122 JUN/JUL 2021
www.arc-magazine.com

arc
LIGHTING IN ARCHITECTURE

Into The Void

On the eve of new show Dark Matter, arc speaks with the creative minds behind WHITEvoid

[D]ARC AWARDS REVIEW • WHITEVOID • BARBARA HORTON & CARRIE HAWLEY
RETAIL FOCUS • LAM32 MINIMUMMAXIMUM REVIEWED • WOMEN IN LIGHTING AWARDS

Lighting Design for the 21st Century
Applied research in lighting practice

Asst. Prof. Dr. Karolina M. Zielinska-Dabkowska IALD, IES, CIE, MSLL, RIBA, discusses three key and pivotal research topics for the future of our profession. She also presents some project examples where research has been performed to help derive outstanding results.

Figure 1 9/11 Memorial, New York/USA demonstrating that if the vertical surfaces of the buildings at the perimeter level in the distance, such as shop fronts or restaurants, are illuminated, pedestrians will feel safe (Pic: © 360images/Jerome Boccon-Gibod).

For those who are unfamiliar with research, it's important to know there are two categories. Fundamental (or basic) research [1] and applied research [2]. Basic research often discusses scientific ideas/theories, whereas, applied research explores testing these ideas in practice to develop technology or techniques. It's applied research which most interests lighting practitioners.

In the recent past, significant discrepancies in the spectral power distribution (SPD), correlated colour temperature (CCT) and colour rendering index (CRI) could be observed between the characteristics listed in lighting catalogues compared to obtained physical working lighting samples. The only explanation for this situation was the fact that previously, research was mainly performed in lighting labs owned by the lighting industry/specific lamp and luminaire manufacturers. Furthermore, professional lighting designers most often, did not have the necessary time, skills and access to the equipment required to verify these results. Therefore, some of the data could be manipulated.

Today though, due to the development of measuring equipment and improved accessibility (for example, small, calibrated handheld spectroradiometers with a flicker option), we as lighting designers can at least verify results by performing alternative measurements in our own practices. Access to free scientific knowledge is also now widely available. Additionally, improvements in research are being made via lighting designers and engineers who teach at the university level, and many students have the advantage of receiving excellent supervision when they perform research on light and lighting during their Master's thesis and PhD studies.

Great lighting design that creates a pleasant and beneficial user experience in any given space doesn't just occur miraculously. Rather, it's built on the designer's insights and understanding, which comes from sound research and years of practice. This awareness comes from knowing the end users, as well as comprehending what's best for them. It's helpful to acknowledge that many of us in fact perform research in our day-to day practice as part of the design process. However, there's a tendency to disregard this, even though what we as lighting designers actually do is applied research in practice.

In my view, there are three key research topics for the future of our lighting design profession that we should become familiar with. They are all based on the mounting research about daylight and artificial light and its impact on circadian relevance and biological stimulus. These are: (1) Environmental impact and light pollution, (2) Biophilic office design and (3) User oriented daylight integrated lighting (DIL). These topics have been demonstrated below by some pioneering project examples, where research has been performed to help derive outstanding results.

Environmental Impact and Light Pollution

Firstly, there's the environmental impact of artificial lighting on humans, flora and fauna, which includes light pollution. When lighting professionals began to illuminate skyscraper buildings in metropolitan cities in the 1920s and 30s to make architecture and urban environments visually more prominent at night, it wasn't even considered that these actions could have adverse consequences for living organisms in the future to come. Light was perceived as a positive medium that can beautify cities and be used as a powerful marketing and advertisement tool [3]. Over time, things have changed for the lighting design profession, as there's an increasing

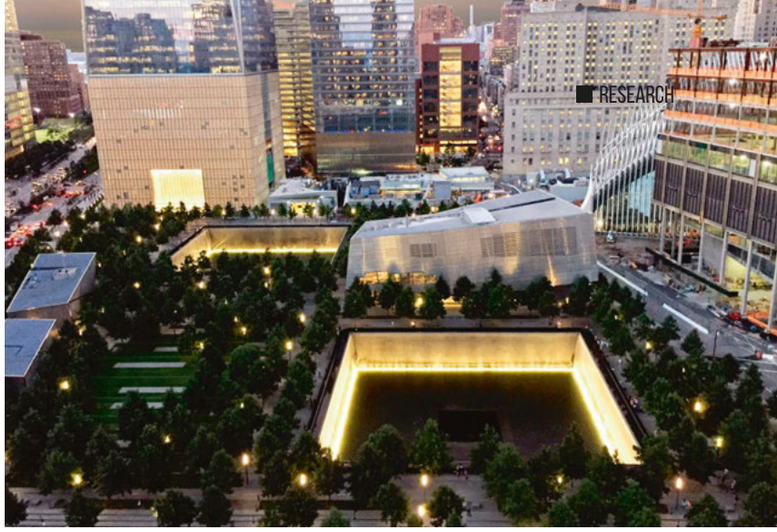

Figure 2 The 9/11 Memorial project is great example of applied research being carried out by lighting designers in the urban environment, proving it is possible to create darker spaces which are also safe, in metropoles such as New York. Lighting Design: Fisher Marantz Stone (Pic: www.exp1.com)

body of knowledge from various research fields such as astronomy [4], biology [5], medicine [6], and ecology [7], all of which confirm that our design actions, if not carefully thought through and skilfully applied, could have far-reaching negative effects.

Due to accessibility of various information on the topic of environmental impact and light pollution from nighttime illumination via the internet, the general public were made aware of the situation and later, began taking things into their own hands, demanding better quality, improved, environmentally sensitive lighting [8]. This means that today, we must ensure that the illumination of urban elements such as buildings, squares, landmarks, and parks etc, is visually pleasing, as well as energy efficient, sustainable and responsible. There's no doubt that lighting designers have a moral obligation to decline urban lighting commissions that do not support human health and environmental wellbeing [9].

While our cities were "painted with light" in the past, we simply didn't have the knowledge that now exists. So, the illumination of our cities today must be executed with far more care, caution and restraint, and furthermore, our actions should bring about positive change. We should always consider the possible impact of lighting projects and be able to provide our clients with evidence-based answers to meet their demands.

Not many of us know that the 9/11 Memorial and its park to honour those who died on September 11, 2001, might have been illuminated as brightly as a baseball pitch. This was one of the requirements of the NYC police to create safe and secure spaces. (It's a common misconception that more light horizontally equates to increased security, when this isn't the case at all.) Thankfully, it was the courage of Paul Marantz, the founder of Fisher Marantz Stone (FMS), who disagreed with this requirement, as based on his years of observation and experience, he understood how people perceive three-dimensional spaces at night (Figure 1). His solution was the proposal of a benchmarking tool. (Benchmarking in lighting design is a tool that has been employed for many years to search for 'best practices'). This project required a few of my colleagues from FMS and I, to travel around Manhattan, where we measured the horizontal illuminance in public parks and squares to prove that with even low levels of horizontal illuminance, if the vertical surfaces of the buildings at the perimeter level in the distance, such as shop fronts or restaurants, are illuminated, then pedestrians will feel safe (Figure 2). This is a great example of applied research being carried out by lighting designers in 2004, before it became more widely applied in practice.

Biophilic Office Design

Secondly, there's the fascinating and important emergence of biophilic design development. This has arisen to address the needs of those people who migrated from rural areas to cities during the 20th century. The abandonment of pastural and natural landscapes had physical and emotional consequences for these individuals, who now lived in man-made urban environments, often without greenery and trees. This urban growth continues to this day with 68% of the current world population predicted to occupy cities by 2050.

Due to the evolutionary disposition of humans, when people live in an urban habitat, they will still seek to restore their lost relationship with plants and the natural world by spending time in open green spaces outdoors, and by bringing plants indoors. As a consequence, at the turn of the 21st century, a noticeable global movement developed in the application of biophilic design principles in the projects of numerous, internationally recognised architectural practices. Clients and architects now expect their projects to incorporate theses new elements. Interestingly, when lighting manufacturers or plant specialists are consulted about how to illuminate ornamental plants in real life interior projects with LEDs, a lack of knowledge is apparent, as there are no worldwide established standards and recommendations regarding how to correctly illuminate indoor decorative vegetation. What's more, if there is no daylight available for built environments, many plants do not survive so they need to be constantly replaced due to insufficiently designed and poorly specified artificial lighting.

When working on the Zurich Innovation Center Givaden, Julia Hartmann and her team from Lightsphere in Switzerland, designed special illumination for 12-metre green columns of ornamental plants in the new laboratory buildings that surround the atrium, which serves as a common space for encounters and exchanges.

It was vital that the plants thrive indoors, and a special luminaire was created using a biophilic approach to provide the right light spectrum (Figure

Figure 3 The Zurich Innovation Center Givaudan, Kemptthal/CH project provided a suitable light spectrum to allow indoors ornamental plants to thrive inside buildings. This is an example of pioneering biophilic office design. Lighting Design: Lightsphere. (Pic: © Filipa Peixeiro)

3). In order to understand the lighting that's best for plants, numerous lighting mock-up scenarios were set up with various light sources, and the results were recorded via photographic documentation. Lighting research was also conducted, and the experiment was shared in an open access publication [10].

User Oriented Daylight Integrated Lighting (DIL)

Thirdly, we should apply user-oriented daylight integrated lighting (DIL) for interior illumination, which combines daylight and artificial lighting in indoor spaces to produce visual and biological benefits for humans. Sometimes the terms "circadian lighting" or "human centric lighting" (HCL) [11] are used interchangeably for interior illumination, yet artificial lighting cannot replace the unique qualities and characteristics of natural daylight. Additionally, it's crucial to acknowledge that removing natural light from this equation is inappropriate because humans as a species, have evolved under natural light. As rightly indicated by Prof. Kevin Houser in his lecture during Light Symposium Wismar 2020/21, "Human Centric Lighting: Myth, Magic, or Metaphor" the term HCL is clearly used for marketing purposes [12]. Researcher and Educator Asst. Prof. Ellen Kathrine Hansen and her team from Aalborg University, Copenhagen (AAU), use the term "double dynamic lighting" (DDL) to describe a concept for office spaces that combines natural daylight with artificial lighting in the space [13].

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. The crucial challenge facing lighting professionals today regarding designing lighting schemes, is to provide LED lighting that is both visually and biologically safe to general health [14]. This is difficult as there's still a wide lack of knowledge about the impact of LED technology, coupled with an absence of lighting products with clearly labelled characteristics such as SPD and flicker [15].

The American Society of Interior Designers Headquarters (ASIDH) completed in 2016, is one of the first pioneering projects that showcases both daylighting and the artificial lighting of interior spaces that's centred on humans, their health and wellbeing. Lighting consultants Benya Burnett used existing research knowledge on light and lighting, and translated it into their unique design (Figure 4). For this project, the luminaire specification was completed in late 2015, when LEDs were still costly, therefore, designers specified and selected high output fluorescent lamps with 5000K uplight, and 3000K downlight components, integrated with the office luminaires. As for the luminaire CCT, the designers specified and selected lamps based on their SPD and the specified work or function of the occupants in that space.

Pre and post occupancy evaluations were conducted. The new design had numerous benefits including the following - "collaborative work increased by 9%, there was improved physical and mental health of employees, their productivity increased by 16%, and there was also an increase of 25% in sleep efficacy" [16].

Figure 4 The American Society of Interior Designers Headquarters (ASIDH) is a pioneering example of user oriented daylight integrated lighting (DIL). Lighting Design: Benya Burnett (Pic: Eric Laignel © ASIDH)

Key Takeaways

1.There is a great deal more to learn
We are facing an unprecedented shift in the lighting profession from a vision/perception-oriented lighting approach, to one that is orientated towards biology [17]. It's imperative that scientists and researchers provide new lighting metrics that can be easily understood and applied by the average lighting professional.

2. Skills require an upgrade
It's essential to upgrade our skills as lighting professionals. More than ever before, we need to become educated in order to interpret the circadian relevance of light and its biological stimulus for health and wellbeing.

3. New lighting equipment is needed
We need to start using spectroradiometers to measure SPDs to assess and specify lighting in individual environments, as CCT is an inadequate metric for LED lighting technology, especially when we look at lighting from a biological perspective.

4. The physics of light must be understood and respected
We need to look at light and its impact on humans, flora and fauna, in a way that takes various lighting characteristics into account, such as the percentage of energy contained within visible light (this means the percentage of both short wavelengths and long wavelengths), as well as flicker.

5. New design rules apply
If we want to provide safer illumination that supports health and wellbeing, we need to approach projects differently to how they have been approached before. This will involve additional time, effort and study.

To conclude, perhaps the words of American lighting designer Paul Gregory can guide us in the 21st century: "We consider every project an opportunity for greatness. We feel we are being given a canvas and a team of collaborators and that the only restriction is our creativity. We approach every project as a new beginning" [18]. So, let us start a new beginning today, by applying the above in our daily practice! ■

An extended version of this article can be found online at www.arc-magazine.com

References

[1] Fundamental research. Available online: https://bit.ly/34gXGMN (accessed on 19 May 2021).
[2] Applied research. Available online: https://bit.ly/34jiwej (accessed on 19 May 2021).
[3] Pérez Vega, C.; Zielinska-Dabkowska, K.M.; Hölker, F. *Urban Lighting Research Transdisciplinary Framework—A Collaborative Process with Lighting Professionals*. Int. J. Environ. Res. Public Health 2021, 18, 624. https://doi.org/10.3390/ijerph18020624
[4] Falchi, F.; Cinzano, P.; Duriscoe, D.; Kyba, C.C.M.; Elvidge, C.D.; Baugh, K.; Portnov, B.A.; Rybnikova, N.A.; Furgoni, R. *The new world atlas of artificial night sky brightness*. Sci. Adv. 2016, 2, e1600377 https://doi.org/10.1126/sciadv.1600377
[5] Longcore, T.; Rich, C. *Ecological light pollution*. Front. Ecol. Environ. 2004, 2, 191–198. Available online: https://bit.ly/34hceMe (accessed on 10 March 2020).
[6] Spivey, A. *Light Pollution: Light at Night and Breast Cancer Risk Worldwide*. Environ. Health Perspect. 2010, 118, A525 https://bit.ly/34TuxaG
[7] Jägerbrand, A.K.; Bouroussis, C.A. *Ecological Impact of Artificial Light at Night: Effective Strategies and Measures to Deal with Protected Species and Habitats*. Sustainability 2021, 13, 5991. https://doi.org/10.3390/su13115991
[8] Zielinska-Dabkowska, K.M.; Xavia, K.; Bobkowska, K. *Assessment of Citizens' Actions against Light Pollution with Guidelines for Future Initiatives*. Sustainability 2020, 12, 4997. https://doi.org/10.3390/su12124997
[9] Zielinska-Dabkowska, K.M. *Knowing when to say no*. Arredo & Citta, 2019, 2, pp. 64-73. https://bit.ly/3wziZFh
[10] Zielinska-Dabkowska, K.M.; Hartmann, J.; Sigillo, C. *LED Light Sources and Their Complex Set-Up for Visually and Biologically Effective Illumination for Ornamental Indoor Plants*. Sustainability 2019, 11, 2642. https://doi.org/10.3390/su11092642
[11] Zielinska-Dabkowska K.M. *Human Centric Lighting. The New X Factor?* arc magazine 2019,108, pp.081-086. ISSN 1753-587 http://bit.ly/3bgHhu5
[12] Houser, K. *Human Centric Lighting: Myth, Magic, or Metaphor*. Available online: https://bit.ly/34kvg4k (accessed on 19 May 2021).
[13] Hansen, E.K.; Bjørner, T.; Xylakis, E.; Pajuste M. *An experiment of double dynamic lighting in an office responding to sky and daylight: Perceived effects on comfort, atmosphere and work engagement.* Indoor and Built Environment 2021. http://doi.org/10.1177/1420326X21991198
[14] Zielinska-Dabkowska K.M. *Home Sweet Home. Connecting the dots for healthy evening residential illumination*. arc magazine 2019, 111, pp.055-060. ISSN 1753-5875 http://bit.ly/30TqCss
[15] Zielinska-Dabkowska K.M., Kelly Waskett R. *Three Principles for Healthy Living with Light and Lighting*. arc magazine 2021, 121, pp. 116-117. ISSN 1753-5875 https://bit.ly/3yJ3bSu
[16] *Impact of Design Series, Vol. 1*. Available online: https://www.asid.org/impact-of-design/asid (accessed on 19 May 2021).
[17] Commission International de L'Éclairage (CIE). *CIE System for Metrology of Optical Radiation for ipRGC Influenced Responses to Light*; Standard CIE S 026/E:2018; Commission International de L'Éclairage (CIE): Vienna, Austria, 2018.
[18] Gregory P. *The Lighting Designer's new role and responsibility. In Proceedings of the 1st Global Lighting Design Convention* PLDC, London, UK, 24–27 October 2007; VIA Verlag: Guetersloh, Germany, 2007; pp. 45–46.

Asst. Prof. Dr. Karolina M. Zielinska-Dabkowska is a chartered RIBA architect and an award winning practicing lighting designer. She is also an Assistant Professor at the Faculty of Architecture, Gdansk University of Technology, Poland, and co-founder of GUT LightLab, where she conducts research on various aspects of light and lighting in the built environment. She is actively engaged in the work of international organisations such as the International Association of Lighting Designers (IALD), the Illuminating Engineering Society (IES), International Commission of Illumination (CIE) and International Dark-Sky Association (IDA), providing guidelines and sharing best practice for nighttime illumination in the built and natural environment. She has participated in a number of international conferences, and has written articles for national and international publications. Karolina joined Women in Lighting (WiL) in March 2018 as an Ambassador for Poland.