Poster

Nonvisual Light-Response Model: A Preliminary Approach to Integrating Recent Findings in Biology into a Lighting Simulation Process

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Introduction

In addition to stimulating visual responses, light induces a range of circadian, neuroendocrine and neurobehavioral non-visual responses in humans. These effects are mediated primarily via a novel non-rod, non-cone photoreceptor, which is most sensitive to blue light (λ_{max} 480nm) and exhibits different sensitivity to the spectrum, timing, intensity, duration and pattern of exposure as compared to visual responses. The discovery of this novel photoreceptor has led to consideration of the nonvisual effects of light as an important element of healthy lighting design in addition to vision. Before application of these new findings, however, it is necessary to first understand, and then model how the nonvisual system responds to light. One challenging aspect is the fact that the nonvisual system adapts its responses to changes in light intensity and spectral composition over a much longer timeframe than the visual system. Here, we propose a functional model of the nonvisual light-response relationship that combines temporal integration and a static nonlinear function.

Approach

We apply a commonly used system approach to describe human processing of nonvisual light. In the model the light stimulus l(t) is passed through a linear filter $L_1(t)$ giving the output u(t). Then u(t) is transformed by a static nonlinear function N(u) describing the intensity-response relationship to the light stimulus. The output of N(u), v(t), is then passed through a second filter $L_2(t)$. Thus, the two linear filters reflect the temporal processing between the light stimulus and the output response. Preliminary results show that the model can capture the nonvisual response of time-varying light exposure, but it is limited to bright light intensities due to lack of experimental data. However, the model is not limited to one type of intensity-response function, which allows for more flexibility as knowledge accumulates.

Application

Linking the model to a lighting simulation process is important, because the ultimate goal is to develop a new type of lighting design support. In the interest of providing the designer with an informative visual representation, an additional user-defined input is required specific to the desired design performance. By evaluating the response output against such user-defined goals, a format can be provided to the designer illustrating whether a given goal is met or not.

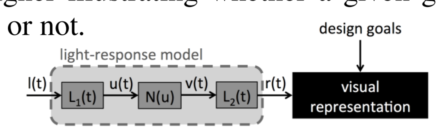

Fig. 1: A diagram of the light-response model structure and its linkage. This type of functional model is referred to as linear-nonlinear-linear (LNL) model.

Conclusion

The light-response model holds promise because it aims to understand and functionally describe the underlying mechanism of the nonvisual system. Moreover, it may lead to a new approach to support healthy lighting design, but further research has to be conducted to refine and validate the proposed model.