Light and Lighting

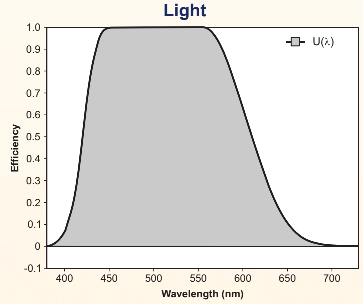
(or, Gloom and Doom for the Lumen)

There has not been a systematic look at the foundations of photometry and lighting applications for nearly a century. Much has been learned since 1924 when the photopic luminous efficiency function, V(λ) was officially adopted, yet we continue to define light and lighting in terms of V(λ). Over the last 90 years, neuroscience has revealed many of the fascinating ways that humans extract information about the luminous environment. But for lighting, it's as if that large body of neuroscience research does not exist.

There are many neural channels emanating from the retina, not just one as implied by the reliance on V(λ). Each channel has a different spectral sensitivity to optical radiation incident on the retina, so to maximize human benefits while minimizing wasted energy and cost, we need to specify lighting for the visual or non-visual channels most important for the application.

Light and lighting are linked, but separate domains. Light is defined as a physical quantity, like mass and time, to support international commerce, and the light produced by a given light source should be measured the same way, anywhere on Earth. Lighting is specified for a given application to provide a benefit to users, and different neural channels in the retina and brain provide different benefits. The lighting should vary depending upon the design objectives. In other words, light should have a single definition with which everyone agrees, but lighting should be different for reading or for driving a car at night.

Light



Universal luminous efficiency function, U(λ)

Citation

Rea MS. Shedding Light on Light and Lighting. 28th Session of the CIE. Manchester, UK. June 28 – July 4, 2015.

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Problems with V(λ) with regard to light

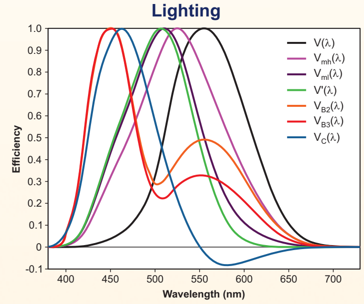
- Too narrow to represent "the eye sensitivity curve" as was intended in 1924 and as commonly thought of today
- Encourages manufacturers to produce green, not white, light
- Adds confusion when other efficiency functions (e.g., scotopic) are used

The solution is a single universal luminous efficiency function, U(λ), that represents the "eye sensitivity curve" because it is based upon all of the photoreceptors in the human retina.

Problems with V(λ) with regard to lighting

- Wasted energy because light source spectra are not tuned to different benefits
- False dichotomies between efficacy and color rendering, circadian regulation, and off-axis detection, which are artifacts of using V(λ).

Lighting



Benefit luminous efficiency functions

The solution is a family of benefit efficiency functions, each characterizing the spectral sensitivity of a different visual or non-visual channel, to determine which light source provides the greatest benefit for a given design objective (e.g., on-axis visual performance, scene brightness perception, off-axis detection, or circadian entrainment).

The family of benefit efficiency functions used for lighting should be conceptually distinct from the single universal luminous efficiency function underlying the definition of light. By analogy, U(λ) represents potential flux emitted by a light source, while benefit efficiency functions represent different amounts of kinetic flux that are applied in lighting.

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Lighting Research Center, Rensselaer Polytechnic Institute • 21 Union Street • Troy, NY 12180 • (518) 687-7100 • www.lrc.rpi.edu