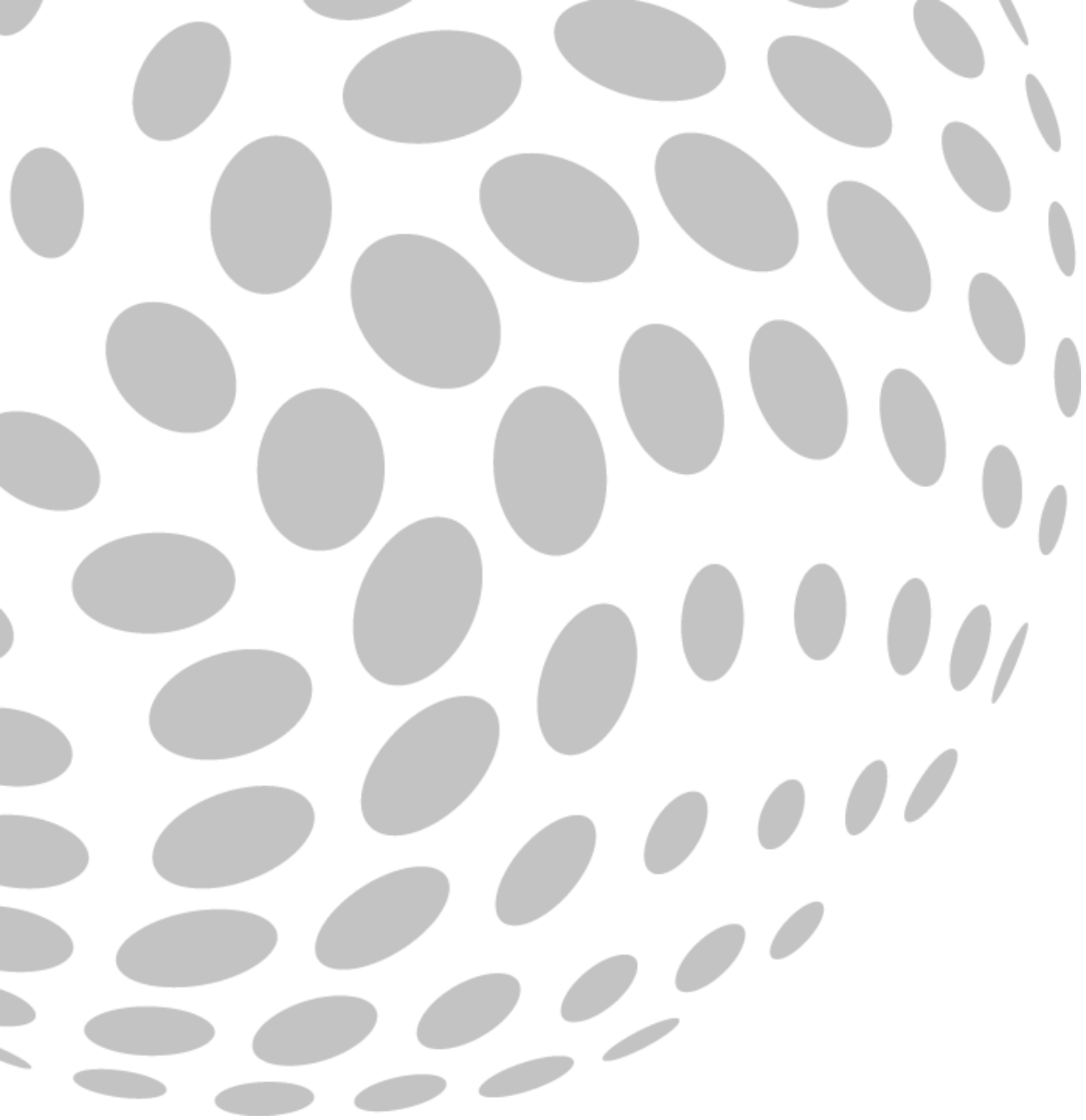




MELANOPIC EQUIVALENT DAYLIGHT ILLUMINANCE

Daniel Stabenau

MAY I INTRODUCE MYSELF?



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THE EYE

Sensitive ganglion cells

Diagram illustrating the structure of the human eye and the detailed view of the retina.

Eye Structure Labels: Iris, cornea, pupil, lens, retina, blood vessels, fovea.

Retina Detail Labels: inner membrane, melanopsin-containing photoreceptors, receptors for visual system, blue-sensitive cone, rod, red-sensitive cone, green-sensitive cone.

Light Path: LIGHT (indicated by a yellow arrow).

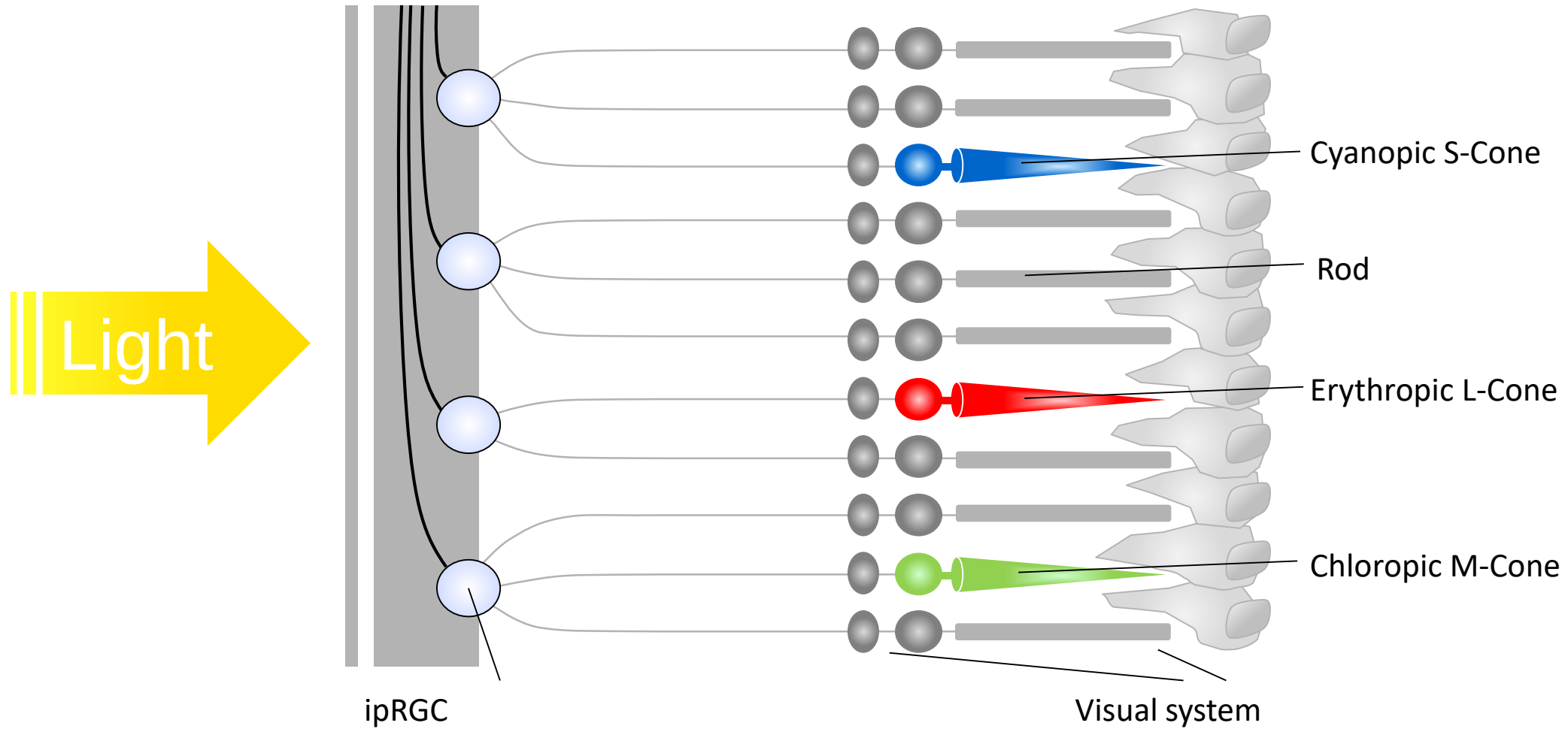
Photoreceptor Distribution:

- Photoreceptors for daytime vision are particularly concentrated in the fovea (the small depression at the centre of the retina responsible for sharpness of vision, Ø~1.5 mm). The area contains around 60,000 cones but no rods.
- Melanopsin-containing ganglion cells are distributed over the entire retina; the most sensitive are in the lower and nasal areas.

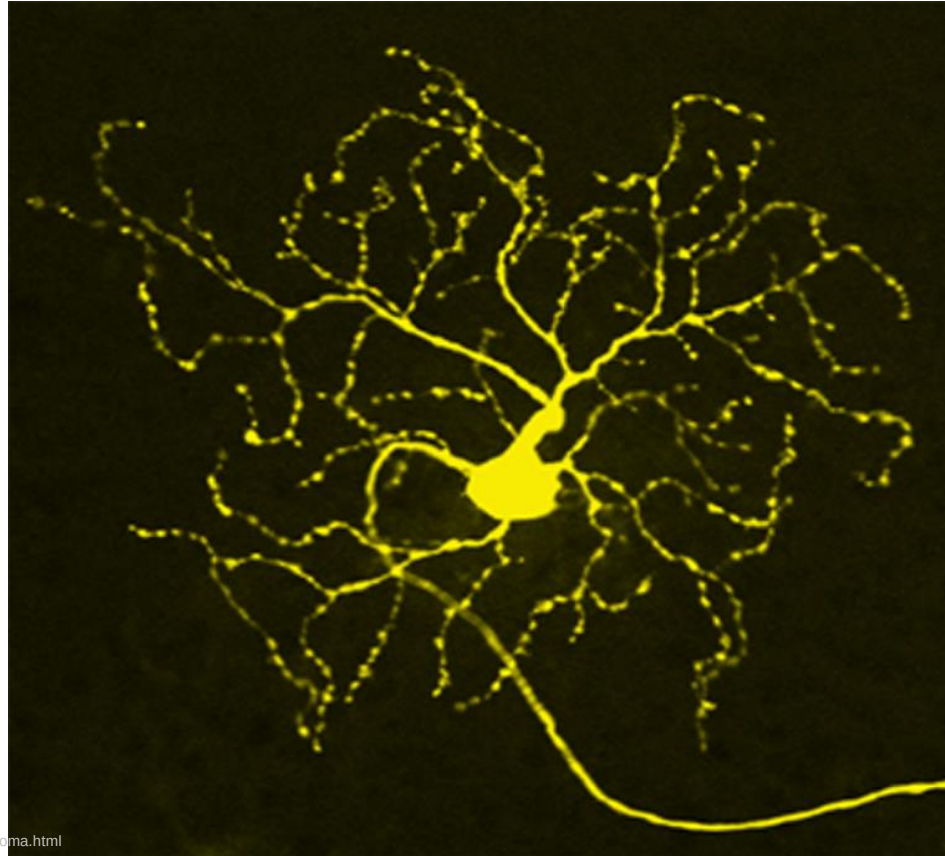
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- 120 million rods are highly sensitive for brightness vision
- 7 million cones are receptors more sensitive for colour vision

INTRINSICAL PHOTSENSITIVE RETINAL GANGLION CELL



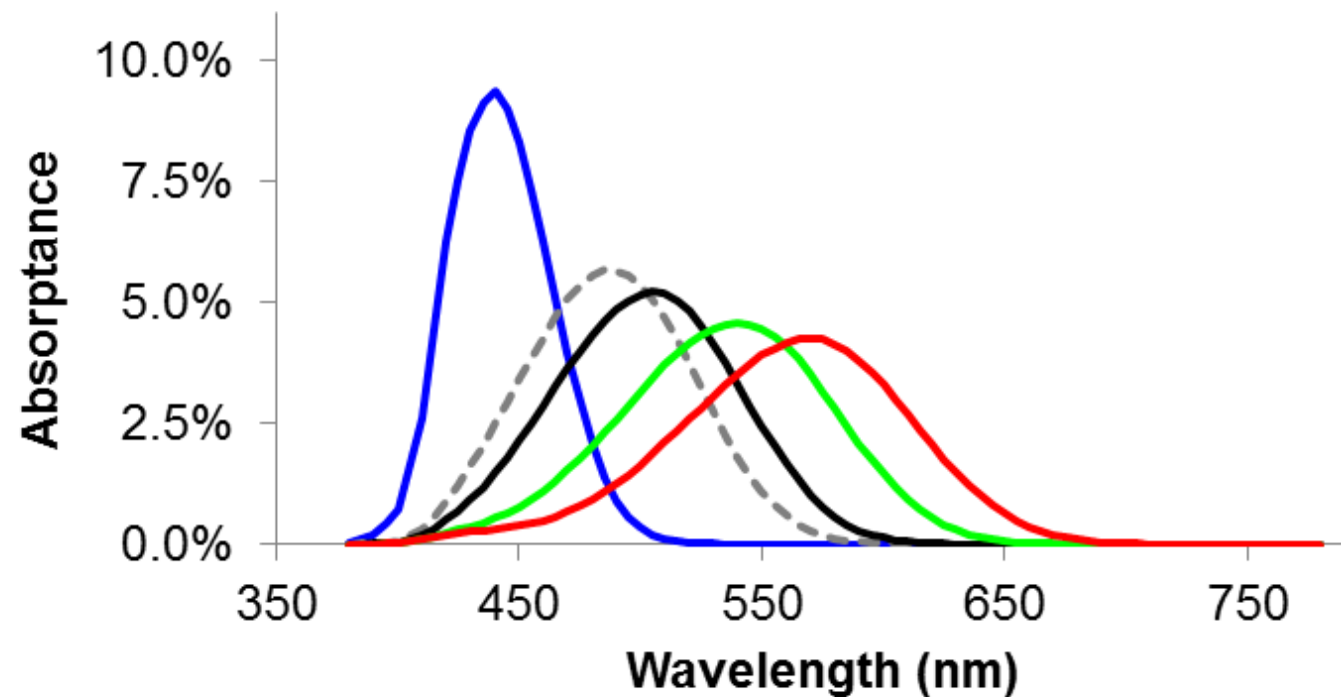
RETINAL GANGLION CELL



http://www.hopkinsmedicine.org/wilmer/glaucoma_center_excellence/book/chapter_what_is_glaucoma.html

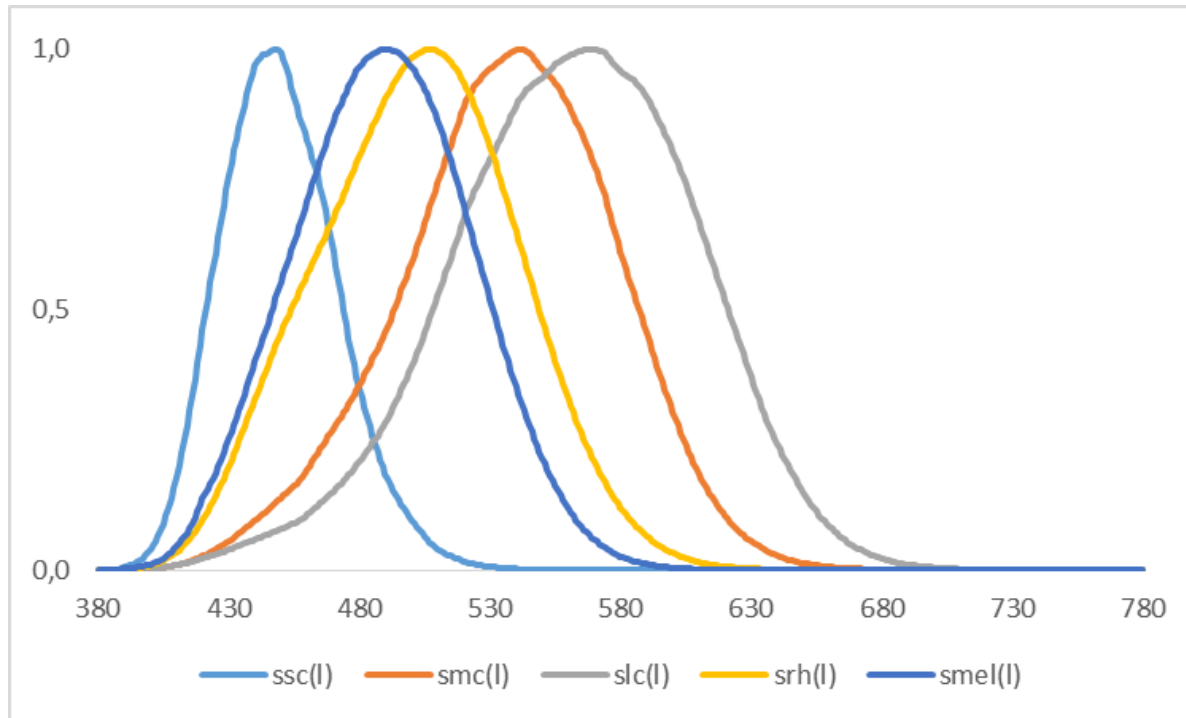
THE MELANOPIC APPROACH BY ROB LUCAS

MELANOPIC IRRADIANCE OR MELANOPIC LUX OR α -OPIC



Symbol	Prefix	Sensitivity	$\lambda_{\max}$	α in $N_{\alpha}(\lambda)$	Curve
E_{sc}	Cyanopic	S cone	419.0	sc	$N_{sc}(\lambda)$
E_z	Melanopic	Melanopsin	480.0	z	$N_z(\lambda)$
E_r	Rhodopic	Rod	496.3	r	$N_r(\lambda)$
E_{mc}	Chloropic	M cone	530.8	mc	$N_{mc}(\lambda)$
E_{lc}	Erythropic	L cone	558.4	lc	$N_{lc}(\lambda)$

CIE S 026/E:2018



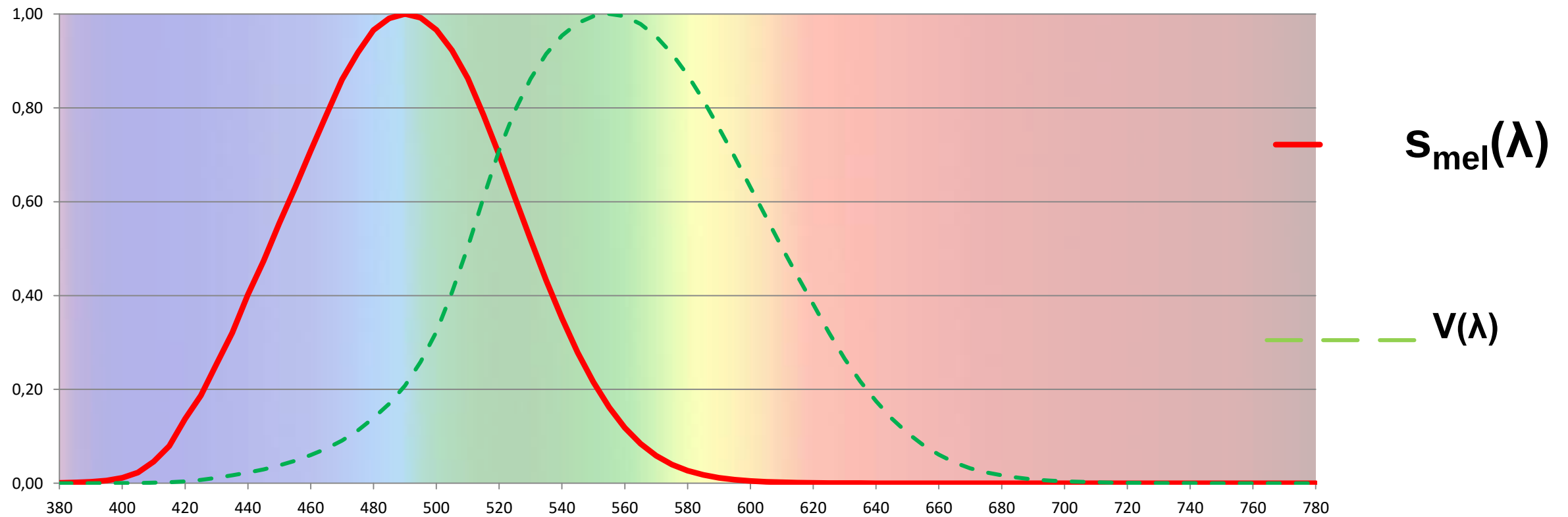
Five α -opic spectra

(based on Lucas et al. 2014)

$s_{sc}(\lambda)$	S-Cone
$s_{mc}(\lambda)$	M-Cone
$s_{lc}(\lambda)$	L-Cone
$s_{rh}(\lambda)$	Rhodopic
$s_{mel}(\lambda)$	Melanopic

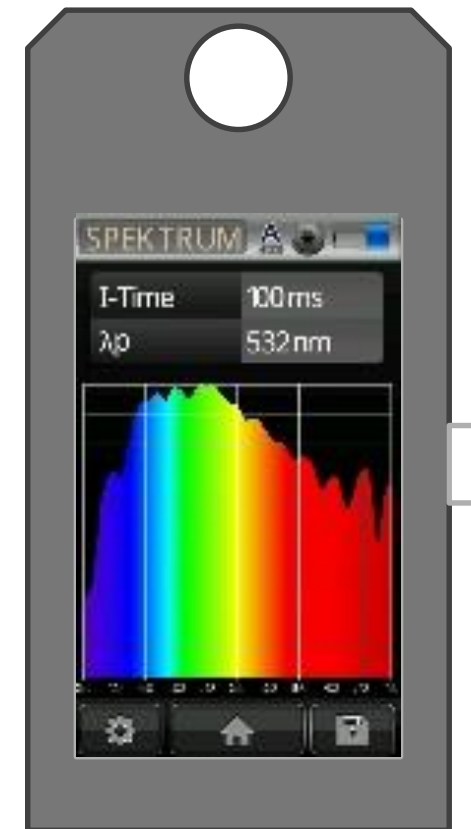
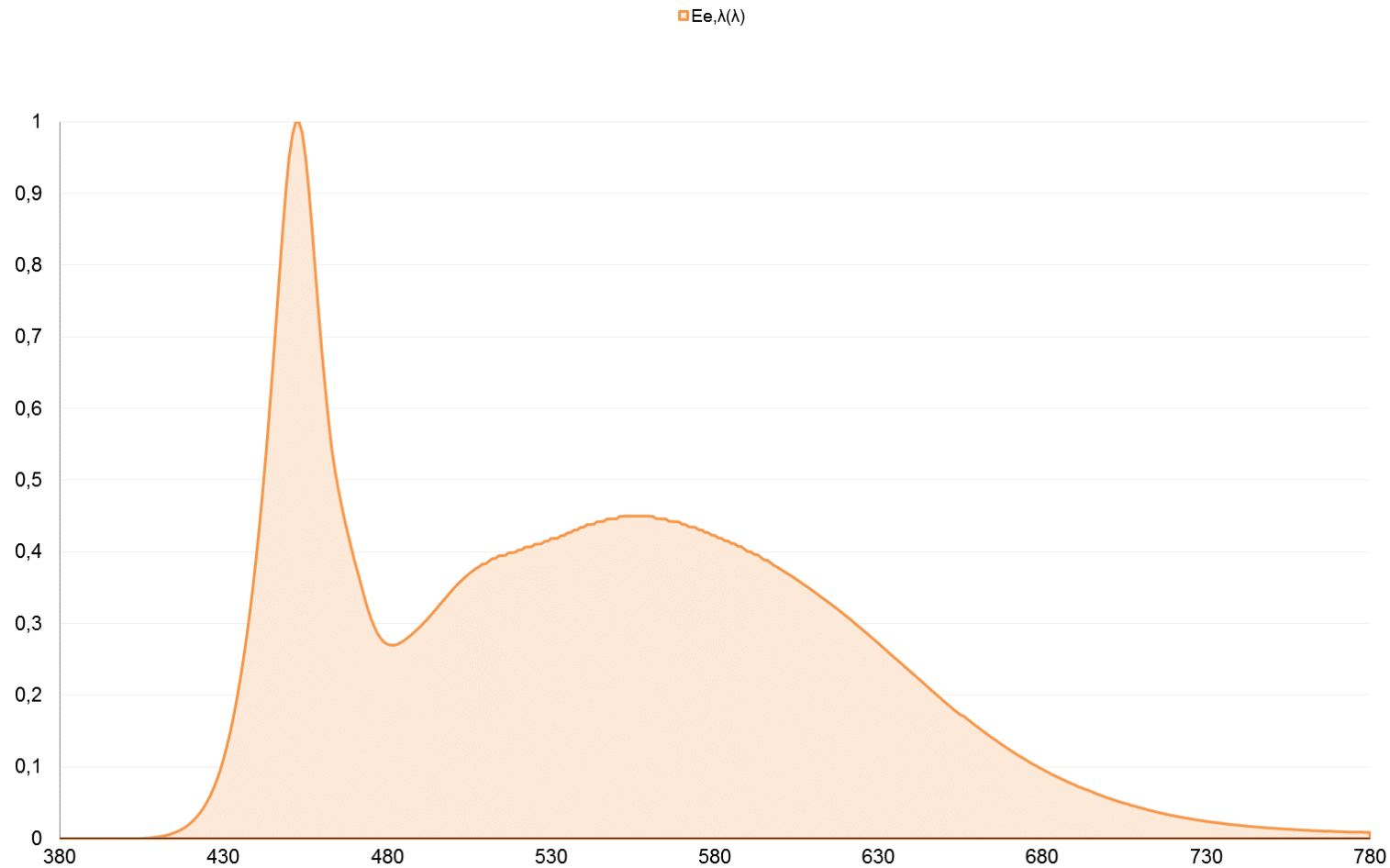
CIE S 026/E:2018

Definition of the **melanopic activity spectrum** $S_{mel}(\lambda)$

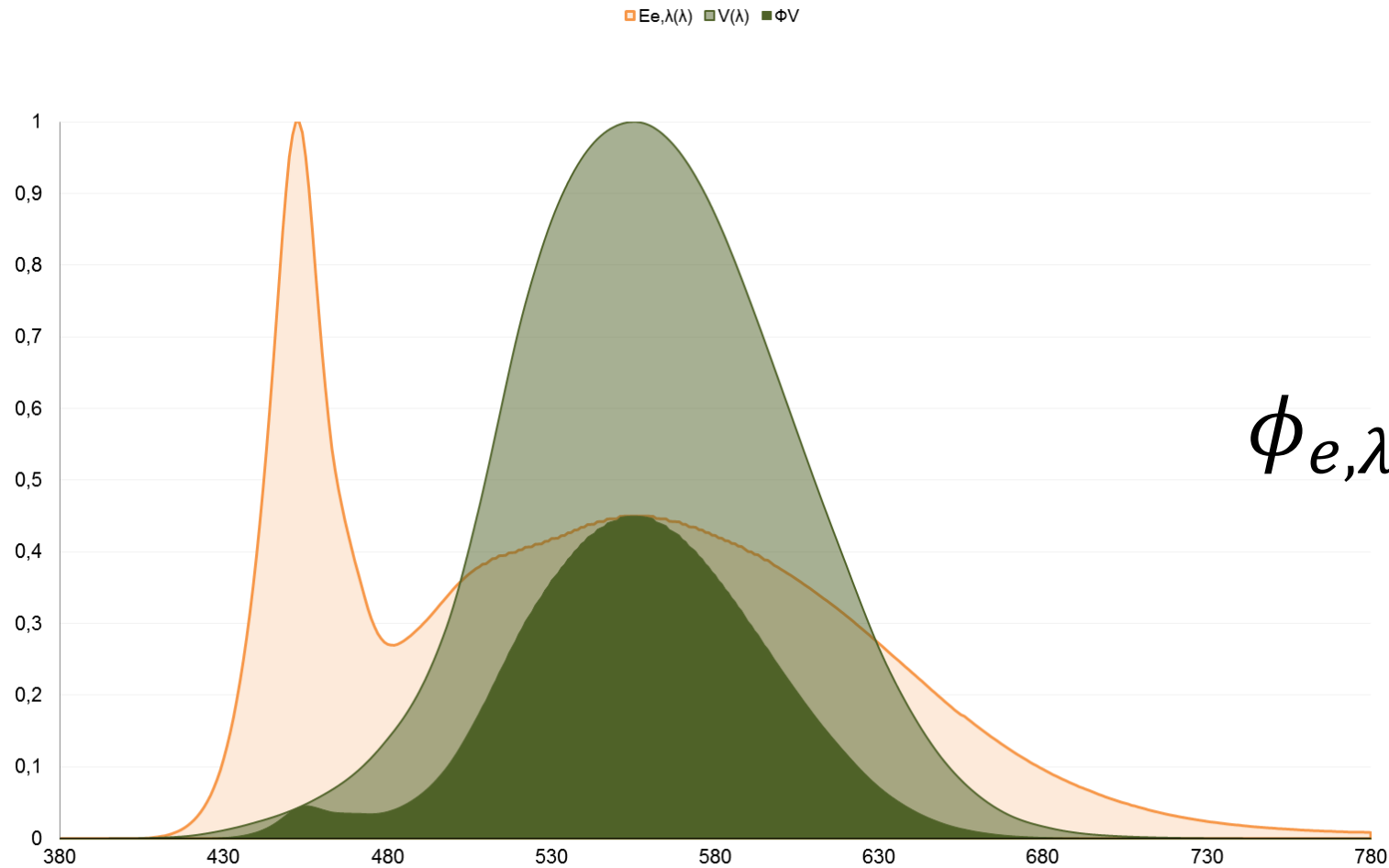


How to calculate the melanopic equivalent daylight illuminance?

1. KNOW THE SPECTRA OF YOUR LIGHT SOURCE

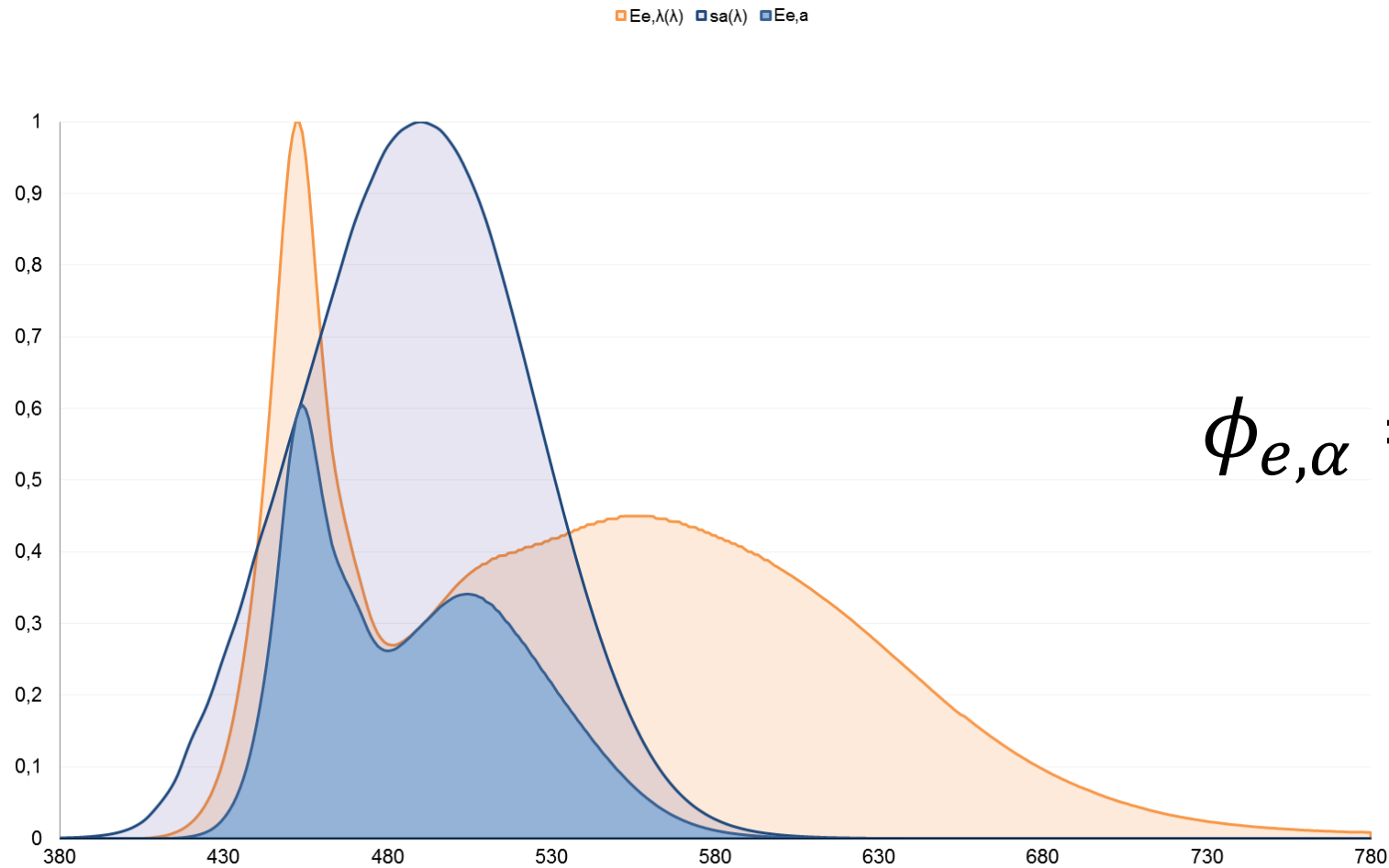


2. CALCULATE THE LUMINOUS FLUX



$$\phi_{e,\lambda} = K_m \int \phi_{e,\lambda}(\lambda) V(\lambda) d\lambda$$

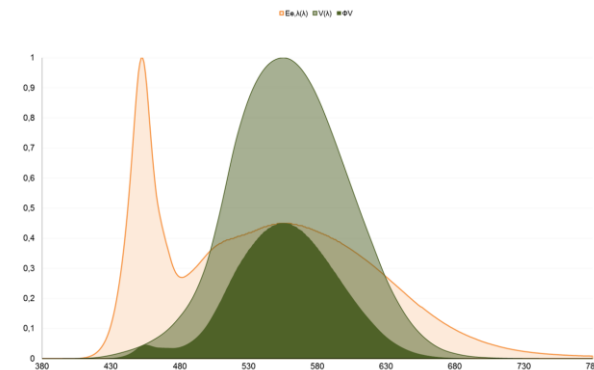
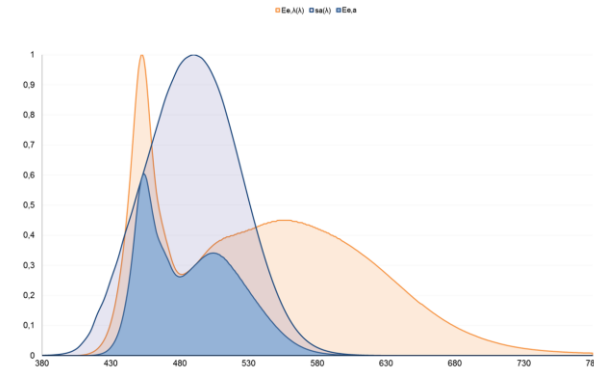
3. CALCULATE THE α -OPIC RADIANT FLUX



$$\phi_{e,\alpha} = \int \phi_{e,\lambda}(\lambda) s_\alpha(\lambda) d\lambda$$

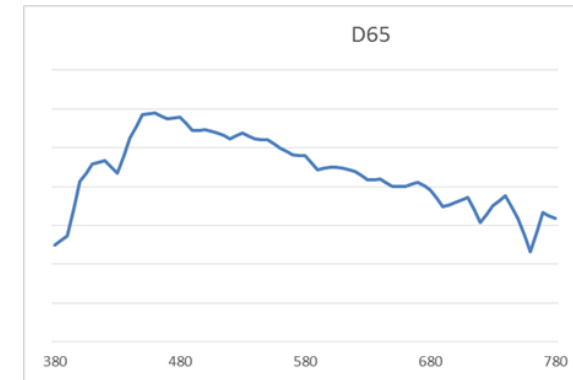
4. CALCULATE THE α -OPIC EFFICACY OF LUMINOUS RADIATION

$$K_{\alpha,V} = \frac{\phi_{\alpha}}{\phi_V} = \frac{\int \phi_{e,\lambda}(\lambda) s_{\alpha}(\lambda) d\lambda}{K_m \int \phi_{e,\lambda}(\lambda) V(\lambda) d\lambda} =$$



5. MELANOPIC DAYLIGHT (D65) EFFICACY RATIO

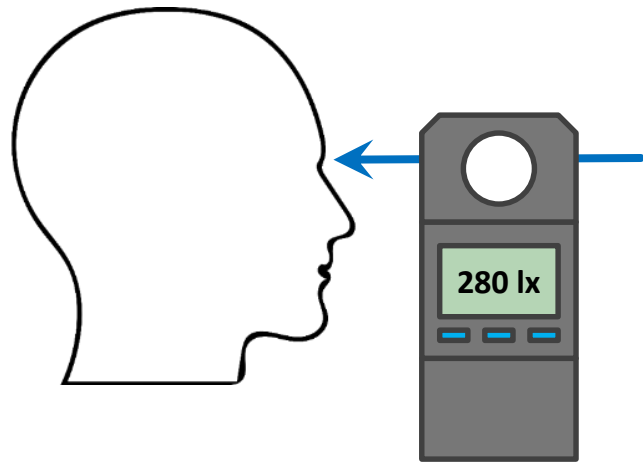
$$\gamma_{mel,V}^{D65} = \frac{K_{\alpha,V}}{K_{mel,V}^{D65}}$$



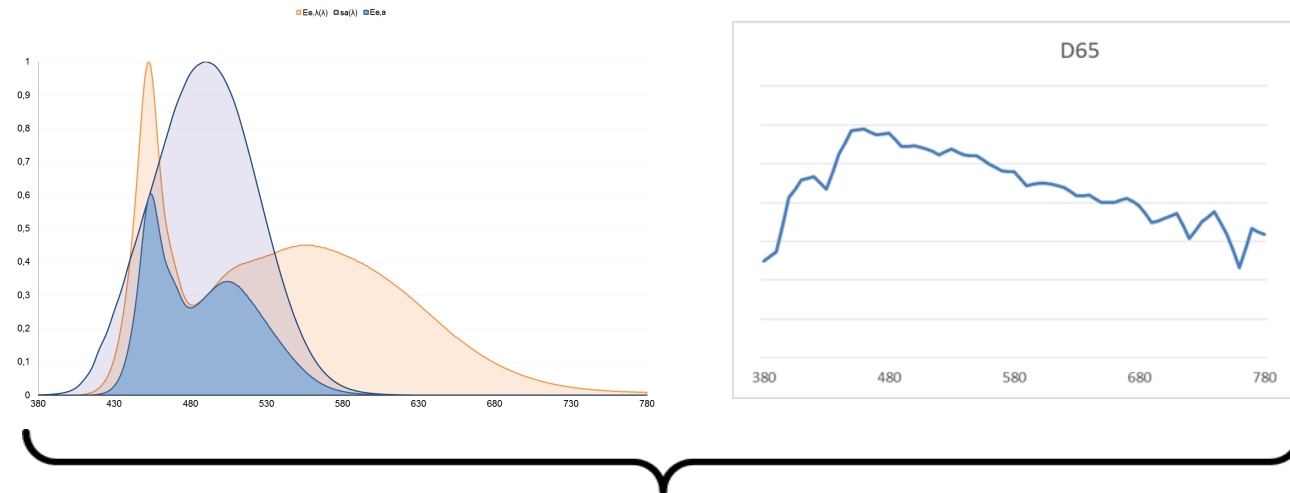
$$K_{mel,V}^{D65} = 1,3262 \frac{mW}{lm}$$

Note: α -opic efficacy of luminous radiation has the inverse units of K_m and is expressed in watts per lumen

Example Melanopic Equivalent Daylight Illuminance



$$E_v = 280 \text{ lx}$$



X

$$\gamma_{mel,V}^{D65} = 0.85$$

=

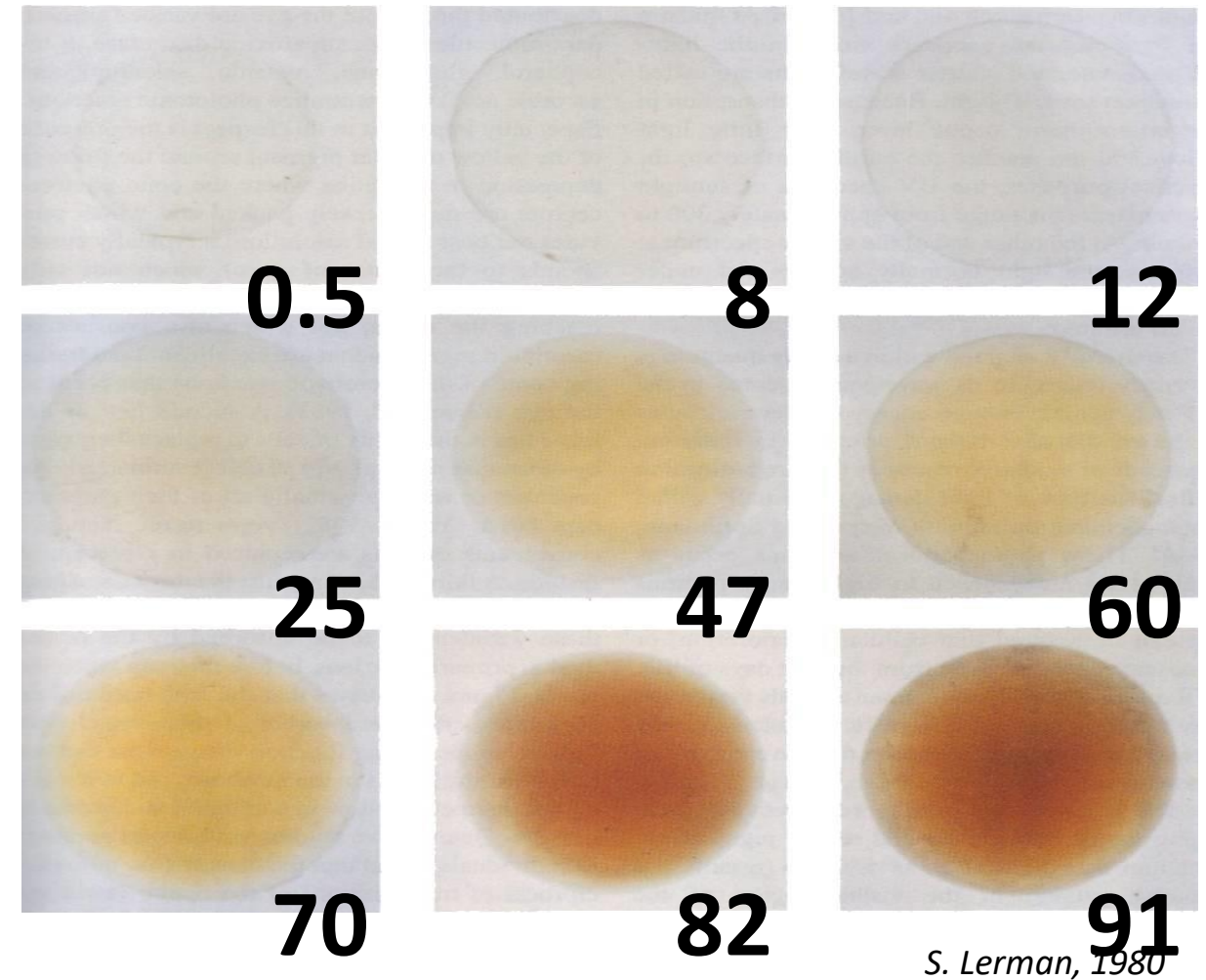
$$E_{e,\alpha} = 238 \text{ lx}$$

THE EYE – AGEING PROCESS

Ageing effects on the eye:

- Dulling of dioptric apparatus (lens, vitreous body, cornea)
- Yellowing of the lens
- Limited work range of iris

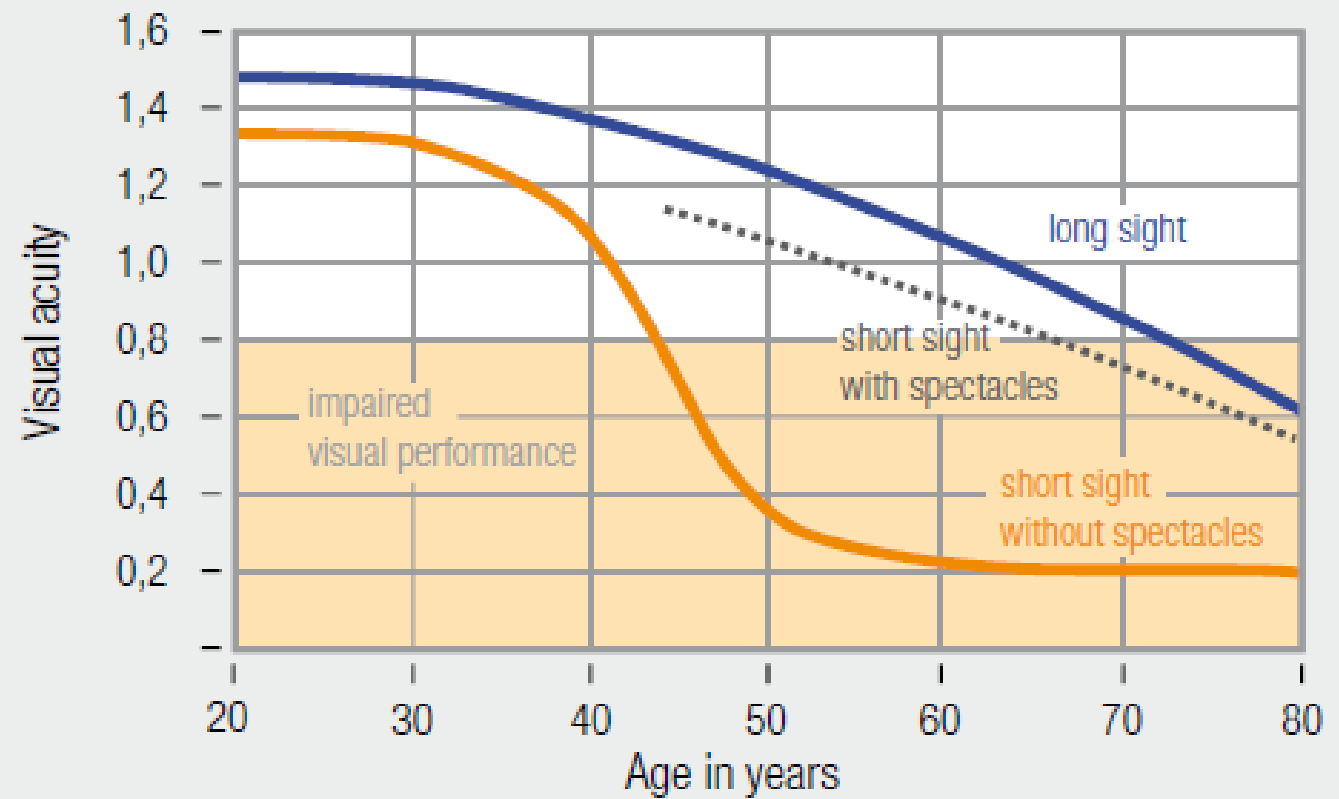
→ Effects make everything similar
→ lowers the circadian effect of light



VISION ACCORDING TO AGE



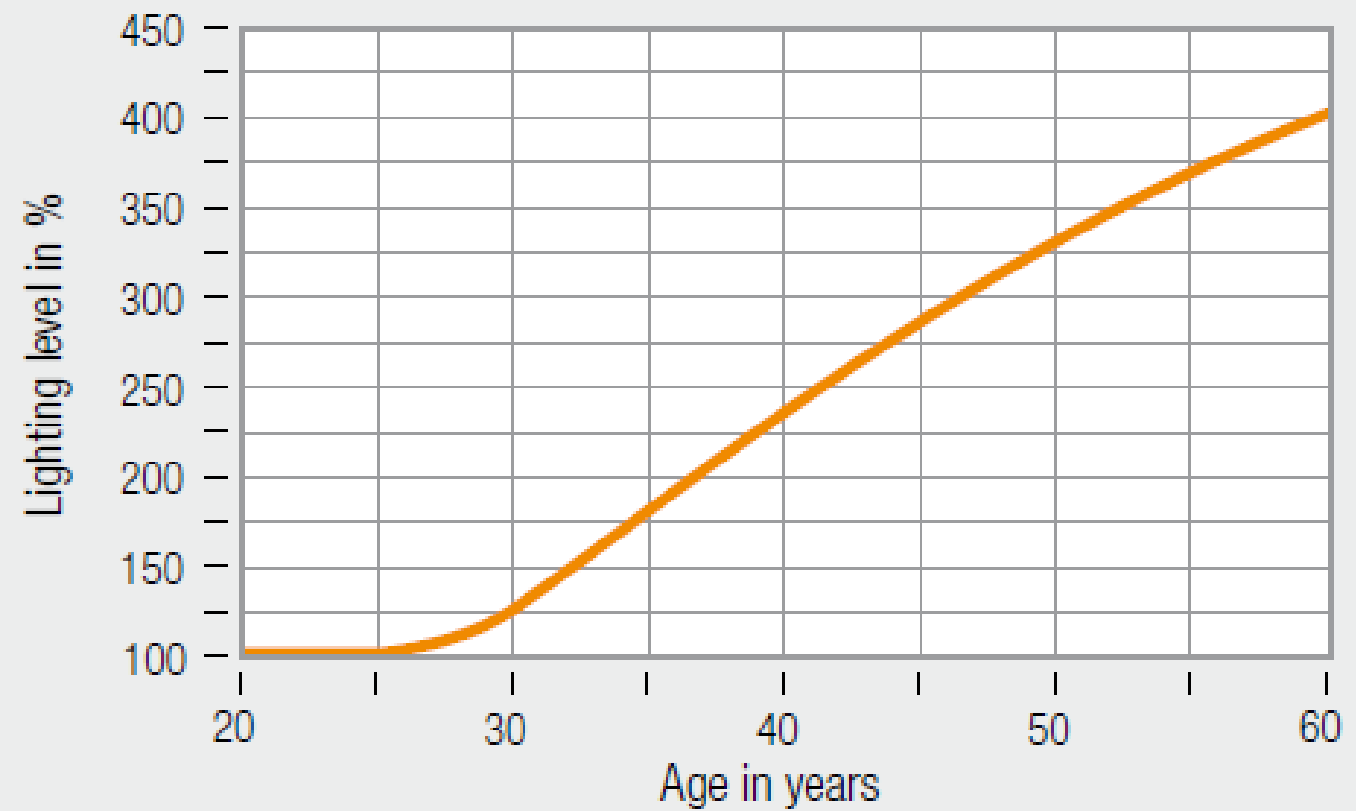
Visual acuity and age



VISION ACCORDING TO AGE



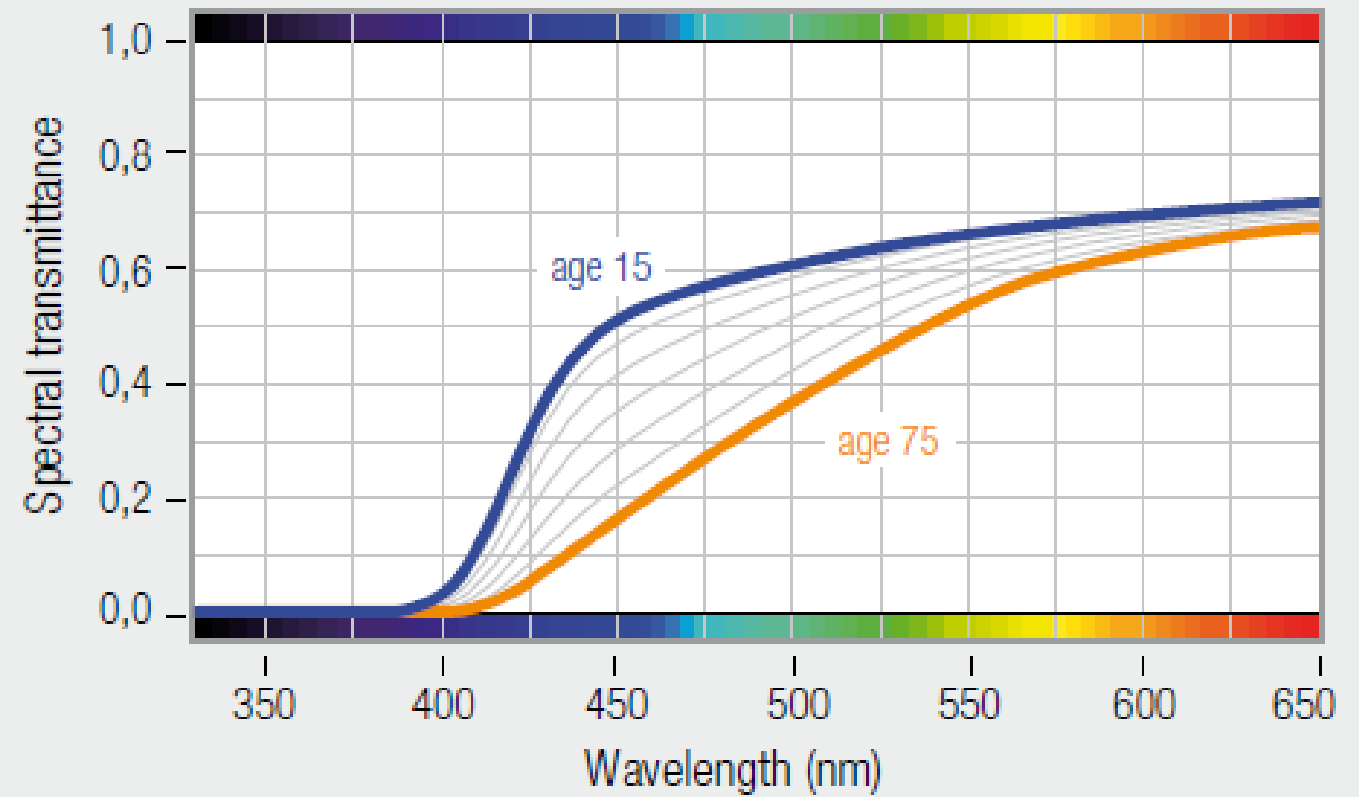
Increased lighting level requirements



VISION ACCORDING TO AGE



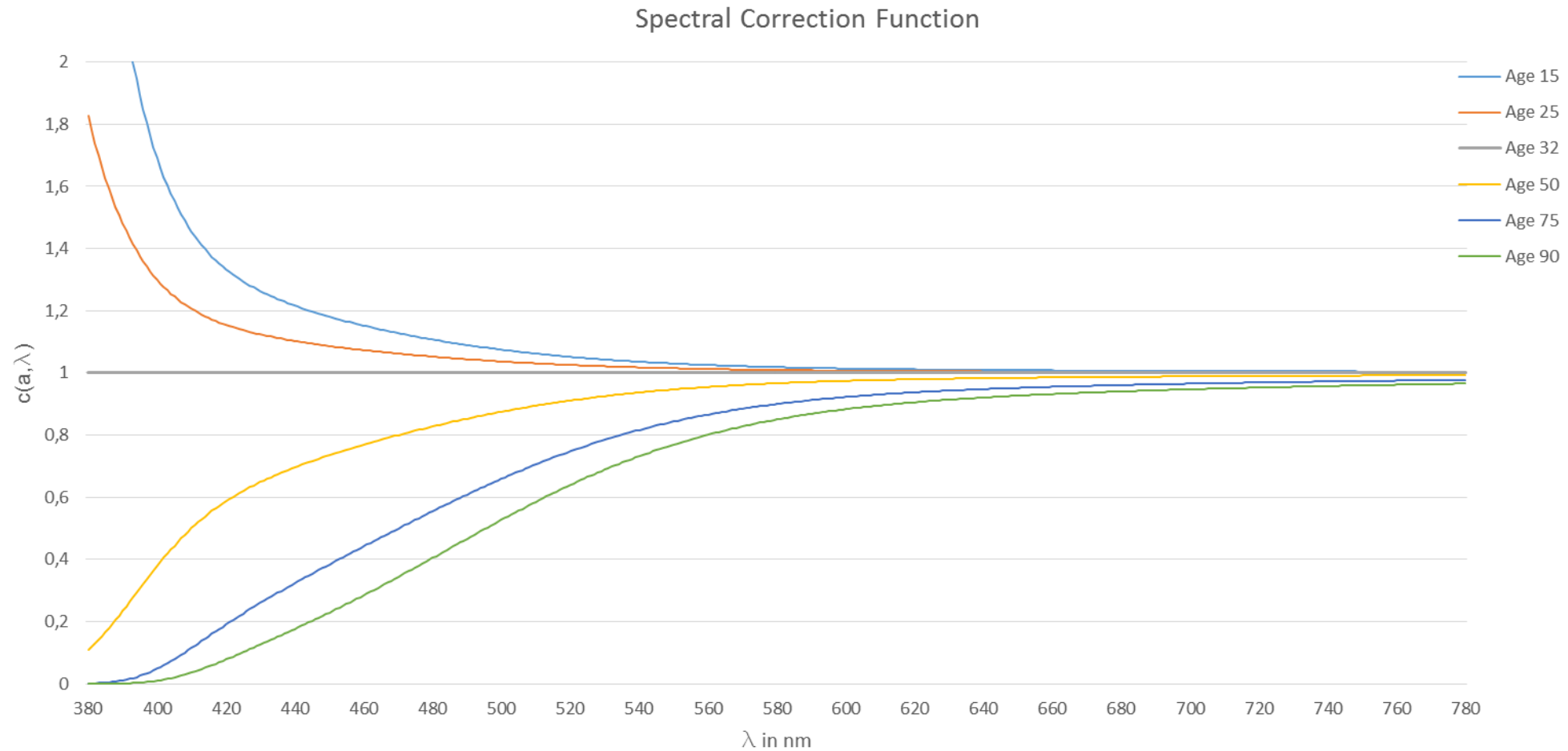
Spectral transmittance of the eye



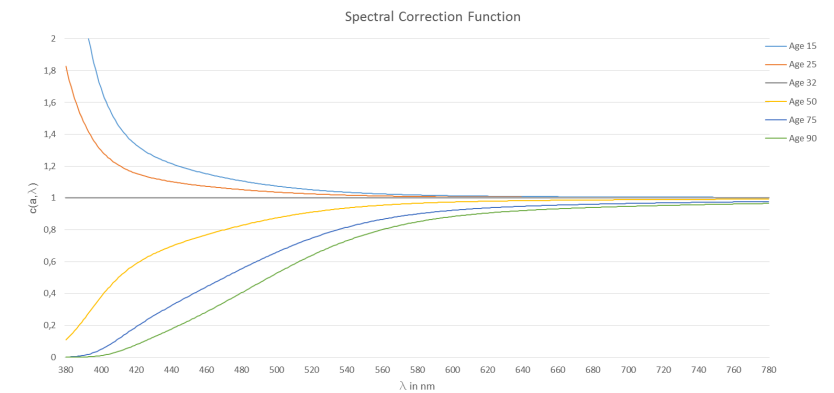
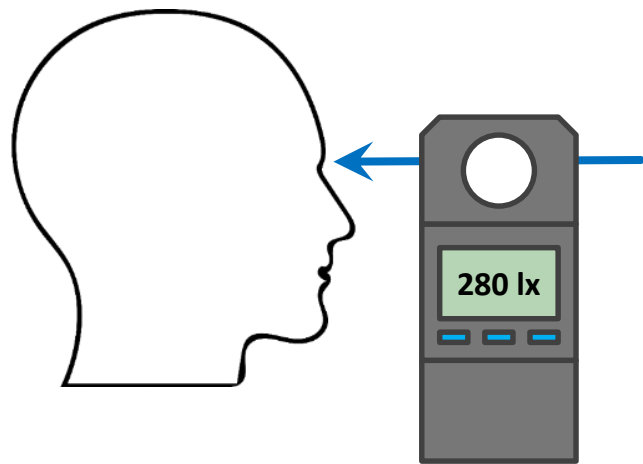
AGE-RELATED CORRECTION FACTORS



SPECTRAL CORRECTION FUNCTION



EXAMPLE OF AGE RELATED MELANOPIC EQUIVALENT DAYLIGHT ILLUMINANCE



Age	25	32	50	75	90
$E_{e,\alpha}(A)_{\text{in lx}}$	271	238	157	75	45

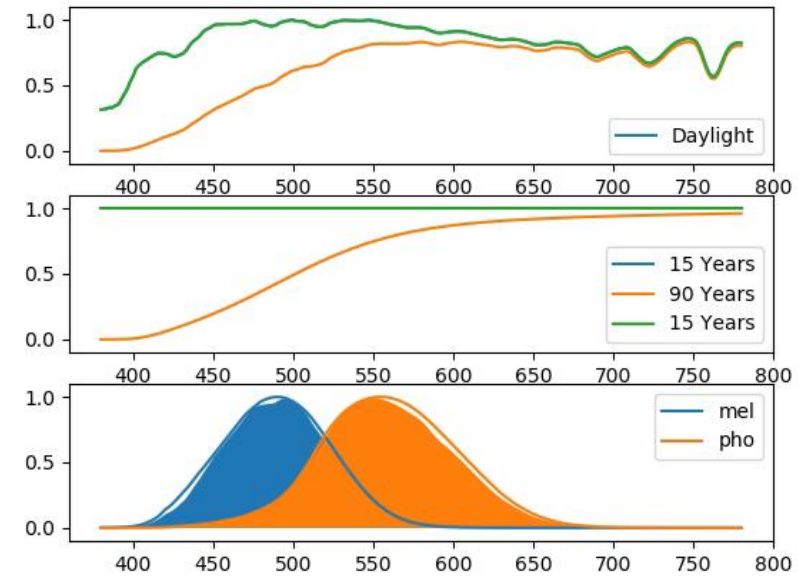
Original



diminished optical transmission



incl. White Balance



OPTICAL TRANSMISSION SIMULATION
by D. Stabenau