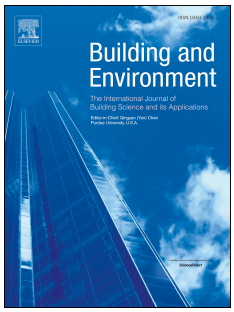
Accepted Manuscript



A proposed lighting-design space: Circadian effect versus visual illuminance

Qi Dai, Wenjing Cai, Wen Shi, Luoxi Hao, Minchen Wei

PII: S0360-1323(17)30260-3

DOI: 10.1016/j.buildenv.2017.06.025

Reference: BAE 4953

To appear in: *Building and Environment*

Received Date: 31 March 2017

Revised Date: 11 June 2017

Accepted Date: 12 June 2017

Please cite this article as: Dai Q, Cai W, Shi W, Hao L, Wei M, A proposed lighting-design space: Circadian effect versus visual illuminance, *Building and Environment* (2017), doi: 10.1016/j.buildenv.2017.06.025.

A proposed lighting-design space: circadian effect versus visual illuminance

Qi Dai [1, 2, 3, *], Wenjing Cai [1], Wen Shi [1], Luoxi Hao [1, 3], and Minchen Wei [4]

[1] *College of Architecture and Urban Planning, Tongji University, 1239 Siping Road, Shanghai 200092, China*
[2] *Institute for Advanced Study, Tongji University, 1239 Siping Road, Shanghai 200092, China*
[3] *Key Laboratory of Ecology and Energy-saving Study of Dense Habitat (Tongji University), Ministry of Education, 1239 Siping Road, Shanghai 200092, China*
[4] *Department of Building Services Engineering, The Hong Kong Polytechnic University, 11 Yuk Choi Road, Kowloon, Hong Kong*

Abstract:

Light causes not only vision, but also non-visual effects such as regulating the circadian system. Although the effort to fully understand the mechanism of non-visual response is still ongoing, quantitative models have been proposed to evaluate light's circadian stimulus based on the characteristics of light incident on human eyes. With the light-emitting diode (LED) technology providing flexibility in spectral design, it is now possible to tune lighting's circadian and visual effects to suit the uses of different built environments. Therefore, it is important to develop a lighting-design approach that considers both visual and non-visual aspects, and understand what combinations are achievable for general illumination applications.

In this work, we propose a lighting-design space that allows the exploration of combinations of circadian effect and brightness (visual lit appearance). To demonstrate the feasibility of this approach, we develop a color-mixing method for four-channel color-tunable LED light sources, and maximize the gamut of the proposed space. This gamut represents the possible design objectives that interior lighting designers can target. As an example of application, we demonstrate that our color-tunable LED solution can be used to dynamically simulate both circadian and visual properties of daylight.

Keywords:

Interior luminous environment; Circadian effect; Spectral power distribution; Mean room surface exitance; Daylight; Light quality

1. Introduction

As noted in the sign of Edison electric light bulbs in the late 19th century, "The use of electricity for lighting is in no way harmful to health, nor does it affect the soundness of sleep" [1], there was no doubt that the only purpose of electric lighting was to provide vision. The lighting technology then evolved rapidly in the 20th century: incandescent, fluorescent and high-intensity discharge lamps lit up numerous homes, offices, industries, and public spaces, and light was found to have impacts on human circadian, hormonal, and behavioral systems [2,3]. In the 21st century, with research breakthroughs in photobiology [4,5] and LED technology [6], the non-visual response of lighting and its potential health benefits for building occupants became a research hotspot [7-16].

Intensive research efforts on light's circadian effect started from the turn of the millennium, triggered by the discovery of the non-image-forming intrinsically photosensitive

* Corresponding author. Tel: +86 21 65982929; E-mail address: qidai@tongji.edu.cn