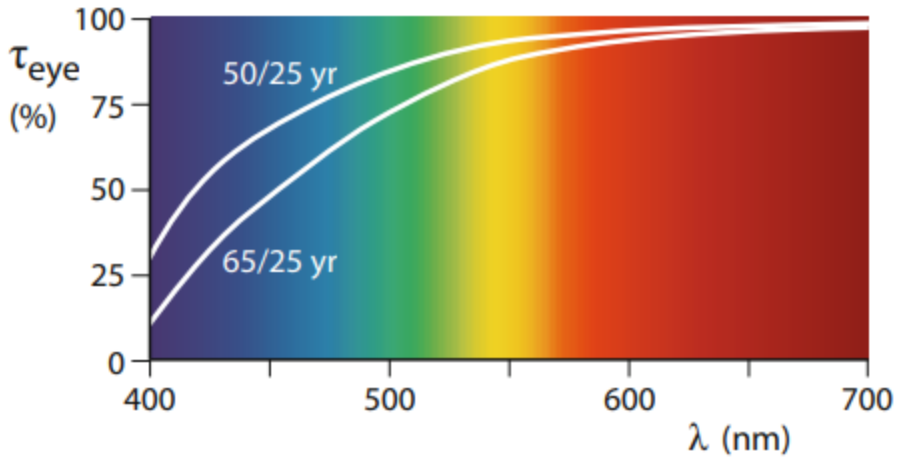
Lighting for the Aging Eye

In 2022 nearly 1/3rd of the US population was over the age of 55. Many of us personally know someone who has struggled with vision as they age, these challenges becoming most present during driving. This issue is reflected in research, with older drivers displaying slower reaction times and higher collision rates compared to younger drivers. Driving performance differences become amplified at night, a time in which the aging eye has its greatest impact on visibility.

The most visible aspect of the aging eye is a constricted pupil opening. Physically, the pupil is the first means of adaptation to light. As the eye ages, the maximum diameter of the pupil dwindles to half of its former size at a younger age. Consequently we see a loss in the quantity of light that is able to physically reach the retina.

Once a diminished quantity of light enters the pupil, older individuals face another challenge in visibility. Over time the lens of the eye yellows and takes on a cloudy appearance, modifying the spectral transmittance of the lens. Large quantities of blue light are absorbed by the lens, along with some degree of green light. Yellow, amber and red light is largely unaffected by the yellowed lens. When the impacts of a narrowed pupil diameter and yellowed lens are considered, the loss of light transmission is comparable to a young person wearing sunglasses at night.



Spectral transmission of the eye's lens for ages 50 and 65, relative to age 25.

Within the Mesopic range of vision, in which both Cone cells and Rod cells are mathematically active, the greatest determining factor of visual performance is luminance levels. In the majority of Mesopic visual performance studies, subjects were in their 20s and 30s. This is important to note, as the goal of Mesopic visual performance studies centers around finding the optimum spectrum for lighting, as well as the minimum luminance level needed to achieve a specified level of visibility. Without taking factors of the aging eye into account, we end up with a Mesopic visual performance model that does not represent people of all ages.

Issues with a lack of accounting for age can be seen in the following scenario; Generic Roadway Lighting Guide lists 0.3 cd/m^2 as the appropriate luminance target for a roadway based on its traffic and speed limit. This number is derived from Mesopic visual performance models, in which 0.3 cd/m^2 correlates to factors of visual performance such as reaction time and the ability to discern object details. While younger individuals will experience the predicted level of visual performance, older individuals are left behind. Unable to physically receive the same quantity of light, their visual performance is below that of the intended target.

A much greater issue brought about in the era of ‘white’ LEDs is that of a shifting spectral sensitivity with age. When the lens of someone aged 50 is compared to that of someone aged 25, the transmission of deep blue light is reduced by over 50%. Cyan transmittance is reduced by ~25%, while losses for yellow light are around 10% or less. In his technical guide, lighting researcher Wout van Bommel calculated the difference in light transmission for someone aged 25 and someone aged 50 under LEDs. The light from a 4000K 'neutral’ LED was 11% less visible than light from a 2700K ‘warm’ LED.

If lighting practitioners wish to provide the best visibility possible to individuals of all ages, several considerations need to be made. Older individuals require a higher luminance level in order to achieve the same visual performance as a younger individual. The difference in required luminance levels becomes greater as the short wavelength content of a light source increases. While increasing luminance targets is a contentious issue, especially among light pollution advocates, there is little question as to the ideal spectrum of light sources for older individuals; The yellow-amber spectrum. Should we desire to reduce accident rates for the most at-risk class of drivers, implementing lighting optimized for all ages is an easy step to take.

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