DRIVING AT NIGHT – How LIGHT Affects the Eyes of Aging Drivers

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In a recent article featured in the international magazine, URBAN NIGHTSCAPE, I expressed my concerns about some of the latest trends in outdoor lighting. URBAN NIGHTSCAPE is a popular magazine and the article was not intended to serve as a technical platform. Nonetheless, my intent is to raise awareness to the growing concern for human ocular and overall health impacts arising from the increased use of new light sources for roadway lighting, automotive headlights and lighting for areas of pedestrian use such as commercial districts and parking lots. I am particularly concerned about the trend towards the increased use of short wavelength light in the range of 450-480 nm (blue-white intonation) due to the negative effect on ocular health and the intrinsic photosensitive retinal ganglion cell (iPRGC) receptors in the eye.

I believe that the detrimental effect of these new light sources will be most noticeable in older people because their vision is adversely affected due in part to two degrading anatomical characteristics. The first is a measurable size decrease of the pupil correlated directly with advancing age. This occurs when tissue of the iris swells thus preventing the pupil from *adapting* by opening to its full extent in dim light. In total darkness, the pupil diameter of a 45 year old is 6.2 mm and decreases to 5.2mm by age 80, while in the light adapted state, it is further reduced to only 3.4 mm. Coupled with the normal 2mm shift of pupil size which occurs when attention shifts between center and peripheral focus in the presence of bright light, the older pupil will have dramatically less ability to admit and shield light at night. Because pupil dilation is influenced by the circadian clock targeted iPRGC response, an increased expression of a stress related neurotransmitter known to control pupil activity can also be expected as the percentage of short wavelength light at night increases. (1. 4. 8. 12. 13.)

The aging process also affects the eye by decreasing ocular cilliary muscle tone and elasticity (recognized by a “flabby” overall appearance) which reduces the normally rapid shape-shift response by the crystalline lens. The purpose of the lens is to swiftly adjust the optical power of the eye to focus and *accommodate* the distance of objects into the field of vision. The human eye recognizes and the brain identifies such objects by contrasting the object’s shape, color and edge alignment against the immediate background. With the increased visual clutter of illuminated roadside objects, irregularly spaced pools of bright roadway light, oncoming headlamps and overly illuminated parking and retail areas, a failure to accurately focus and identify roadway objects and landmarks can be predicted. Short wavelength light can be expected to increase this affect leading to a decrease in visual recognition as the lack of ‘critical spacing’ brought about by light generated visual clutter diminishes the edge features of most objects. (1, 5. 6. 10.)

Many of the negative effects of light are identified as “glare”. As experienced by the aging eye, glare is a sensation of blinding whiteness, blackness and/or physical irritation. Physiologically it is a metabolic

failure of the retinal surface to quickly remove cellular waste in response to changing light conditions. When light strikes a photoreceptor, the retinal cell generates a unit of work which produces a waste by-product that dissipates swiftly in the younger eye. As the eye ages, the rate of removal slows and the waste by-products build up thus causing the temporary "blinding" effect we identify as glare. Since short wavelength light peaks strike the retina closer together, it causes the cellular "work" to occur up to 2 trillion times faster than longer wavelengths thus causing the cellular waste to build up faster than can be processed. This in turn exacerbates the sensation of glare in a manner that will increase with age. (2. 3, 9.)

Short wavelength light also plays a role in the metabolic process called the 'visual cycle'. Normally when light hits a photoreceptor the photon is absorbed by a receptor protein which immediately converts or *transduces* the stimuli into an electrical signal. This metabolic process 'bleaches' the photoreceptor rendering it useless until a specific period of time has elapsed. The recovery time is needed for the regeneration of the photopigments to regain full sensitivity especially when exposed to bright light, However, in the presence of bright short wavelength light, current scientific opinion is that this process is reversed and the cell becomes receptive again before it has had time to fully recover, thus possibly leading to retinal distress. (7. 9.)

In summary, several well known negative impacts to human ocular health and acuity in the aging eye are exacerbated by short wavelength light. With the historic balance of most outdoor lighting being the long wavelength light of incandescent and high pressure sodium lamps, the new short-wavelength dominated LED and HID light sources will tend to create more glare and acuity issues with night vision. This has already been noted and readily apparent to most drivers since the introduction of xenon HID headlights. And with short wavelength LED street lighting having many of the same issues, it legitimately raises the question of whether these new light sources are introducing as many problems as those they are claiming to solve.

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Urban Nightscape

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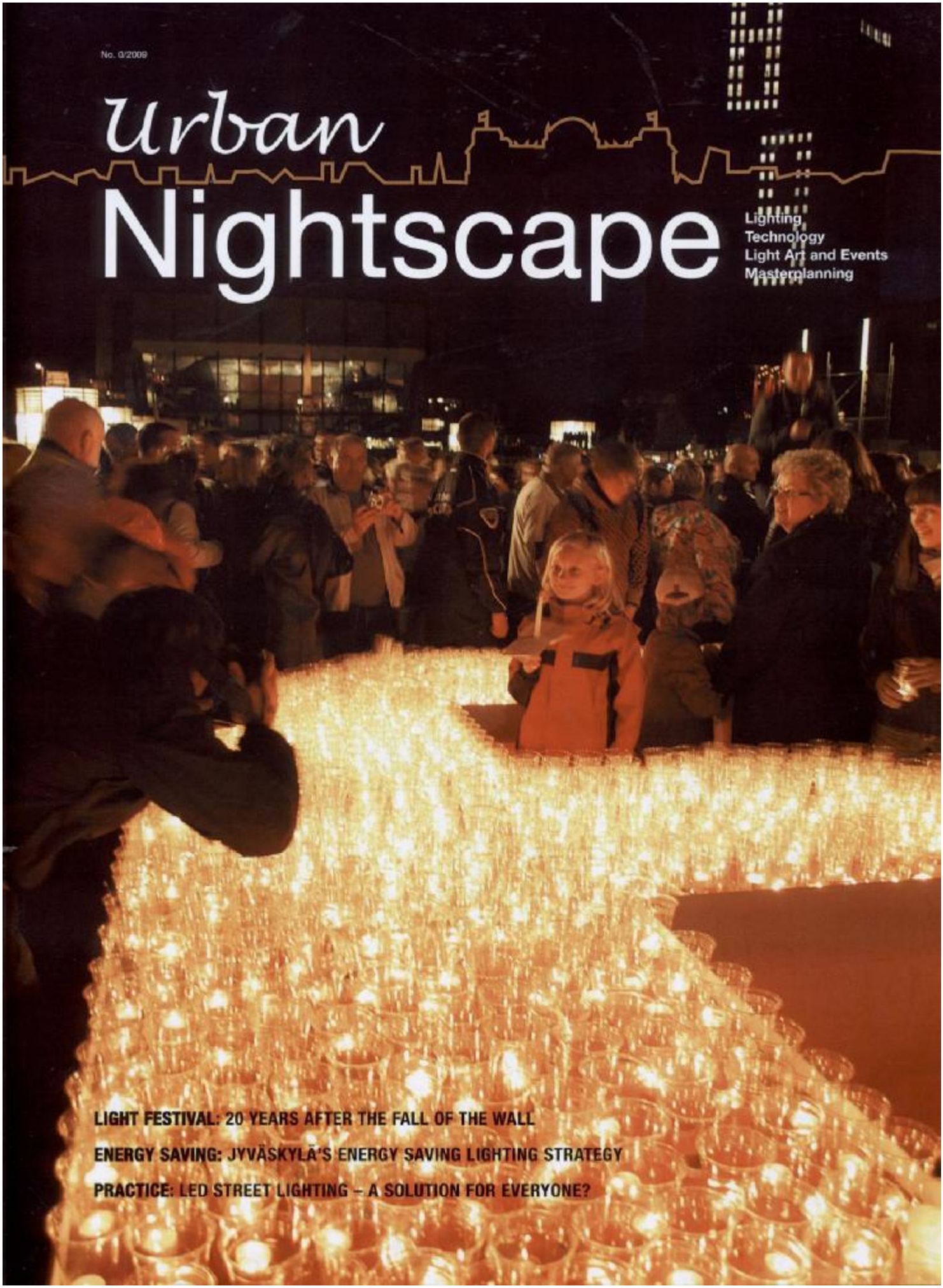

LIGHT FESTIVAL: 20 YEARS AFTER THE FALL OF THE WALL

ENERGY SAVING: JYVÄSKYLÄ'S ENERGY SAVING LIGHTING STRATEGY

PRACTICE: LED STREET LIGHTING – A SOLUTION FOR EVERYONE?

LED STREET LIGHTS – A GREAT SOLUTION FOR EVERYONE?

Text: Deborah Burnett

As we get older, our eyes start to age subtly and in our 20's we can actually "see" the first very slight effects of the aging process. Granted when you are that young, the aging process has not taken a dramatic toll, but nonetheless, the damaging is visible. Some time ago I was able to see and compare the lenses of one family. The first patient was a twelve year old girl whose lens was crystal clear whereas the lens of a 90 year-old was so amber yellow that it actually appeared brown. The other family members of various ages had lenses that ranged from slight yellow to a dark golden yellow. The thirty year old in that group was the most surprising as his lens was more yellow than I had expected until I learned that he regularly went outside without sun protection... in other words, the UV light accelerated his eye aging process.

As you know, the human optical lens is a flexible crystalline structure supported by a pair of opposing lengths of muscles called the cilliary muscles. These muscles act to protect and enhance the lens in its job of receiving the image viewed, inverting it and then sending it through to the retina. As we age two things happen to the lens and cilliary muscles: the muscles get flabby and cannot respond very easily or quickly which results in the older eye not being able to focus clearly as well as becoming more sensitive to glare. Also the lens, affected by the damaging properties of UV radiation, will oxidize the lens causing it to become more brittle and take on an increasingly yellow appearance as the years roll by.

Why do the elderly have trouble with LED and other bright lights at night?

So when does this aging process really become noticeable? For most people, the flabby muscles start to make their presence known about age 42 and become more pronounced throughout the forties stabilizing by the early fifties. This is why most people start to wear reading glasses around this time, and they start to notice that driving at night is becoming a problem. The yellowing of the lens called "necular scolerous" doesn't start to become a problem until the late 60's when most people start noticing that their favorite colors do not appear as fresh or perky as thy once did. The funny thing is that these people do not realize that they are seeing the world through an ever increasing yellow filter.

So why do the elderly have trouble with LED and other bright lights at night? Because light of any quality will strike the lens which is supposed to rapidly adjust during any condition, especially at night where the eye is exposed to bright light. This is the body's protective measure to prevent an undue amount of light getting through to the retina. With flabby ciliary muscles this does not happen as quickly nor does it work with the needed agility and speed. Glare then sets in, which elicits a neurological reaction called accommodation which allows the retina/brain to have time to get used to and adjust to the bright light source. At night when you have an inconsistent lighting plan such as street lights (bright pools of light spaced yards apart within a darkened environment) you are setting the older eye up for trouble because the time needed for accommodation is non-existent thus keeping the older eye in a constant glare condition which causes the viewed image to appear fuzzy distorted and scattered.

And since scattered light will revert to the most prominent wavelength, the blue wavelength as a basis for the LED technology will become more noticeable and problematic because blue light is inherently brighter and more powerful than any of the other wavelengths. For the aging eye, this will result in more glare, which in a moving car means NO accommodation time to recover thus the older eye is in a constant state of disability glare... a very uncomfortable and dangerous state to be in as you are speeding along at 60mph and not able to see clearly!