Human Centric Lighting The New X Factor?

Following a workshop held at last year's **[d]arc room**, Asst. Prof. Dr. Karolina M.Zielinska-Dabkowska IALD, IES, CIE, MSLL, RIBA, reflects on the known and unknown aspects of Human Centric Lighting (HCL).

Figure 1 The Human Centric Lighting workshop at **[d]arc room**, featuring (L-R): Mark Ridler (Director of Lighting at BDP), Stephen Lisk (President of CIBSE), Rebecca Weir (Creative Director at Light.iQ), Iain Carlile (President of the SLL) and Dr. Karolina Zielinska-Dabkowska (chair of the event, a practicing lighting designer, researcher and educator)
Pic: Sarah Cullen

We live in challenging times, and one could even claim we're experiencing a revolution in lighting with LED technology taking over the world. Part of this rapid change involves a concept called Human Centric Lighting (HCL). At last year's Light+Building, it was the buzzword, with nearly every second manufacturer's stand claiming they had figured out the special formula necessary to create perfect HCL illumination. But how can such claims be legitimate when we know so little about the full and complex impact of artificial lighting on human biology, let alone how to responsibly apply this new approach?

Many experts in this area of research are aware that their knowledge is still fragmented, that they don't have the whole picture and thus, are unable to draw final conclusions that can guide the design and implementation of responsible LED lighting. This includes Dr Russell Foster from Oxford University: the neuroscientist who, with his team in 1991, identified the eye's third photosensitive cells, called intrinsically photosensitive retinal ganglion cells (ipRGSc) whose function, unlike that of rods and cones, is unrelated to vision. He recently stated: "We can't develop human-centric lighting until we know what impact light has upon human biology across the day and night cycle." Also according to Dr. George Brainard, a well-known researcher in the field, "light works as if it's a drug, except it's not a drug at all," so if this is the case, why don't we follow the medical industry and their best practice?

All modern medication requires various testing on animals and humans to obtain approval, and it might take ten to fifteen years or more to complete all three phases of clinical trials before the licensing stage, whereas, with lighting, we have omitted this stage. Rather than apply the precautionary principle, we allow ourselves and our clients to be unwitting guinea pigs without knowing or even anticipating the long-term consequences. Are we as lighting designers practicing medicine without a licence?

There are several reasons why our understanding of the impact of light on the human body is so limited. Firstly, the discovery of new photoreceptors is relatively new; less than two decades, and there is insufficient interdisciplinary research in this area.

Secondly, we've grossly underestimated the powerful influence of light on biology and therefore incorrectly assumed lighting plays a minor role in health and wellbeing. Now we know the opposite is true, we need to be more resourceful in our research because medical ethics prevents direct study on humans (unlike other animal subjects, researchers cannot, for example, induce rod and cone loss to investigate the ganglion cells in humans, neither genetically nor with chemicals). We do know from numerous research on test animals and the information obtained, that artificial light at night can have serious negative effects, including alterations to the circadian clock, patterns of behaviour, or biochemistry, as well as an increase in various diseases.

What's become obvious in recognising the limits of our understanding about this topic, is just how complex it is to mimic natural light, and that far more research is required to identify what's needed to apply artificial lighting safely and effectively. This is why the Human Centric Lighting workshop, held during **[d]arc room** on 19th September 2018, took place – to initiate the important discussion between UK-based lighting practitioners, representatives of established lighting bodies, lighting industry partners and the general public.
The panel featured **Mark Ridler** (Director of Lighting at BDP); **Rebecca Weir** (Creative Director at Light IQ); **Stephen Lisk** (former President of SLL and current President of CIBSE) and **Iain Carlile** (Associate at dpa lighting consultants and President of the SLL) and also included myself as chair of this discussion, a practicing lighting designer, researcher and educator (see Fig.1).
If one had attended this event and expected a clear and obvious solution, they might have left disappointed, as the focus was on the known and the unknown aspects of HCL. As indicated by the sheer number of participants, including John Lincoln of LightAware (a registered UK charity dedicated to supporting light-sensitive people), as well as numerous comments from the audience, it was obvious this subject is a serious challenge for many.
To further complicate matters, lighting practitioners, responsible for designing artificial lighting are overwhelmed with recently developed metrics such as: circadian action factor, melanopic sensitivity, melatonin suppression index, circadian light, etc., and they need clear guidance on which ones to use and why (see Fig.2). In Europe numerous associations with various task groups including SLL, CIBSE, and CIE are working around the clock on appropriate guidelines and standards; and overseas, IES is doing the same. But without proper, repeated long-term research involving humans of different ages, sex and sensitivity towards LED artificial lighting, all the proposed metrics might be just guesswork.

Figure 2 The above diagram indicates the potential complexity of artificial light on humans, involving many interconnected factors that create a cascade effect. © Shutterstock

The Definitions

Human Centric Lighting (HCL) is defined by LightingEurope as a type of lighting that "supports the health, wellbeing and performance of humans by combining visual, biological and emotional benefits of light". This is achieved by dimming and a change in Correlated Colour Temperature (CCT) of a smart light source (most likely an LED), to mimic the appropriate levels of irradiance and spectrum of sunlight throughout the day. But how can this be achieved to a satisfactory degree when daylight constantly changes?
If we look closely at the whole HCL concept, gaps in our comprehension become obvious. How can we confidently claim to replicate daylight/sunlight and therefore provide its many benefits without taking into consideration all of its known components including: light intensity, timing, duration, spectral power distribution, irradiance, the angle where light comes from, and perhaps also even the variation of light due to different seasons? We also need to be aware that just like with the discovery of ipRGSc in the human eye, there may also be important aspects of our biology and factors regarding the properties of sunlight that we haven't yet considered or even know exist.
LED lighting technology has been designed to reduce energy consumption, and therefore minimise global warming, but there are certain inherent shortcomings with this technology as well as a great deal of misunderstanding about the unique characteristics of light produced by LEDs, that directly conflicts with the core principle of HCL. For example, the most energy efficient LED lighting produces blue-rich white light. While the CCT of a 6000K LED may appear similar to the bright light of midday, the actual spectral power distribution (SPD) is noticeably different to natural

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sunlight as it lacks infrared wavelengths and also has a trough in red wavelengths of light. Therefore, its biological effects are different, so it cannot be compared. Even with LEDs that emit less blue wavelengths of light and appear warmer to the human eye (for instance 2400K), important parts of the spectrum present in natural sunlight are still missing. It's short-sighted to focus on changing the CCT of luminaires, especially when it's a limited and insufficient metric. We should pay attention to the spectral power distribution (SPD) of a light source as this provides information about its light spectrum. As mentioned before, certain parts of the spectrum present in natural sunlight that benefit our biology, are absent with LED technology. We also need to consider that due to the 'rebound effect' humanity is now using far more energy to illuminate our surroundings than we did before the advent of LED technology (as this form of lighting is now cheaper, we use more of it, and we also light up areas that were not lit up before). If we are to embrace HCL, we need to accept that the less lighting we use at night the better, that it's well positioned, and that the light it emits has the most appropriate SPD, is evenly distributed, and dimmable.

An alternative term often used to **HCL** is **Circadian Light** or **Circadian Lighting**, as "spectrally weighted retinal irradiance that stimulates the human circadian system". The word circadian comes from the Latin circa, meaning 'around' or 'nearly', and diēm, meaning 'day'. Circadian rhythm is approximately a 24-hour cycle in the physiological processes of living organisms that involves exposure to light during the day and darkness throughout the night, with the only sources of light being the moon, stars and planets. The very term 'circadian light' is an oxymoron, and more accurate terminology is needed to describe what we are doing or should be doing with artificial lighting.

Based on the above, I would like to propose a new term: **Research Informed Human Light (RIHL)** which more accurately describes benign light for humans in interior spaces, applied by lighting professionals based on solid knowledge and research. This type of lighting follows the natural patterns and properties of day and night. During the day, natural light via windows and skylights should be provided and only supplemented with artificial light where there is insufficient daylight available. Such light is of a continuous spectrum, brighter compared to natural early evening light, tuned to what is outside and from above. In the early evening, the rule should be warm white lighting with a colour temperature below 3000K, and 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, red colour). All forms of this lighting at night should be indirect, preferably positioned at a low level, flicker-free and also dimmable.

The challenges for lighting designers

As our clients follow multimedia and become more knowledgeable about the impact of natural and artificial light on their health, wellbeing and productivity; they want to apply this new knowledge, supported by technological advancements in LEDs, in their projects. They are given promises by lamp, luminaire and control manufacturers, based on claims that HCL can solve all sorts of problems (without understanding the complexity involved), and often they want to achieve circadian credit from WELL Building Standard (a performance-based system for measuring, certifying, and monitoring features of the built environment that impact human health and wellbeing, through air, water, nourishment, light, fitness, comfort, and mind).

This means discrepancies result between the client's expectations and what professional practicing lighting designers can actually deliver based on scientific knowledge. We have a moral responsibility and obligation to ensure the lighting provided by professionals is safe and effective because designing healthy lighting "is becoming an important ethical issue that cannot be ignored".

There is hope. CIBSE's environmental team and SLL in the UK, are currently working together on guidelines and memorandums related to HCL. For example, Technical Memorandum TM-40: "Health Issues in Building Services" is currently under review. There is also an RLRCL Report that describes an initial Literature Review on Circadian Lighting, which was updated with new research in 2018.

Table 1. Impact of artificial light on humans from modern light sources such as LEDs, based on available scientific research © K.M. Zielinska-Dabkowska

What we already know	What we need to learn
There is a new non visual photoreceptor type in the human eye named intrinsically photosensitive retinal ganglion cells (ipRGCs) unrelated to vision, which have a different function to rods and cones	The exact number and location of new photoreceptor type in the human eye
Light that reaches the human eye has visual and non-visual effects - with the latter influencing our biological clock	How ipRGCs communicate to rods and cones and why?
Light has an impact on physiology of humans	The long term impact/effects of different lighting conditions
We're aware of irradiance and that this new receptor is sensitive to it, but our knowledge is still fragmented	The dose (how much is enough or too much in terms of light irradiance)?
We're also aware of the light spectrum, and that this new receptor is sensitive to specific parts of it, but our knowledge is still fragmented	Which light frequencies should be avoided (having potentially deleterious effects) and which ones should be present due to their positive effects
Exposure to light has an affect on people	The impact based on age (young children, adults, elderly)
Exposure to light has an affect on people	Impact on Chronotype. (People are different 'chronotypes' - 'larks' or 'owls' - and lighting affects each group differently. One third of the world population has a different circadian rhythm)
Exposure to light has a significantly adverse affect on some people (approximately 1% of the population experiences hypersensitivity)	Impact based on specific light spectrum frequency. Which light frequencies should be avoided (due to potentially deleterious effects) and which ones should be present due to their positive effects
Exposure to bright light containing the blue part of the spectrum at the beginning of the day can have a stimulating impact on the body clock, and can promote alertness	The exact wavelength of spectrum, timing and duration
Exposure to light with the blue part of the spectrum in the early evening can stimulate wakefulness and disrupt sleeping patterns during the night	The exact wavelength of spectrum, timing and duration
Approved metrics and tools are required	What are the best tools and metrics to apply

Conclusion: What are the next steps and action plans for the future?

The lighting community needs to acknowledge health and wellbeing as a major principle in engineering and the design of light and lighting systems – Primum non nocere (ang. first, to do no harm). Additionally, we must recognise that the effect of lighting on human health based on current research is not fully understood, and accept too, that its complexity requires further discussion and the necessary means to better understand it, necessitating financial support to conduct such independent research, the application of appropriate research tools and development of methodologies used.

It's imperative we come together to define what is required in terms of design related questions (too many researchers and scientists from academia conduct research studies without being aware of what's needed by lighting professionals). As LED technology is constantly evolving, relevant questions need to be framed in a practical fashion in the form of applied research. Respected **Model for Applied Research Collaboration (MARC)** (see Fig. 3) between **Lighting Professionals** (1), **Professional Associations** (2), the **Lighting Industry** (3) and **Academia** (4) need to be established.

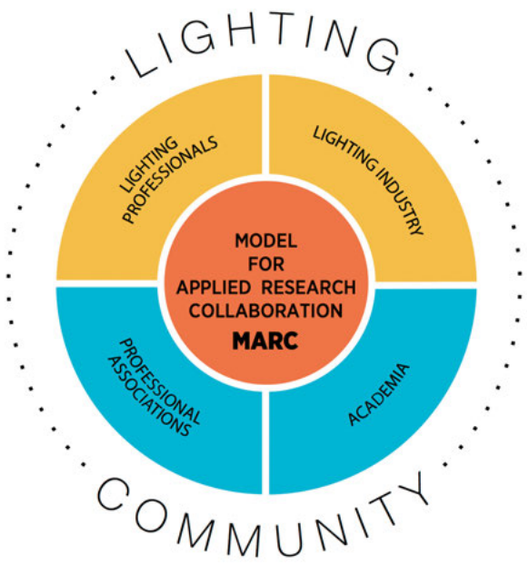

Figure 3 The Model for Applied Research Collaboration (MARC) based on four key partners in the Lighting Community © K.M. Zielinska-Dabkowska

Proposed actions to be taken by the lighting community:

– To prioritise research in different areas and identify the most urgent issues.
– To accept and acknowledge that natural light is superior to all forms of artificial lighting.
– To encourage sharing and promote events such as Light Symposium Wismar, Stockholm (lightsymposium.de), and educational platforms/Consortia such as LLRC (www.LLRC.edu.com) etc, and use them as vehicles to network and spread the latest available knowledge for best lighting practice.
– To establish how research funding can be matched with academia and the lighting industry.

Proposed actions to be taken by lighting professionals

– To prioritise research in different areas and identify the most urgent issues.
– To be involved in/oversee professional, independent, interdisciplinary research that will enable the design community to answer clients' needs.
– To educate the public and build on growing public awareness of this topic.
– To understand the influence of culture on lighting preferences and what kind of impact it might have on overall health and wellbeing. For example, Asian people often prefer bright, cooler light at night compared to Europeans.
– To seek collaboration with RIBA, as architects have the most profound impact on daylight design in buildings.
– To ensure healthy lighting is prioritised on the agenda of Governmental bodies.
– To find people who can translate the needs of lighting professionals into a series of academic questions that can then be collated to produce documents a layman understands and finds useful.

Proposed actions to be taken by the professional associations

– Professional associations such as IALD, CIBSE, SLL, IES, CIE should be involved in identifying what questions need to be collated from their professional members, as these will become an important resource for future research developments of MARC.
– To collate peer reviewed documents using current interdisciplinary, independent research, so lighting professionals have something to refer to that backs up their decisions, and informs clients of the latest research.
– To connect the lighting industry with academia to create access to funding, and also provide academia with questions that needs to be answered.

Proposed actions to be taken by academia:

– Scientists and researchers from different fields of academia need to be involved in research to allow complex understanding of different interrelated aspects of light and lighting.
– Peer reviewed research must be generated. European Commission will only change their polices if there is evidence that proves or disproves certain research theories/hypotheses.

Proposed actions to be taken by the lighting industry:

– To create a pool of various LED lamp manufacturers that have a joined approach to research (commercial advantage) with a shared outcome, as this provides more resources for lighting professionals and academia.

A Nobel Prize should be awarded to those who discover the key to healthy artificial lighting. One day soon, we may realise/admit that incandescent illumination provided as close to a perfect form of light as we've come – and that perhaps we made a grave error in banning it, in our rush to save energy and embrace LED technology with its many shortcomings. **For now, we must ensure the necessary research is undertaken to develop recommended practices to support our responsibilities as lighting designers and to focus on making LED lighting safer and healthier.** ■

For a full list of references, visit www.arc-magazine.com/human-centric-lighting-the-new-x-factor

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