Adaptation

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Bright light stimuli cause bleaching of the photopigment of retinal light receptors, resulting in prolonged reduced visual performance; this only recovers slowly while the photopigment regenerates.

Absorption of photons converts the 11-cis retinal chromophore into the all-trans stereo isomer.

Rhodopsin (Rh) is converted into a photoactivated metarhodopsin II - all this is followed by a cascade of complex biochemical processes.

Before a bleached rhodopsin molecule can absorb further photons, the pigment must be regenerated - a difficult process in the vertebrate retinas:

Rh conversion into metarhodopsin III - all-trans chromophore then separates from opsin and is reduced to retinol etc.; via interphotoreceptor retinol binding protein (IRBP) all-trans retinol reaches the retinal pigment epithelium (RPE). This causes regeneration in several steps, so that IRBP can transport the 11-cis retinal back to the photoreceptor and finally, recombined with the opsin, completely dark-adapted - has now regenerated into a fully functional Rh.

This regeneration is extremely slow. After intensive light exposure, around 30 to 45 minutes pass until a state of complete dark adaptation is reached - one possible explanation for this is the extreme complexity of the "Retinoid Cycle and Whole-Body Retinoid Metabolism" (1, 2, 3).

The cone and rod adaptation time is far exceeded by that of the blue-sensitive Intrinsic Photosensitive Melanopsin Retinal Ganglion Cells (MRGC); their (4) dark adaptation takes several hours - this explains, among other things, disturbed biorhythms after chronodisruption.

Short-wave light has particularly bad effects when it comes to adaptation, biorhythms, road safety and – in the worst case: potential phototoxicity.

"Short-wavelength light, such as blue light, plays an essential role in light-induced retinal injury, so filtering out short-wavelength light may be an important strategy to prevent light injury-related retinal degenerative diseases" (5,6).

Both indoors and outdoors, our retinas are bombarded with extreme high-energy short-wave light intensities without the retina having a chance to recover from 'light stress' episodes.

Reference

1 Fain G.L. et al (1996) Dark adaptation in vertebrate photoreceptors, Trends in Neurosciences;19(11) 502-507,

2 McBee JK et al (2001) Confronting complexity: the interlink of phototransduction and retinoid metabolism in the vertebrate retina. Prog Retin Eye Res. ;20(4):469-529.

3 Kiser PD et al (2014) K. Chemistry of the retinoid (visual) cycle. Chem Rev. 8;114(1): 194-232.

4 Heilig P (2019) MRGC, eine retinale Schlüssel-Zelle. Conc Ophthalmologie 6/2019 https://ub.meduniwien.ac.at/blog/?p=33336

5 Fan B et al (2022) The Molecular Mechanism of Retina Light Injury Focusing on Damage from Short Wavelength Light. Oxid Med Cell Longev. ;2022:8482149.

6 Salceda R. (2024) Light Pollution and Oxidative Stress: Effects on Retina and Human Health. Antioxidants (Basel);13(3):362.

Gender: beyond Interest: no conflict