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TECHNICAL NOTE

Second International Workshop on Circadian and Neurophysiological Photoreception

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The following 18 members of the Second International Workshop on Circadian and Neurophysiological Photoreception, 2019 (“the workshop”) took part in the preparation of this Working Draft Technical Note.

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Second International Workshop on Circadian and Neurophysiological Photoreception

Summary

This Technical Note reports on the proceedings and consensus of the invited experts of The Second International Workshop on Circadian and Neurophysiological Photometry, 2019. This workshop acted on the basis of a consensus of the participants, who are also the advisers to this report.

The two papers that followed from this workshop in 2020 and 2022 are cited in the report, and these take precedence for the interpretation of its scientific consensus, which is also set out here. Although Technical Notes can also include the personal views of the reporter, the contents of this report have been agreed with all the advisers, unless explicitly stated. The consensus and recommendations summarized in this Technical Note do not necessarily represent the views of the CIE in relation to circadian and neurophysiological photometry.

1 Introduction

The focus of the 2019 Manchester (UK) workshop (“the workshop”) (Brown et al., 2022) related to making recommendations about how to optimize light exposures for promoting circadian health, well-being and performance. It identified the central role of melanopsin-based photoreception in the eye for predicting human physiological responses to light. Its outputs are intended to provide an interpretation for governments, the lighting community and professionals working in public health, whilst highlighting the importance of scientific advances and the growing evidence base in this area.

This Technical Note summarizes the proceedings and consensus of the Second International Workshop on Circadian and Neurophysiological Photometry held in 2019 in Manchester. CIE TN 003:2015 (CIE, 2015), Technical Note on the First International Workshop on Circadian and Neurophysiological Photometry, 2013, dealt with the first workshop in a similar way. Publications following from both workshops are set out in Table 1.

The workshop considered new evidence about what constitutes healthy light and lighting, and the workshop’s recommendations are deliberately built on a measurement system introduced by the 2013 Manchester workshop (“the first workshop”; see CIE TN 003:2015). CIE later formalized this system as the international standard CIE S 026:2018 (CIE, 2018). The 2019 workshop provided a key next step by agreeing the first explicit international consensus recommendations for light exposures that support healthy daily variation in physiology, sleep, and alertness. The recommendations are specified in terms of appropriately quantified numerical threshold levels and associated timings for when light should be sought or avoided.

The three main recommendations from the workshop below deal with daily exposures to light for healthy day-active adults (aged between 18 and 55 years), using exposure thresholds as a function of time-of-day (Brown et al., 2022). The thresholds are expressed in terms of the melanopic equivalent daylight (D65) illuminance (CIE, 2018) (melanopic EDI, in lx) measured at eye height and in the direction of view. The workshop recommendations are described below (for terminology, see Table 2).

- **During the daytime the recommended minimum melanopic EDI is 250 lx**, using daylight if available or, where addition of electric light is required, via white light with a high melanopic daylight (D65) efficacy ratio (melanopic DER¹).

¹ During the daytime, Brown et al. (2022) recommend “polychromatic white light [with] a spectrum that, like natural daylight, is enriched in shorter wavelengths close to the peak of the melanopic action spectrum.” Melanopic DER is the ratio of melanopic EDI to photopic illuminance, sometimes called the “M/P ratio”.

- **During the evening the recommended maximum melanopic EDI is 10 lx**, starting at least three hours before bedtime. To achieve low melanopic EDI values, using electric lighting with a low melanopic DER is advisable.
- **During the night, the recommended maximum ambient melanopic EDI is 1 lx**, and the sleep environment should be as dark as safely possible, reverting to the 10 lx maximum melanopic EDI for unavoidable activities where more light is required for vision.

These three recommendations relate to the shaded areas shown in Figure 1 (to blue, grey and dark grey, respectively), and derive from an interpretation of the data that are summarized in that Figure.

Whilst there are exceptions to these guidelines, for a range of practical reasons, the workshop's consensus view is that these principles now have a sufficiently reliable evidence basis, drawn from good quality scientific research, and that these initial recommendations can be applied to architectural and integrative lighting designs, as well as lifestyle advice.

Table 1 — Timeline of key publications following from the 2013 and 2019 Manchester workshops

The First International Workshop on Circadian and Neurophysiological Photometry was held in Manchester (UK) on 10-12 January 2013.	
January 2014	A review paper (Lucas et al., 2014) setting out the first workshop consensus, with research and α -opic metrological recommendations. The 2014 “irradiance toolbox” first supported the use of five α -opic irradiances and α -opic equivalent illuminance quantities relating to non-visual photoreception in humans.
July 2015	A Technical Note (CIE, 2015) interpreting the first workshop consensus. This included the second, SI-compliant, irradiance toolbox as a CIE publication.
November 2018	An International Standard (CIE S 026/E:2018, http://doi.org/10.25039/S026.2018) for the α -opic measurement system, “CIE System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light.” The standard retained the approach of the recommendations of the first workshop, harmonized rod and cone action spectra with existing CIE publications, and adopted the CIE standard illuminant D65 as the reference daylight spectrum for normalizing α -opic equivalent photometric quantities, via five new α -opic efficacy constants.
March 2019	A CIE “ α -opic toolbox” based on CIE S 026:2018 (CIE, 2018) to replace the irradiance toolbox. The 2019 beta-version and user-guide are superseded by maintained CIE versions (Schlangen et al., 2019): (http://doi.org/10.25039/S026.2018.TB , http://doi.org/10.25039/S026.2018.UG).
May 2019	The 9th edition of the Système International (d'unités) (ISBN 978-92-822-2272-0), incorporating a CIE reconciliation of the photon and energy systems of radiometry (from the conversion basis in the first irradiance toolbox)
The Second International Workshop on Circadian and Neurophysiological Photometry was held in Manchester (UK) on 21-23 August 2019.	
October 2019	The latest CIE Position Statement on Non-Visual Effects of Light (CIE, 2019). Its guidance, informed by the 2019 workshop, is for high melanopic EDI during the day, and low melanopic EDI at night, for people with a regular, day-active schedule.
April 2020	A meta-analysis of ecologically valid studies of physiological responses to light exposures (Brown, 2020) to investigate the explanatory power of the five spectral sensitivities in CIE S 026, the follow-up to one of the workshop papers
March 2022	A review paper setting out the latest workshop's consensus (Brown et al., 2022), with recommendations about healthy exposures to light.