Healthy lighting: integrating non-visual responses into simulation framework

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Photobiology

Is it possible to predict if spaces are good or bad for health using models based on the discovery of a novel non-visual photoreceptor?

Develop a model to predict the nonvisual responses to light

Modeling & Simulation

Integrate health aspects of light into a simulation-based framework

Architecture

Validate novel guidelines that can support the design of healthy lighting environments

Motivation: The eye has a dual role

- In addition to vision, light induces a range of physiological and neurobehavioral non-visual responses in humans, including synchronizing circadian rhythms and directly alerting the brain.
- These non-visual effects of light are mediated primarily via a novel non-rod, non-cone photoreceptor.
- The novel photoreceptor exhibits different sensitivity to the intensity, spectrum, duration, history and timing of light exposure as compared to rods and cones.
- The dynamic behavior of the non-visual system provides new challenges in evaluating light performance of buildings.

Daylighting simulation

The necessary input is:
- a 3D building model
- a climate data file
- a sensor point file

Light pattern generation

The movements of humans must be simulated to estimate the total light exposure received.

Human light-response simulation

- Non-visual responses must be evaluated based on dynamic threshold values, which depend on intensity, spectrum, duration, history and timing of light exposure.
- Currently, there is no mathematical model that incorporates all five variables to predict the non-visual effects of light on humans.
- A block-structured model is proposed that combines temporal integration and a static nonlinear function to describe human processing of non-visual light.
- The two linear filters reflect the temporal processing between the light stimulus and the output response.

Results interpretation: Temporal maps show the annual performance of daylighting design

Illuminance map resulting from daylighting simulation.

Temporal map for non-visual responses as predicted by our proposed light-response model.

Conceptual map based on user-defined goals specific to the desired design performance.

Pattern

Intensity

Duration

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