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Home Sweet Home
Connecting the dots for healthy evening residential illumination

In this issue, Asst. Prof. Dr. Karolina M. Zielinska-Dabkowska IALD, IES, CIE, MSLL, RIBA, turns her attentions a bit closer to home, looking at the importance of having healthy residential lighting schemes.

Figure 1 A crucial challenge facing lighting professionals today who design residential lighting schemes, is to provide LED lighting that is both visually safe and harmless to general health.
Pic: Light.iQ

During the twentieth century, lighting designers would commonly use incandescent light sources for residential homes as they provided a visual comfort, with high quality colour rendering properties, along with relaxing ambient atmosphere. Unfortunately, it's now difficult to buy incandescent light sources because they have been banned in many countries*. This article addresses some of the challenges in regards to health, brought about by the changeover to new LEDs and other related technologies, and tries to offer some context on how to keep up with these rapid transformations.

While we know it's necessary to limit blue-rich light at night (as it prevents melatonin production and impaires nocturnal sleep), and that it's important to maximise exposure to the blue wavelength of light in the morning (to trigger circadian timing, increase alertness), there are other issues that are misunderstood and often ignored. This includes flicker from LEDs and electromagnetic fields (EMFs), which can be produced by smart home lighting technology.

To begin, it's difficult to quantify the impact LEDs have on the human body because not only is this complex, it's also challenged by the fact there are currently no worldwide accepted, health-related standards or metrics in use with LED lighting products that can adequately guide consumers and specifiers. Although studies confirm excessive exposure to visible light can cause phototoxicity related damage to eye tissue, there are three variable factors that need to be more thoroughly researched and taken into account in residential applications. Namely, the levels of retinal irradiance (dose rate); the specific wavelength of light; and the duration (length of exposure). In retail outlets today, most customers are only able to buy light sources according to their wattage, lumen output, voltage, lamp life, CRI, and/or the CCT, which indicates their perceived colour, measured in Kelvin, listed on the packaging.

Unfortunately, the CCT metric is limited. It only tells the customer how warm or cool a light source appears to the human eye, and it fails to show the visible light spectrum generated by the light source which reveals how much blue light content it emits. This means two different LEDs with the same CCT can produce different amounts of blue wavelengths of light. Ideally, all packaging should provide the spectrum of light of LED lamps, using a metric called Spectral Power Distribution (SPD) but they don't, and without this information, consumers are kept in the dark about what they're buying (Lighting professionals have the opportunity to acquire more information directly from lighting manufacturers or they can measure the light source themselves with available tools).

While we know that the spectral composition of blue enriched light at home in the evenings negatively affects circadian physiology*, a possible alternative metric for residential lighting that could be

included on packaging is the spectral G-index, introduced in 2019 by the European Commission's Joint Research Centre*. It defines the amount of short wavelength light in a light source relative to its visible emission. LEDs with a higher colour CCT have more blue or violet content, and will therefore usually have lower G-index.
As recent research also indicates that removing the blue component of light significantly decreases retinal damage after high intensity exposure*, it would be interesting to confirm the G-index of products that use violet, blue-violet or purple LEDs instead of blue. Some medical researchers warn that blue-violet light has a much higher irradiance (photon energy) compared to standard blue-rich LEDs and might be linked with the development of age-related macular degeneration (AMD) and 415-455 nm are the most harmful to retinal pigment epithelial cells*.
Although human centric lighting (HCL) or circadian lighting has been promoted in recent years, the impact of artificial light on human physiology is complex and it requires far more investigation, research and testing*.
Another concern is a flicker created by rapid fluctuations in the voltage of power supply or a dimming type called pulse width modulation (PWM). Although the flicker is often not consciously perceived by our eyes, the human brain can detect it, as it responds to light at frequencies up to, and beyond 120Hz*. Flicker can cause various unpleasant symptoms such as headaches, visual fatigue and annoyance, as well as reduced task performance. Some individuals may also experience migraines and even worse, epileptic seizures*.
Alas, today we will not find flicker-free retrofit LED lamps if they are powered from 110-220V AC, as the space available in such lamps means the LED drivers are not sophisticated. This is why it's recommended that new homes have Cat6A structured cabling* so luminaires can be plugged in like computers or wireless hubs. It's also best for older homes to replace their cabling, but for many, this may be economically unsustainable.
There are simple devices such as a flicker wheel that can be purchased to examine if a light source in the home is flicker free. It should be tested when the LED is at full brightness and also when the light source is dimmed*. Professional lighting designers can use an Illuminating Engineering Society (IES) approved flicker meter, which is integrated within a spectrometer*.

Figure 2 In the early evening, the rule for living room, kitchen and bedroom should be warm white lighting with a colour temperature below 3000K, containing as little blue light in the spectrum as possible. © Shutterstock

Smart Home Lighting

Another aspect worth mentioning that can impact residential spaces is the introduction of smart home technology, which connects devices to the Internet of Things (IoT) to automate and monitor in-home systems*. It's possible to connect lighting to this system as well, instead of using standard analogue switches. A smart home often uses two forms of wireless connection: Bluetooth and Wi-Fi, as part of a Wireless Local Area Network (WLAN). Both will produce EMF as data is constantly exchanged. Some scientists still have reservations about the safety of this technology, as new studies reveal there may be adverse health effects from EMF*.
Also, there are risks involving cyber security, including the invasion of privacy and easy access to sensitive data*. Urgent improvements are required before the technology is rolled out.
To measure Wi-Fi and Bluetooth, professional lighting designers can use Radio Frequency and Microwave meters*. At night, it's a good habit to switch off and unplug all electronic devices so our DNA gets the opportunity to repair itself, but in the case of smart home lighting, this might not be possible as the system is interconnected and is constantly operating to collect data and then process and analyse it.

How do we minimise the negative impact of light at night?

During the day, we should aim to have natural light via windows and skylights and only supplement with artificial light where there is insufficient daylight available, for instance on gloomy overcast days, after sunset and during winter. In the early evening, the rule should be warm white lighting with a colour temperature below 3000K and it should contain as little blue light in the spectrum as possible. Ideally, at night, artificial lighting should be kept to a bare minimum with a recommendation of light with a spectrum greater than 600nm (amber, amber-red colour). All forms of this lighting at night should be indirect, preferably positioned at a low level, flicker-free and also

dimmable. It's also good to have the option of dim, diffused, warm white/amber coloured lighting in the bathroom that can be turned on when getting ready for bed. And a soft amber/red nightlight for the hall and toilet are a great idea if there's the need to get up throughout the night. Remember too, that a bright LED bedside reading light can cause insomnia as well if not properly specified.

Another aspect of lighting that is often overlooked are LED lit screens. While there is research regarding their disruption to circadian health*, there are no standards regarding their use. Preferably, we should put devices away at least two hours before sleep. This is especially important for children as the healthy development of their brain and body requires human growth hormone, which is only produced during the phase of deep or slow wave sleep, also called Rapid Eye Movement (REM). Generally, this phase occurs about 90 minutes after falling asleep. Exposure to any source of artificial lighting with blue light content such as mobile phones, iPads, TVs, as well as general lighting, delays this stage, resulting in fewer cycles of the REM phase and less growth hormone*.

A positive update is that exposure to bright natural light during the daytime seems to prevent sleep disturbances related to two hours use of blue-light emitting self-luminous tablets and the effects it might have on the suppression of the sleep promoting hormone melatonin*. This highlights the importance of respecting the natural cycles that we have evolved with.

It's also important to recognise that there are critical immune and repair processes that can only occur when we sleep in complete darkness, and whilst this benefits everyone, it's absolutely critical for cancer patients in order for their body to regenerate and their immune system to fight the disease. The following study shows that even a little light at night can negate the effectiveness of certain cancer treatment*. A dark bedroom is also vital for those with diabetes and obesity as blue-rich lighting at night has a negative impact on hormone and metabolic function.

For these reasons, ensure no light invades your room from outside, especially if your street has energy efficient cool white LED street lighting, as the light they emit will have the same detrimental effects*.

Your best option for now?

If possible, it's best to use an incandescent light source in your home. These can still be bought online in clear and frosted versions. Do check the wattage allowance (there should be a sticker on the luminaire near the base) and the base type, and it's prudent not to go over 100W. In most situations 60W will be more than enough for general lighting, with 20-40W for desk/bedside lamps. Also Himalayan rock salt lamps that use incandescent light sources can be used as night lights for bedrooms, children's rooms, hallways and toilets.

My favourite light source for food illumination is still a simple wax candle, although I would recommend it only for special occasions. Even with all the latest lighting technology, dinner by candlelight cannot be matched for an ambient atmosphere of warmth, beauty and magic. Candlelight is very similar to the spectrum of sunset and

Figure 3 Even with all the latest lighting technology, dinner by candlelight cannot be matched. It creates at ambient atmosphere of warmth, beauty and magic. © Shutterstock

with a high CRI, it provides a beautiful warm quality of illumination that's flattering to skin tones. Plus, food served under this light will also look natural and healthy. There are also vintage-style 'Edison' incandescent lamps with a visible filament, often used as light sources for high-end restaurants and bars, which can add some sparkle to a room.

Although energy efficient, most vintage-style 'Edison' LED lamps (with fake filaments comprised of tiny LEDs arranged to look like the real deal), still have drawbacks and they cannot replicate the quality of light and properties of incandescent lamps. But saying that, they may be an acceptable compromise if a low CCT is chosen, for instance 2200K, with a coloured coating to make their light warmer. Be aware though, these factors can vary depending on the brand.

Back to basics - two useful lighting design concepts

When designing human friendly home illumination, not only do the light sources matter, there are also two key design concepts to consider for quality lighting practice. The first I like to call the "layers of light" or "layering" for space perception. It was developed in the last century by American lighting designer Richard Kelly. This approach integrates three distinct types of lighting: ambient luminescence, focal glow and play of brilliants. Each type serves a different purpose and creates a different effect, all of which can be found in nature*.

"Ambient luminescence is the uninterrupted light of a snowy morning in the open country. It is fog light at sea in a small boat, it is twilight haze on a wide river where shore and water and sky are indistinguishable. It is in any art gallery with strip-lighted walls, a translucent ceiling, and white floor. (…) Ambient light produces shadow-less illumination. It minimises form and bulk." Lighting professionals might use pendant, credenza or standing lamps made of diffused material or cove lighting to create general, background lighting in residential applications.

"Focal glow is the follow spot on the modern stage. It is the pool of light at your favourite reading chair. It is the shaft of sunshine that warms the end of the valley. It is candlelight on the face, and a flashlight on a stair… Focal glow draws attention, pulls together diverse parts, sells merchandise, separates the important from the unimportant, helps people see". Focal glow is used to keep our attention where

it needs to be, creating pools of light for example on a dining or kitchen table, highlighting a favourite painting, etc. *"Play of brilliants is the eighteenth century ballroom of crystal chandeliers and many candle flames. It is sunlight on a fountain or a rippling brook. It is a cache of diamonds in an opened cave. It is the rose window of Chartres… Play of brilliants excites the optic nerves, and in turn stimulates the body and spirit, quickens the appetite, awakens curiosity"*. This form of lighting adds sparkle and it can be introduced as a decorative pendant lamp above the dining table or in a hall.
The second concept is that "light follows its function" where a lighting professional considers how each room will be used (to support the illumination based on the function of the room), and ensures there's enough light so the people who use the space can easily perform their tasks. This system uses different light levels based on analogue switching or dimming, which can be activated by built-in wall controls with pre-set lighting scenes or a touch screen lighting control panel*.
People require different light when performing visual tasks such as reading, watching TV, having dinner or relaxing on a sofa – and these are defined in lighting standards

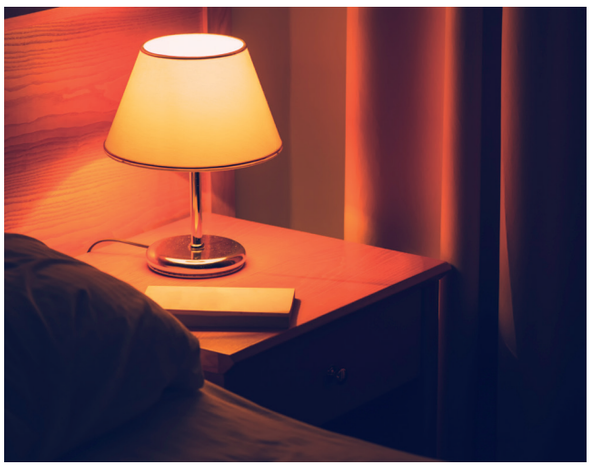

Figure 4 A bright blue-rich white LED bedside reading light can cause insomnia, if not properly specified. © Shutterstock

and guidelines. Unfortunately, these documents do not consider the ageing process, and as we mature we require more light to see at night. Also, these standards are very static and do not adjust for changing conditions such as a sunny summer's day versus a gloomy winter's morning or evening. Let's hope this improves in the near future as we all often have a need for individualised lighting.
Both concepts are required to create pleasing, coherent residential lighting to support user needs and preferences. For all of these reasons, well-chosen and carefully positioned lighting equipment (in the form of downlights in the ceiling, pendant luminaires, standing and credenza lamps, and reading lights, as well as hidden lighting integrated within furniture and indirect cove lighting etc.), coupled with quality light sources and scene settings can create human-friendly lighting, that supports health while also adding a visual comfort to residential spaces.

Worth The Wait

The crucial challenge facing lighting professionals today regarding designing residential lighting schemes, is to provide LED lighting that is both visually safe and harmless to general health. This is difficult as there's still a wide lack of knowledge about the shortcomings of the technology, coupled with an absence of lighting products with clearly labelled characteristics such as SPD and flicker. Plus, in the case of smart lighting, EMF levels need to be considered. Unless people stock up on incandescent light sources (which, while less disruptive to health and life quality, are not as energy efficient), the main option is to buy LEDs, even though this technology requires far more testing and development before it can be considered fit for purpose and appropriate for residential lighting.
Light, be it natural or artificial, has a profound impact on our biology and the environment, so we need metrics that provide information relevant to this to enhance the existing practice of lighting design.
While the lighting industry has finally acknowledged the issue of blue-rich light disrupting the circadian clock, and numerous new metrics have been developed to help market "circadian lighting" such as circadian action factor, melanopic sensitivity, melatonin suppression index - these are very new, as is the field of chronobiology, which is still considered an emerging science. Without proper, repeated, long-term research and investigation, these metrics might not deliver either, so as lighting professionals it is our responsibility to push for unified science-based answers from the lighting industry and standard committees to address existing challenges. ■

** Academic references are available in the online version of this article on www.arc-magazine.com and in the digital version of* ***arc 111****.*

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