damages in human ocular system

However, patient complaints on reduced visual comfort and asthenopic symptoms such as headaches or burning eyes are common and well-known issues for eye care professionals.

5. Why is there more blue light today?

The digitalization trend and modern artificial light sources are increasing our eyes' exposure to artificial or digital blue light. The COVID19 pandemic accelerated this trend, changing the way we work, learn and socialize.

6. What are the positive health effects of blue light?

The human retina can synchronize the local circadian rhythm to light - dark cycles. The so called photoentrainment seem to specifically benefit from existence (day) or absence (night) of blue light to impact the metabolic process of segregation of melatonin, also known as the sleep hormone. As long as blue light is detected on the retina the melatonin segregation is suppressed and the human stay rather alert and awake. Once the intensity of blue light is being reduced and dropping, the segregation is not suppressed anymore, and the "sleep hormone" is flushing through the body. Fatigue is an effect. Science has shown that a strong difference in suppression and release of it has a positive impact on sleep quality. The fatal effects of disturbed sleep quality had also been scientifically shown. So, our biological rhythm benefits from a blue-light rich day.

The long-wave portion of blue light, which runs up to 510 nanometers, is even considered to have a positive effect on mood, and special intensive blue light lamps are used to treat seasonal affective disorder (SAD) during the "darker" months of the year.

7. Can blue light cause digital eye strain (DES)?

Digital screens and indoor LED lighting emit a higher proportion of blue light than traditional incandescent or halogen-type light bulbs. In addition, we are often exposed to this blue light for long periods of time, often until late at night at short visual distances. This combination strains the eye muscles and can contribute to visual discomfort and asthenopic symptoms associated with digital eye strain.

The Vision Council's Digital Eye Strain Report, and other sources, show that more than two-thirds of adults in the US who regularly use digital devices experience various symptoms associated with Digital Eye Strain.[1]

[1] The Vision Council, 2016 Digital Eye Strain Report

8. Do tablet and smartphone displays cause sleep disturbances?

Excessively intensive blue light exposure during the evening and night can lead to sleep disturbances. Observations suggest a link between the existence of smartphones, tablets and mobile devices and their excessive utilization by children and teenagers with symptoms linked to sleep disorders. Studies have started to investigate the effect of so-called ALAN (artificial light at night) to sleep disorders and its consequences to the patients.

9. Does intensive use of digital devices pose health-related risks for the eyes?

This question is an ongoing subject of research as well. Due to the lack of definitive evidence, there is plenty of room for hypotheses and speculation in this regard. Most scientific studies which investigate the potentially hazardous effect of blue light radiation from digital displays to the human visual system, rely on animal or in vitro cell testing. The relevance of these results and its extrapolation to the human eye needs to be considered with caution and skepticism. Many of these studies also work with light intensities which are not found in daily life and /or normal use of such devices. None of these studies so far has been able to show an increased risk for the human eye from modern displays. The primary explanation proposed for this conclusion up to date is that displays have a significantly lower light intensity as compared to the sun.

10. Is it possible to protect yourself against blue light? Should you?

For wearers of eyeglasses, protecting yourself against blue light is an easy choice. ZEISS BlueGuard Lenses are the latest in blue light protection, providing comfortable vision and excellent clarity and aesthetics, while blocking up to 40% of potentially harmful and irritating blue light.[2] Using the latest organic-chemical technology, ZEISS BlueGuard Lenses are an “in-material” solution engineered to balance protection, clarity and aesthetics to mitigate the potential challenges of digital light sources.

[2] Inhouse measurements and calculations based on the BVB (Blue-Violet-Blocking) metric. Analyses by Technology and Innovation, Carl Zeiss Vision International GmbH, DE, 2020.