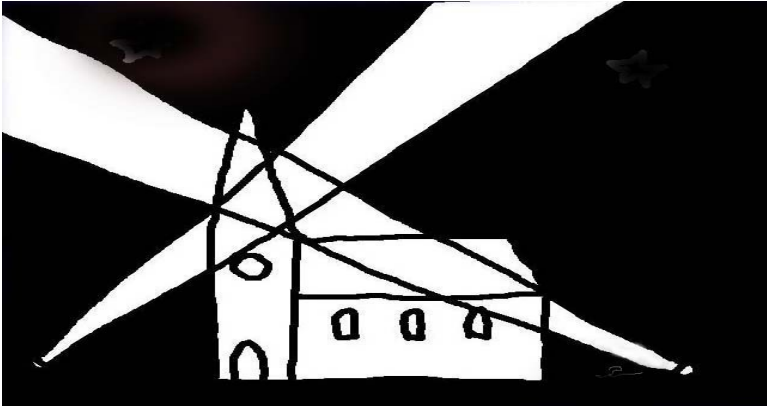


## TAILORED TO THE EYE



P Heilig

The eye appears to be our dominating sensory organ. This has to be taken into account in our increasingly denaturalised environment with artificial light, 'filtered' or even polluted air and some unwanted poorly adapted buildings, constructions and maladjusted contraptions. Hence planning (architecture, design, light-engineering etc) and constructing have to be guided - among other prerequisites - by the demands of vision, i.e. sensory physiology, cognition, perception, processing in higher visual pathways and centers and the highly sensitive circadian rhythm.

Light receptors, cones, rods and intrinsic photosensitive Melanopsin-containing retinal ganglion cells (mRGC or pRGC) operate like 'light traps' detecting and capturing photons. Even a single photon can trigger neuronal retinal excitation (11-cis to all-trans- Isomerization) thereby initiating the molecular cascade of excitation transfer: Hundreds of Na-channels are closed thereby changing membrane potentials in the neuronal circuits of the visual system. This would be one example for the utmost sensitivity of this highly developed sensory organ. Another observation informs us about longer lasting effects of even moderate light: The so called 'standing potential' of the eye reacts with slow oscillations to light stimulation. The steady state of this system, the fading out of this phenomenon, initially responding to the light stimulus, is attained after more than two hours (when recorded in darkness). Another example, like the well known after-images, sequelae of bright light stimuli ('overstimulation') can be observed over surprisingly long periods of time.

Sensitivity and vulnerability are associated features, *Rule Number One*:

**Overstimulation has to be avoided.** 'Phototoxicity' means that undesired effects of overdosed visible light (natural and artificial) can cause retinal lesions, either as acute or chronic *retinal light damage*, (chronic: via temporal summation).

**Glare**, a warning signal sends a message to the brain: Stop! The 'dosage' has to be reduced immediately in that very moment, comparable to pain, signalled by an overstretched joint. Overstimulation means: Unphysiological stimuli, too bright, increasingly dominated by short waves ('bluish white, cold' light). The energy of blue light is much higher (twice as much ElectronVolts (eV)) than that of red light at the long wave end of the visible spectrum. The eye has to be protected from ultraviolet radiation which otherwise could cause cataract, or even retinal damage in babies.

Overstimulation means also: Too many overdosed light sources, flashing into pupils, an unutterable and intolerable torment of 'modern' traffic scenarios.

Disregarding sensory and electro-physiological characteristics 'overdosed' light pounds incessantly 'like a steam hammer' as it were, on highly vulnerable retinal photoreceptors and structures - during day and night. Isotropic daytime running lights (HI-LED-DRL) - 'eye-catchers', radiating intense blue-white light, irritate and distract. Disorders of cognitive processing (multiple dynamic DRL- stimuli incapacitating visual short term memory VSTM) etc.) like '*Inattentional Blindness*' are a threat to the 'weakest' and most vulnerable under all traffic participants - those who are in need of protection particularly, our children - at zebra crossings.

By the way: ***DRL violate against***

*The Convention Concerning the Power of Authority, The Law in Respect of the Protection of Infants (1969), The Obligation of Protection, The Principle of Equality, The Declaration of Human Rights (1948) Article Three, The Laws of Logic, Public Ethics and Morals..*

*(Attorney-at-Law Dr. Gerald G. Sander, M.A., Mag.rer.publ.)*

Too many inputs functioning not only as distracters may spoil also sport performances: Suboptimal illumination of sport-halls or stadia distracting players, referees and fans needs redesign. Overhead-tennis balls can be missed even by experienced tennis-champions because of transitorily impaired psychophysical performance. Too many separated lamps – too many light stimuli, when looking upwards at the ball possibly causing overflow of working memory, short term memory etc.: with the result '*Inattentional Blindness*' and related phenomena like the undesired side effects of Daytime Running Lights (DRL) - worst-case-scenario - killing children at the 'Schutz'-Weg (zebra-crossing).

'*Light Pollution*' depicts it nicely: '*Waste Light, Light Smog, Errant Stray Light Rays, Lost Light*'. Outdoor and Indoor Light Pollution - a modern plague.

The antidote?

*Light Hygiene*, i.e. Measures which lead *Back to Nature*, that means to physiological conditions, considering all the capacitive limitations and restrictions of our sensitive sensory organ, the eye, together with working memories, visual short term memories, sophisticated and susceptible neuronal circuits and delicately balanced CNS-processing in cognition and perception .

Years ago astronomers warned already that our starry skies were veiled by *Light Pollution*. Thousands of stars should be visible to the unaided eye in unlit places. More and more 'The end of Dark Nights' spoils this delight. Most city children know the 'Milky Way' from hearsay. Urban globe and wide spread diffusely light exposed areas are sprawling and expanding like invading metastases.

The 'glow' is propagated by flare, stray light and scatter, due to dust, fine dust, aerosols etc. Within a radius of more than hundred kilometers the darkness of the night is fading. In the south of Vienna a gloomy red false 'dawn' seems to be gleaming from a strange direction - from the North.

All sorts of '*Light Artists*' displace and replace the night with '*Lost Light*'. High-Intensity-LED (HI-LED e.g) spots, embedded in pavements, ramps and streets shoot rays into the sky. Pointless. Senseless. The beams are targeted at the stars. Those inverted, floodlights blind and irritate pedestrians, cyclists, bikers and other traffic participants.

Luminous advertising of any kind, 'dynamic', flashing and blinking, inapt street lighting, imperfect accent- and effect lighting, flood lighting, bright skyscraper-illumination, inaccurate 'decorative' steeple-, skyscraper-, monument-lightings, light installations for 'mega-events', glaring night-skiing-slopes, skybeamers, laser shows, and blazing 'Mega'- fireworks (plus firework-competitions – creating light- and other kinds of pollution), chintzy illuminations of waterfalls, light-'embellishments' in the streets, in nature (waterfronts) etc.

'Rottweiler'-light, brutally bright, seemed to protect property and to improve security – supposedly. It proved to be wrong. Continuous light – the whole night long – did not solve the problem either. The 'intelligent light control systems' (with integrated motion sensors), as experience could show, are preferable to a 'solution' that harms both ecology and economy.

Light rays gone astray - 'light trespassing' – inapt streetlight (lacking the 'full - cut – off - technology') or inaccurate building illumination; or dynamic luminous advertising light, 'over the fence', intruding into bedrooms, can cause irritation, offense and – even worse - 'chronodisruption' i.e. circadian disruption (CD). Equilibrium and the physiology of Melanopsin- and Melatonin - metabolism, mRGCs, suprachiasmatic nuclei, circadian clocks or – better – the circadian metronomes – are losing 'the beat' – with possible undesired health-sequelae.

The 'quality' of light: More and more intense-blazing bluish-white artificial light conquers and dominates almost all spheres of life. Compared to 'sunny'-warm yellowish illumination seems bluish light to convey rather cool and less comfortable sensations.: ..„Dass Blau immer etwas Dunkles mit sich führe“ - .. „Blau steht auf der negativen Seite“.. *Johann Wolfgang Goethe. Zur Farbenlehre* (1810).

*Coextensive large receptive fields and slow 'off-mechanism', and "the scarcity of blue sensitive cones in the fovea": Blue colours are not an ideal solution, because blue sensitive cones (S-cones) are lacking in our retinal center (fovea centralis). .."they do not provide a significant contribution to the sight" (Brindley 1954). Another argument against the blue – plus – 'the contrast-reducing blue blur' – a chromatic-aberration-phenomenon impairing contrast vision: Yellow light (or filters) improve contrast vision. Overdosed bluish light, a trend nowadays, and quite a nuisance, used as a 'drug' to improve alertness, vigilance, workaholism, zeal of children and grownups, even more important - shopping behavior (!) and brighten the dull and mentally retarded(??)*

Monitors, displays, etc.: 'Crisp' Brightness is touted, promoted and sold as a *quality feature*: Experience has shown that the vast majority of these - sometimes reality replacing - gimmicks and working tools appears to be designed exaggeratedly - too bright, the light spectrum being dominated by visible shortwave radiation. Chronobiologists alert: Bright bluish-white light until late in the evening or night may cause disturbance of circadian rhythms and – finally – health problems, as there are: Elevated blood pressure, metabolic disorders together with obesity. More and more carcinophobia is cultivated by some 'false prophets':

Higher risk of cancer in 'Chronodisruption'- groups was ascribed to the influence of light being the sole and exclusive cause - allegedly - suppressing Melatonin, triggering or inducing interferences with physiological hormonal and immunological functions. However, abridgements and simplifications like 'mono-causal-constructs' are out of touch with our overly complex reality. There are more entrainment pathways for circadian clocks and a considerable number of disease - causing factors during shift work. Sleep deprivation per se, stress, food quality (unwholesome 'night shift – snack' – causing obesity etc.) untimely food intake timings and intervals, sick building syndrome, smoke, air condition side effects, frequent relationship-conflicts (family, partners), pill taking habits - a 'morbid' way of living - etc. Of course, the influence of light, the very timing ('Zeitgeber'- role), wavelengths and dose of light are of particular importance for health or disease in man. The answer to that must be '*Light - Hygiene*' and a general '*Zeitgeber - Hygiene*' - a more rational use of light and sensible patterns as well as attempts to prevent undesired side-effects of the 'drug' light. But, once more, all these numerous factors as mentioned above with possible side effects have to be taken into consideration seriously when analysing possible light- side-effects, and have to be prevented by rational planning and designing.

Blue font: *blue font* does not "help to make the Web accessible to people with disabilities". Most of visually handicapped people prefer dark background with bright scripture.

Visual disabilities: Exhaustive information would be beyond the frame. Although it may be sufficient, that human eye-diseases or -ailments, congenital or acquired, hereditary or spontaneous occurring pathologies, reveal all kinds of visual disturbances: Reduced central or peripheral vision (visual field defects), disturbed dark adaption or color blindness etc.

Eyes with 'macular degeneration' - a widespread eye disease of the elderly - affecting the posterior pole of the eye, has to be protected from light-damage. Anyway, it is common to all, that sick eyes are more sensitive and vulnerable to light and particularly to glare than healthy ones. '*Disability Glare*' – a serious problem in traffic scenarios.

For some retinal dystrophies (inherited category of eye-diseases) the flash of a camera alone might be 'phototoxic'. Hence - prudent design is imperative for light engineers, architects etc.

Light-sources: Lamps, spotlights, floodlights, headlights etc.: Once again – 'Direct' Glare has to be avoided - also glare caused by reflections – due to improper position of lights and/or objects (Monitor, keyboard, e.g. in the wrong position, reflecting artificial or natural light).

Diffusers over HI-LED etc. are a must, absolutely essential, indispensable. Also: UV- filters; No UV should ever reach the eye. Ultraviolet is worthless (information-theoretically); the eye uses only the full range of visible light. Besides - UV is extremely 'phototoxic' for the eye.

*Influence of architecture and room – design*: again – beyond the scope. Pitfalls and stumbling blocks have to be avoided. Also: Shady islands or glare-'tempests' in interiors, at events and shows – esp. laser-rays into eyes, low contrast (stairs, ramps, all kinds of level-differences, signs), various over-stimulations, complicated and confusing arrangements. Self-explanatory, clearly arranged contrasting structures are required and have to be postulated. Checked and proven guidance systems have to be planned in '*universal design*'.

*The air*: Airconditioning, central heating, fine dust, dust, smoke etc., together with ubiquitous monitor- and display- landscapes, reduced blinking frequency and allergies cause tearfilm-problems, Meibomian gland disease (MGD) – evaporative dry eyes. Result: "Sand in the Eye" - foreign body sensations, redness, itching, reduced visual acuity, a series of work hindrances – in extreme cases even working inability or -disability.

*“Nonvisual light perception”*\*: Does not exist. Except - perhaps: *“Transcranial brain- targeted bright light treatment via ear canals in SAD.”* Who really knows??  
Though: Light stimulation of the knee revealed no measurable results.  
Unfortunately.

Résumé: Improper artificial light: Light at the wrong time, at the wrong place, radiating into the wrong direction, with wrong intensity and wrong spectral composition, a nuisance in early childhood from nurseries over shopping halls and - 'temples' to old age – in retirement homes, needs redesign. Preferable: Precautionary prophylaxis, i.e. properly prudent – future planning and designing – including *Accessibility Planning*, *'Universal Design'* or the like. Interdisciplinary cooperation is desired.

\*Visible light (excluding UV and IR). The author was asked for his opinion.

## References

[www.hellenot.org](http://www.hellenot.org)

[www.lightmare.com](http://www.lightmare.com)

[www.darksky.org/](http://www.darksky.org/)

<http://www.darks skies awareness.org/>

## Universal design

[www.udeducation.org/about.html](http://www.udeducation.org/about.html)

[www.ncsu.edu/ncsu/design/cud/](http://www.ncsu.edu/ncsu/design/cud/)

[www2.ed.gov/about/offices/list/ovae/pi/AdultEd/disaccess.html](http://www2.ed.gov/about/offices/list/ovae/pi/AdultEd/disaccess.html)

[www.aaate2015.eu/wp-content/uploads/2013/10/AAATE-STSLegal-framework-of-universal-design.pdf](http://www.aaate2015.eu/wp-content/uploads/2013/10/AAATE-STSLegal-framework-of-universal-design.pdf)

[http://userwww.sfsu.edu/dcgn/universal\\_design/links.html](http://userwww.sfsu.edu/dcgn/universal_design/links.html)

[www.nahb.org/generic.aspx?genericContentID=89934](http://www.nahb.org/generic.aspx?genericContentID=89934)