Measuring lightness constancy with varying realism

David-Elias Künstle and Felix A. Wichmann

Photorealistically 3D-rendered stimuli provide fine control over cues that might contribute to lightness perception.

Triads and ordinal embedding methods provide lightness scales and allow comparisons between cue conditions.

Responses are not affected by scene realism but by surround contrast in realistic scenes.

Motivation

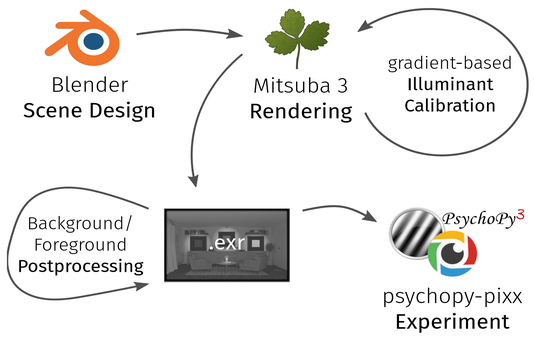
Lightness constancy is achieved if, effectively, the surface reflectance is perceived independent of illumination.

Lightness constancy has been reported to be stronger in complex, realistic scenes.

In the real world, various cues might help separating reflectance and illumination:
For example, surround contrast, visible light sources, gradients, or shadows.

Which cues contribute to lightness constancy?

3D-rendered stimulus



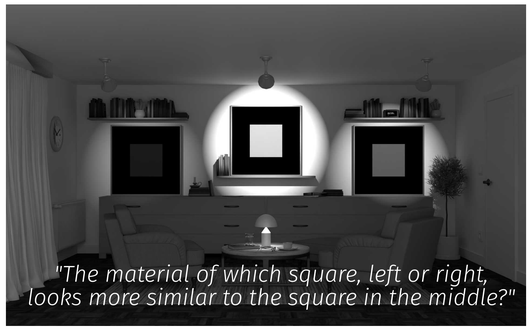
Illuminants and center-surround reflectances are parametrized.

Illuminants are calibrated; they have the same intensities at different locations.

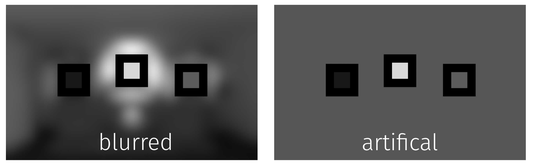
Rendering is fast & parallelized on compute clusters (~60 HD images/hour/GPU).

16-bit luminance resolution in PsychoPy on ViewPixx LCDs with our plugin *psychopy-pixx*.

Triads & Conditions



Background realism



Surround contrast

Eight observers, 500 trials per condition.

Estimate psychophysical scales of lightness perception per observer and condition.

Scales estimated from triad responses with *ordinal embedding* algorithms using the *cblearn* Python package.

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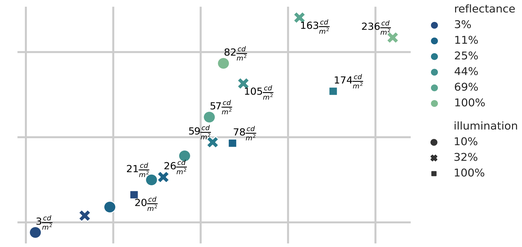
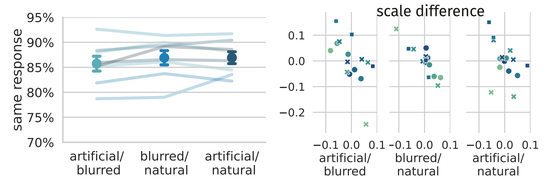
Lightness scaling

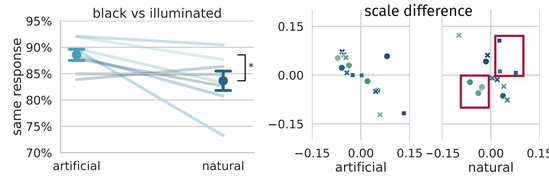


Patches that are perceived as more similar are drawn closer together.

Realism shows no effect



Surround changes responses



The lightness scale seems to be dominated mainly by brightness for dark patches;
only from around 50 cd/sqm, the scale splits into reflectance and illuminance.

Most responses are identical for all background variations, indicating that background realism does not affect lightness perception.

The visible surround illumination supports the independent perception of reflectance and illumination—but only in the realistic condition.

References
[1] Logvinenko, & Maloney (2006). Perception & Psychophysics.
[2] Murray, R. F. (2021). Annual Review of Vision Science.
[3] Haghiri S., Wichmann F. A., & Luxburg U. (2020). Journal of Vision.

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