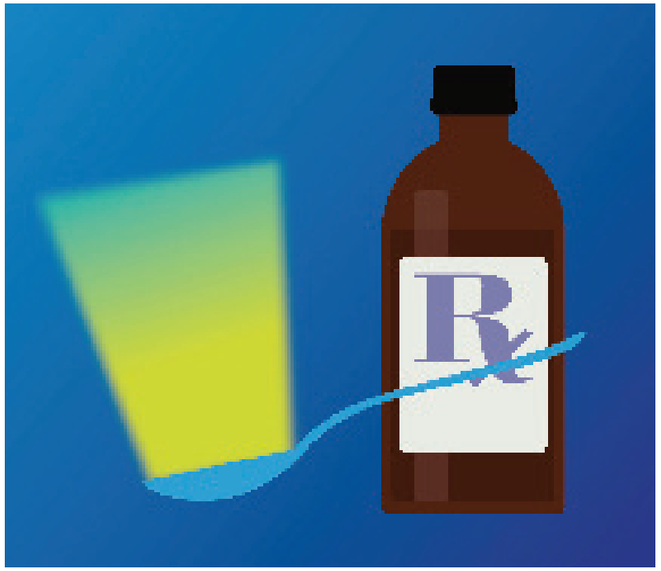

Prescribe With Caution

It is the lighting professional's bioethical responsibility to understand the challenges—and consequences—of specifying, producing or designing with light

BY DEBORAH BURNETT

In June 2016 the American Medical Association (AMA) took the unprecedented and unilateral step of adopting community guidance for outdoor lighting, recommending a maximum correlated color temperature (CCT) limit of 3000K. This report, the third in a series of warnings dating back to 2009, sent virtual shock waves around the lighting world. Within the lighting industry, the most commonly heard protests questioned the AMA's lack of research and its jurisdiction in lighting matters (*LD+A*, August). For dark-sky advocates and environmentalists, the response was overwhelmingly positive, with one U.K. engineer, Simon Nicholas, noting on LinkedIn, "…at least the AMA is actually doing *something* in terms of raising valid concerns, and providing some form of framework and guidance."

At the core of the AMA's warnings, specifically regarding the use of excessive short wavelength light at night, is the medical professional's bioethical responsibility to "first do no harm." The International Commission on Illumination (CIE) has also cautioned against another use of short wavelength lighting: that of specifying light to impact building occupants' biology and behaviors. Taken together, the concerns of these respected groups are painting a picture of caution that the profession might also want to consider before embracing light as "a drug," of sorts, in the built environment. This is especially true of "wellness" or circadian lighting, a field now straddling the line between traditional lighting practice and using light, in effect, to "practice" medicine. Do we not also have a bioethical responsibility to understand the medical challenges, and consequences, of specifying, producing or designing with light?

RESPONSES AND CONSEQUENCES

For almost 50 years, medical and scientific research discoveries have progressively built upon a body of knowledge indicating strong connective links between light and human health and wellbeing. Countless reports have demonstrated that light sources with abundant short wavelength emissions are an important light delivery system with major biological implications. White LED lighting is of particular concern because most common LEDs have an unusual concentration of their short wave radiation between 440 and 490 nanometers: the most biologically active bandwidths for humans and other living beings. Key biological effects include:

Glare & Vision. We are designed to use light, not look at it. Our visual process depends upon light capture, while sight depends upon contrast conditions for definition. According to colleagues Brent York (founder and CEO of Tangenesys Consulting Ltd.) and Jim Benya (principal and partner at Benya Burnett Consultancy), the maximum luminance level that a light-adapted human eye can tolerate (directly viewed light source) without a glare aversion response is around 50,000 nits (1 nit = 1 candela per sq meter). This corresponds roughly to the brightest part of the daytime sky, such as the aura around the sun at noon on a hazy day.

But, according to York and Benya, a commonly available LED, especially unshielded and visible diodes, produce a much higher luminance intensity, measuring upwards of 130 million nits, or almost one-tenth the brightness of the sun. When broadly applied to include most LEDs, this poses a concern based on two factors: the inequity between what the eye can tolerate and the higher luminous intensities common to LED sources, and the disproportionate contrast between the night sky and roadway lighting.

Genetics & Circadian System. Light is the major stimulus for maintaining our diurnal function and activating specific genetic responses critical for survival. Both long wavelength and short wavelength light are vital for initiating genetic expression (turning genes on and off systematically), but only during biologically appropriate time periods. Naturally changing ambient light conditions are the primary cues utilized by regulatory circadian genes and the anticipation-based circadian system. This system, comprised of our master biological clock, the 24.2-hour (average) circadian rhythm and the sleep/wake cycle, sets the timing pace for every cell, organ and muscle throughout the body. The master pacemaker sets into motion the process of aligning the circadian rhythm to the Earth's 24-hour light/dark cycle which then governs the timely operation and function of every biological system throughout our being. This includes all of our major operational functions such as the skeletal system, endocrine system, nervous system and even the timing of wound healing and urine output. The brain, operating on the principle of expectation, also notes the circadian rhythm by initiating predictable, appropriately timed neurochemical responses so that we function within a state of optimized health and wellbeing.

Critical Timing. Humans are diurnal; we are designed to cycle between alertness during the bright light photoperiod and asleep during the naturally darkened evening hours. Without a normal waking and sleeping cycle, we increase our risk of disease initiation and progression. Although robust, the current research is not yet sufficient to direct designers as to the exposure limits. However, it seems that even limited exposures of blue rich white light during evening hours disturbs the cycle, causing endocrine disruption, or as it is commonly referred, *circadian dysfunction*. This is an especially relevant concern for medical clinicians as it applies specifically to the formation and spread of hormonal tumors such as those found in breast and prostate cancers. According to AMA CSAPH Report 4-A-12, exposure to short wavelength white light at night has also been shown to disrupt our metabolic process and immune function, leading contributors to diseases such as diabetes and obesity.

But not all short wavelength light poses a biological problem. In fact, if we do not receive ample amounts of short wavelength light exposure during daytime hours, we run the risk of living and working in "biological darkness." This condition, first observed by Dr. Till Rodenburgh, a German chronobiologist, posits that by spending the majority of our daylight hours indoors with inadequate exposure to bright light, we fail to receive enough light stimuli necessary for optimized wellness and health.

LIGHT AS A DRUG

Because light exposure is known to directly affect biology, many within the research community now consider light to be in the same category as a drug. However, research on the interconnections

between human vision, the circadian system and endocrine disruption is still evolving, so designing circadian lighting interventions is complex. Many factors including light qualities and individual health and lifestyle details must be considered to safely specify or prescribe the right light dose. The 2015 CIE *Statement on Non-Visual Effects of Light: Recommending Proper Light At The Proper Time*, cautions against industry generalized attempts to prescribe light for circadian benefit, stating: "*The missing understanding of the input-output characteristics between light stimulus and the resulting non-visual response seems to make tailored light application for a desired lighting effect impossible*."

Once researchers and medical clinicians develop the correct dosing protocols, the lighting industry had better be ready

Unfortunately, the lighting industry's attempts to sell and specify lighting for circadian benefit rarely, if ever, consider these relevant circadian-protective dosing factors:

1. Knowledge of light source spectrum distribution, and in particular the short wavelength energy percentage to overall bandwidths: here SPD (spectral power distribution) is more important than CCT when it comes to specifying electric light sources intended to deliver biological interventions.
2. Occupant details and biological factors currently outside of our standard practice methodologies: age, individual health variables, lifestyle choices, prior light histories, likelihood of reproductive viability and expected lifestyle photoperiod exposures of the people that will occupy the space we're designing.
3. Project-specific details: window compass direction, building location within the time zone, project site latitude, identification of consistent daylight penetration zones within each space, contributing integrated and reflected light levels from vertical surfaces and flooring, and knowledge of miscellaneous surface finishes so as to determine the complete luminance pattern of the space throughout the daily duty cycle.
4. Specific factors relevant to the light source specified and actually installed, such as intensity, spectral distribution, timing, duration and location.

It is easy to see why attempting to apply lighting intent on delivering biologic or behavioral response is outside lighting designers' normal practice realm. Nonetheless, it is the future, and once researchers and medical clinicians develop the correct dosing protocols, the lighting industry had better be ready.

WHO'S ACCOUNTABLE?

For almost 10 years the lighting industry has been interested in the science of light as it relates to the non-visual impacts on living beings, but there has been precious little in the way of official guidelines or updated recommended practices regarding the use and specification of blue-rich white light, a known biological stimulant. This lack of action, coupled with the recent AMA report and other research with precautionary conclusions, opens the door for potential litigation based upon the legal premise of *failure to warn*. Unlike failure to disclose a product defect, this applies to our responsibility to warn clients and/or occupants when to use or not use lighting because there is the potential for harm or injury.

Without awareness, the lighting industry could potentially be held accountable for not informing occupants of the possible negative biological impacts and resulting health damages from exposures to biologically stimulating light sources. This could apply to the lighting products we manufacture and sell, as well as those who specify the light source. This does not mean, however, that we should not be doing our best to protect the circadian systems of end users until such time that medically accepted "prescriptions" for light are determined. We can begin with three simple protective measures:

- Take responsibility now for expanding biological knowledge and informing both clients and occupants as to the potential *benefits and risks* associated with the light we specify.
- Request consent of building occupants as to the acceptance of any color tuning strategy specified with the intent to deliver wellness benefit.
- Become vigilant throughout the VE processes so that our exacting spectral specifications (based on SPD not CCT/CRI alone) cannot be substituted in favor of poor quality lighting at reduced cost.

The best way, however, to not only protect the health of occupants, but also our business and professional legal exposure, is to develop a personal bioethical responsibility that asserts a "first do no harm" approach for every product sold, specified and installed. ☐

This article is based on the LIGHTFAIR 2016 seminar "First Do No Harm."

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REFERENCES

AMA CSAPH Report 4-A-12: REPORT 4 OF THE COUNCIL ON SCIENCE AND PUBLIC HEALTH (A-12) Light Pollution: Adverse Health Effects of Nighttime Lighting.

Benarroch, E (2009). The locus ceruleus norepinephrine system: Functional organization and potential clinical significance Neurology, 73:20 1699-1704; doi:10.1212/WNL.0b013e3181c2937c: 1526-632X.

Gabay S1, Pertzov Y, Henik A (2011). Orienting of attention, pupil size, and the norepinephrine system Atten Percept Psychophys. 2011 Jan;73(1):123-9. doi: 10.3758/s13414-010-0015-4.

Jaadane I et.al (2015). Retinal damage induced by commercial light emitting diodes (LEDs). Free Radic Biol Med. Jul;84:373-84. doi: 10.1016/j.freeradbiomed.2015.03.034. Epub 2015 Apr 8.

Joyce D, Feigl B, et.al (2015). Temporal characteristics of melanopsin inputs to the human pupil light reflex. Vision Research Vol 107: pp. 58-66.

Mariana G. Figueiro and Mark S. Rea, "Short-Wavelength Light Enhances Cortisol Awakening Response in Sleep-Restricted Adolescents," International Journal of Endocrinology, vol. 2012, Article ID 301935, 7 pages, 2012. doi:10.1155/2012/301935.

Okamoto K1, Tashiro A, Chang Z, Bereiter DA. (2010). Bright light activates a trigeminal nociceptive pathway PAIN May;149(2):235-42. doi: 10.1016/j.pain.2010.02.004. Epub 2010 Mar 4.

Pierre K , Schlesinger N, et al (2016). The Role Of The Hypothalamic-Pituitary-Adrenal Axis In Modulating Seasonal Changes In Immunity Physiol Genomics. 00006.2016.doi: 10. 1152/physiolgenomics.00006.2016.

Shang YM, Sliney D, et al. (2014) White light-emitting diodes (LEDs) at domestic lighting levels and retinal injury in a rat model. Environ Health Perspect. 2014 Mar;122(3):269-76. doi: 10.1289/ehp.1307294. Epub 2013 Dec 20.

Smith, S. M., & Vale, W. W. (2006). The role of the hypothalamic-pituitary-adrenal axis in neuroendocrine responses to stress. Dialogues in Clinical Neuroscience, 8(4), 383–395.

Spector RH. The Pupils. In: Walker HK, Hall WD, Hurst JW, editors. Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd edition. Boston: Butterworths; 1990. Chapter 58. Available from: http://www.ncbi.nlm.nih.gov/books/NBK381.

Srinivasan V1,et al (2011). Melatonin, immune function and cancer. Pat Endocr Metab Immune Drug Discov. 2011 May;5(2):109-23.