

Effect of Field of View and Cosine Correction on Spatial Efficiency for Indoor Lighting

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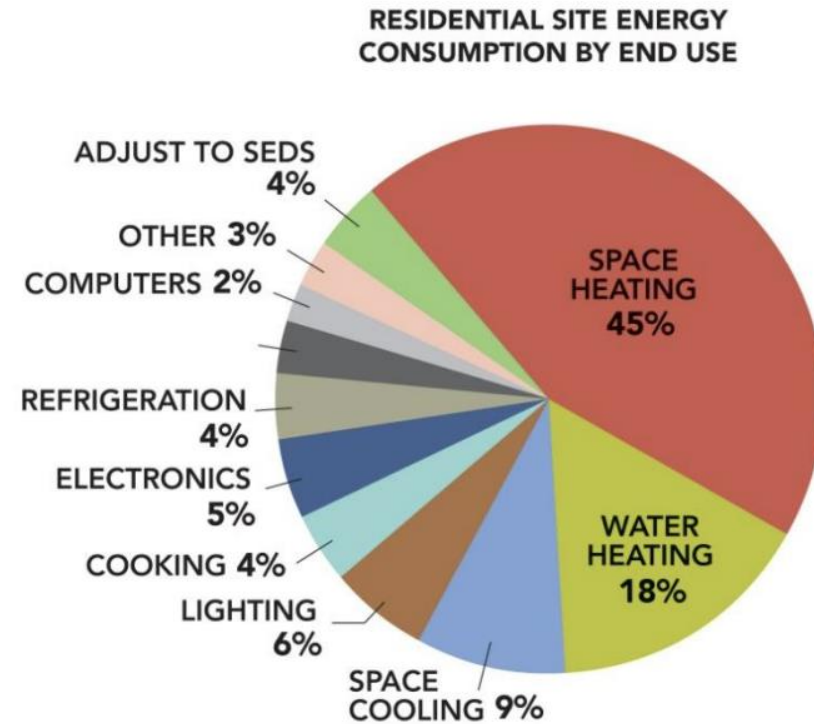
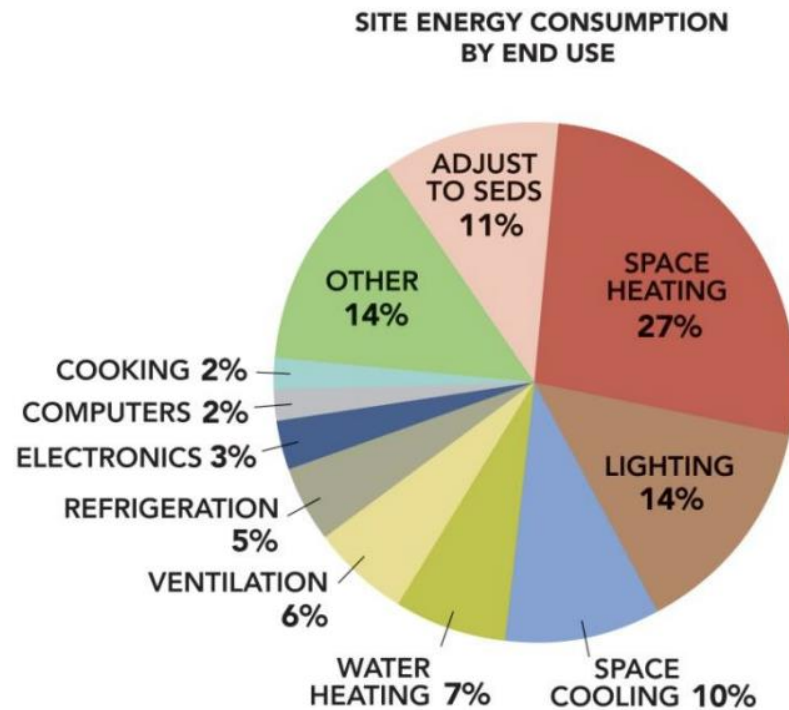
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Outline

- Introduction
- Background
- Lighting application efficacy framework
 - Spatial efficiency for FOV
 - Human visual system sensitivity to light
- Results
- Conclusion
- Future research

Introduction

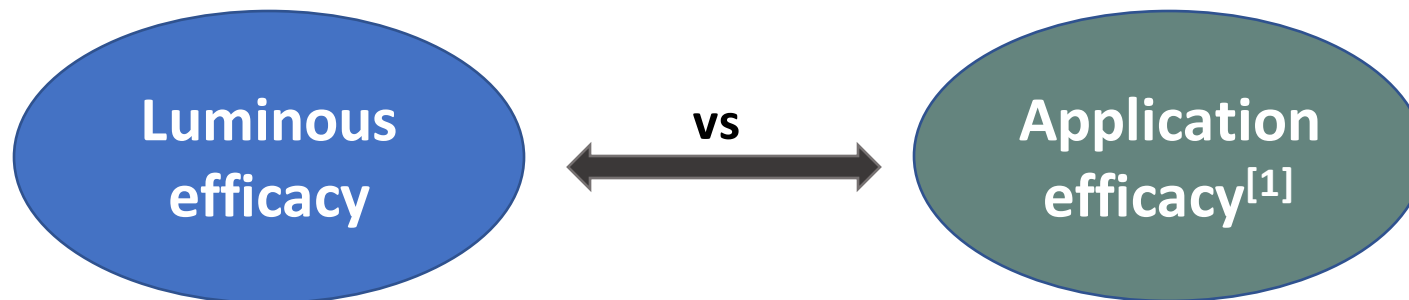
- Optimizing the use of electric lighting in buildings



Background

The focus of current lighting efficiency metrics^[1]:

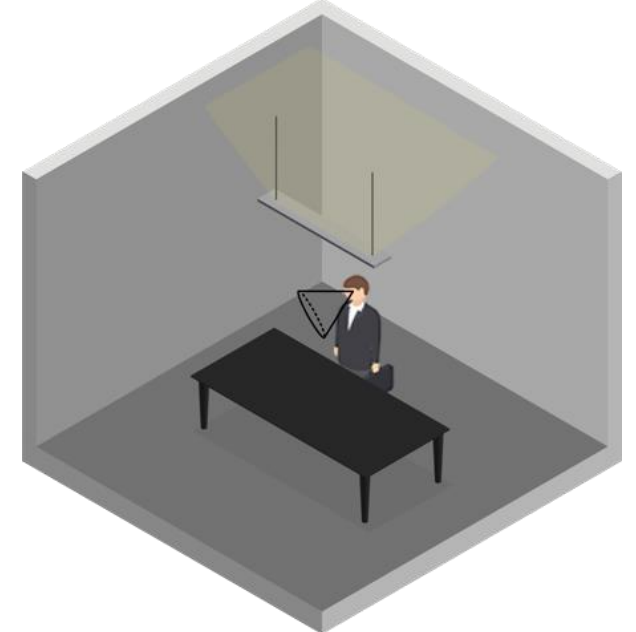
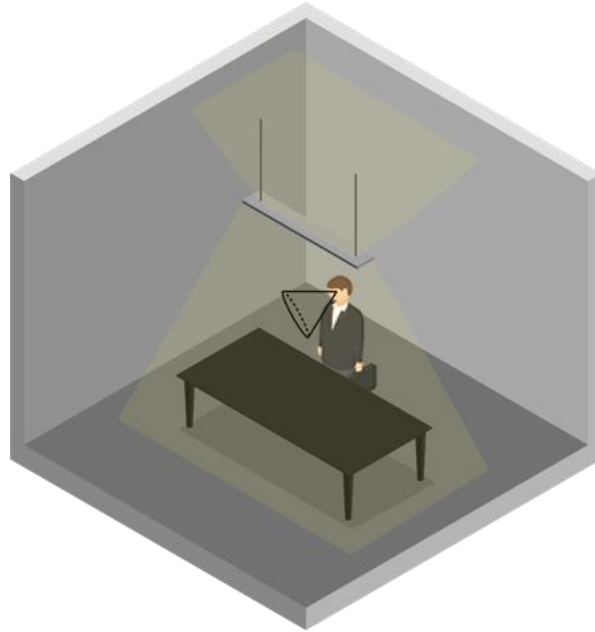
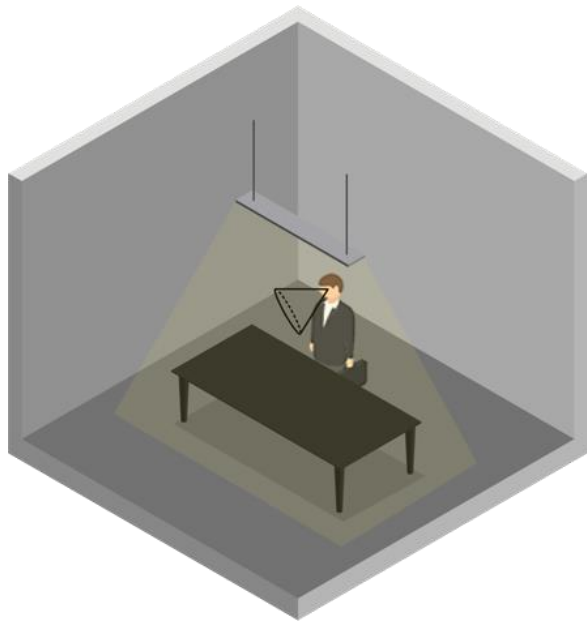
- Components of lighting installations, such as luminous efficacy
- Lighting power density
- Energy consumption



[1] Rea, M. S., & Bullough, J. D. (2001). Application efficacy. *Journal of the Illuminating Engineering Society*, 30(2), 73-96.

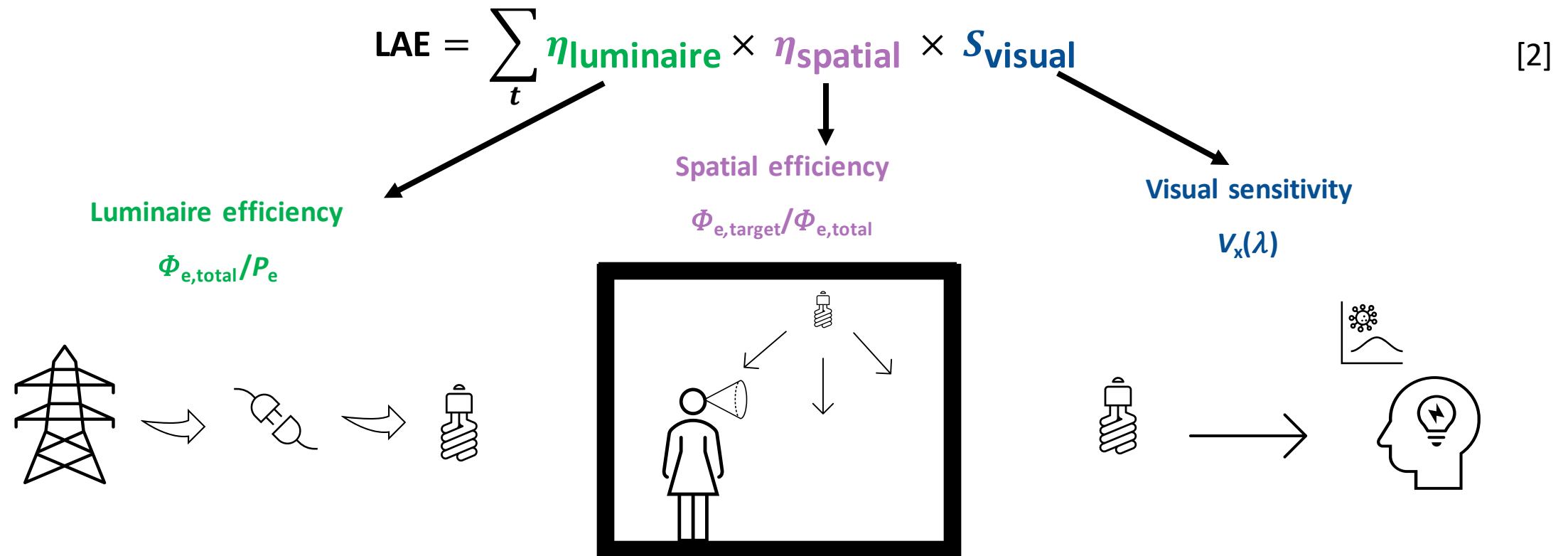
Motivation

- Lack of effective quantification of the useful light, which is perceived by occupants or can have an impact on the human physiology or psychology



Lighting application efficacy framework

- The efficient delivery of light from light source(s) to the target(s)

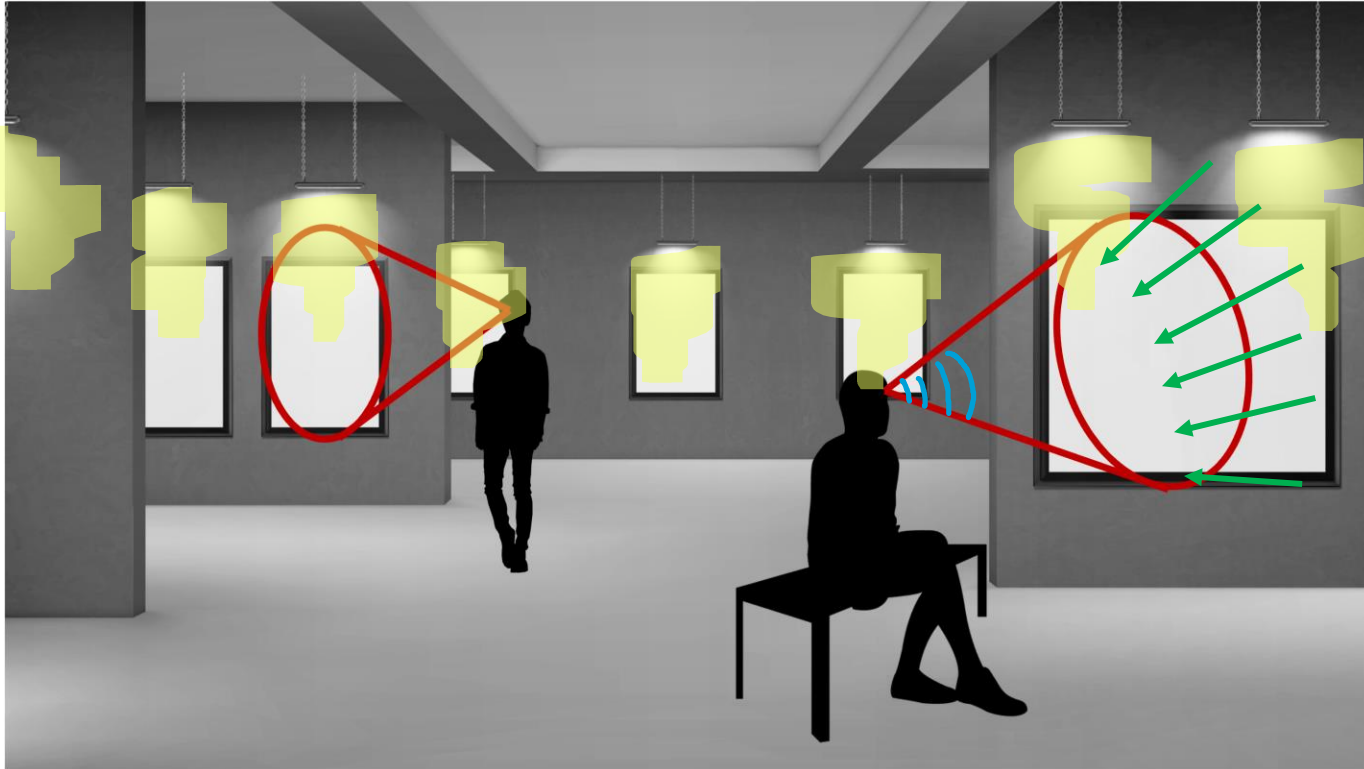


Spatial efficiency for field of view (FOV)

- The amount of radiant flux emitted by the luminaire(s) that reflects off surfaces and reaches occupants' eyes

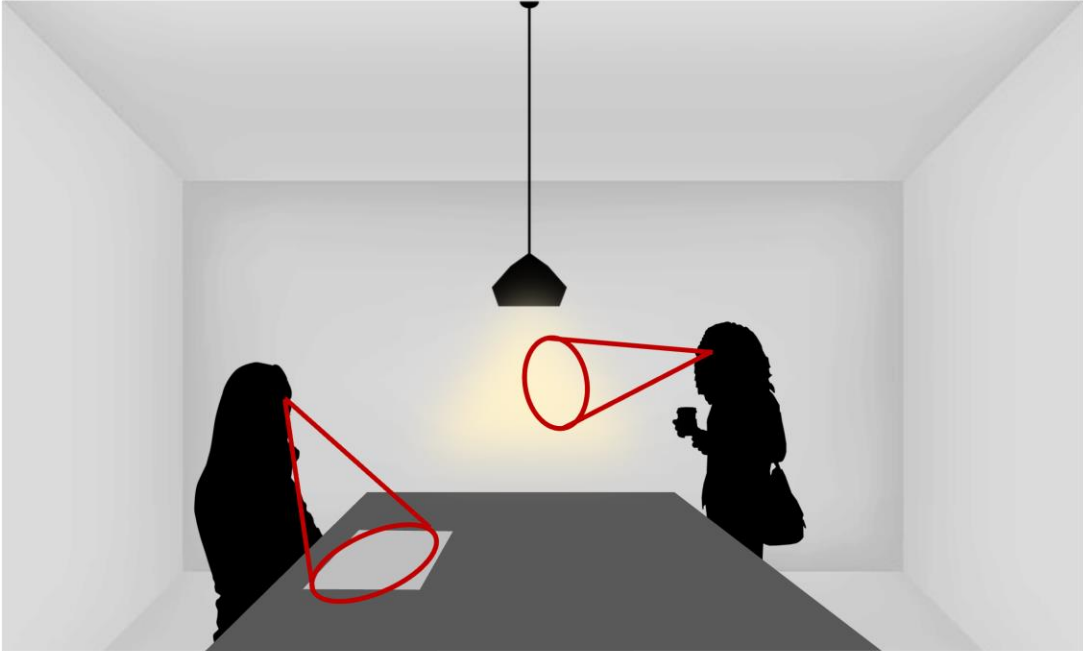
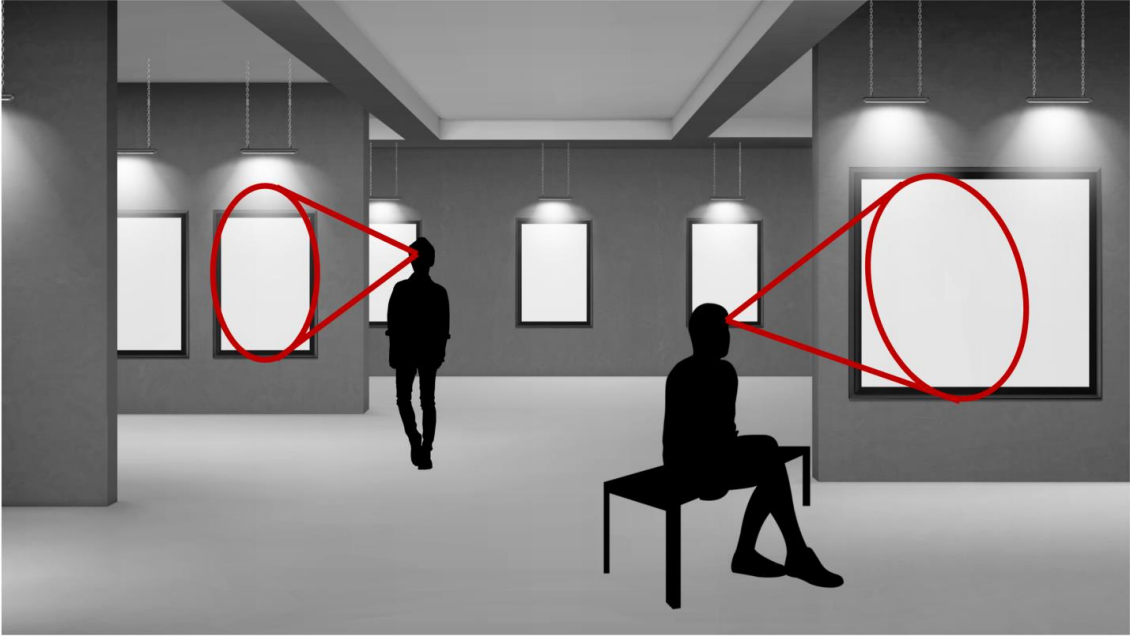


Spatial efficiency for FOV



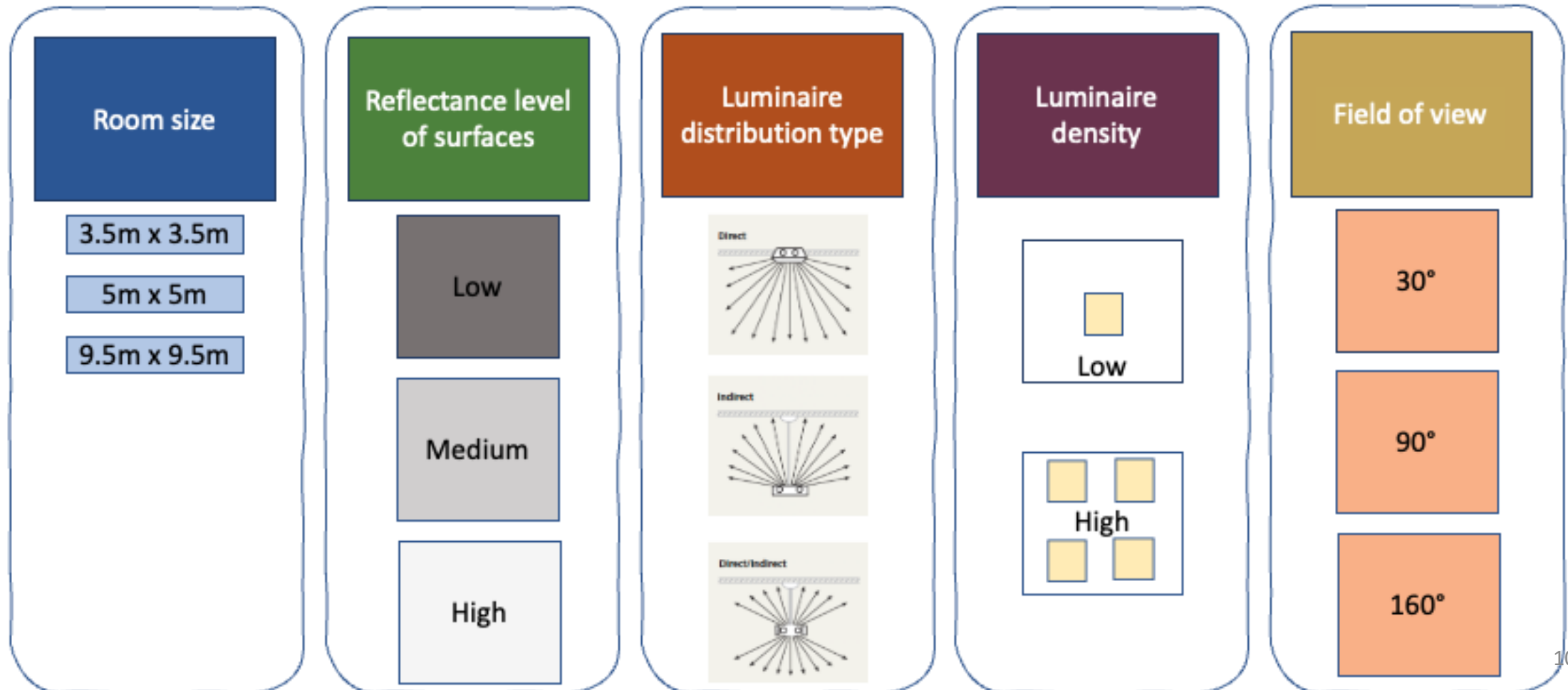
$$\eta_{\text{spatial, FOV}} = \frac{\int_0^{\Omega} L_e d\Omega}{\phi_{e,\text{total}}} \quad (\text{m}^{-2})$$

Spatial efficiency for FOV



Spatial efficiency simulations using Radiance

Parameters used in simulations for spatial efficiency for FOV

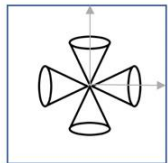


Spatial efficiency simulations using Radiance

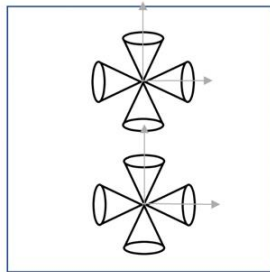
Homogenous sensitivity to radiance across all angles of the FOV

vs

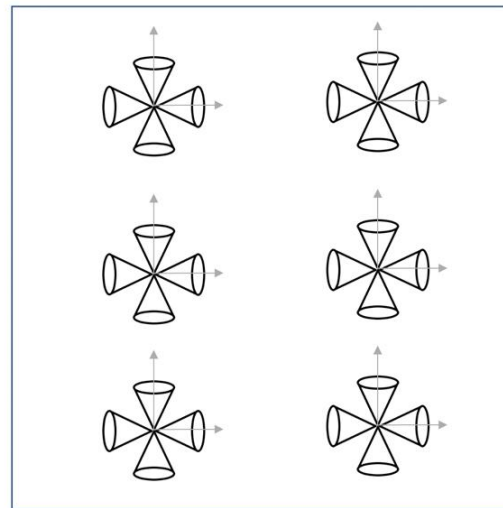
Cosine correction to the rays coming from different angles to the FOV



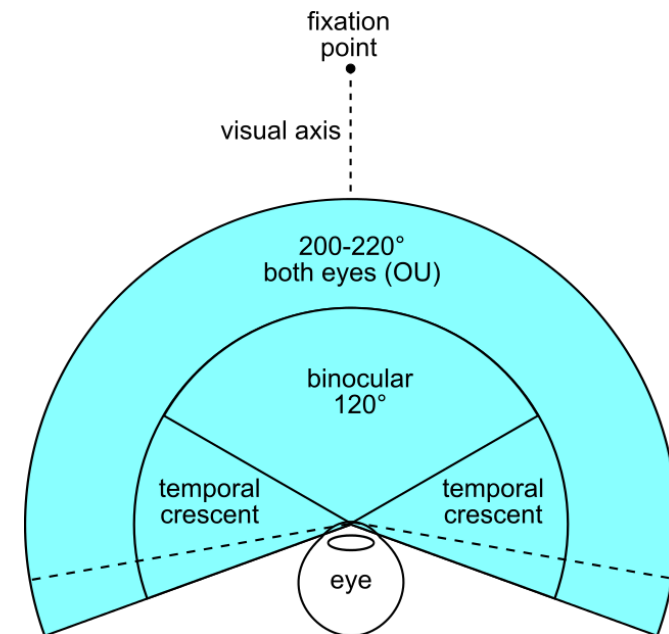
$3.5 \times 3.5 = 12.25 \text{ m}^2$
(per occupant)



$5 \times 5 = 25 \text{ m}^2$
(12.5 m^2 per person)

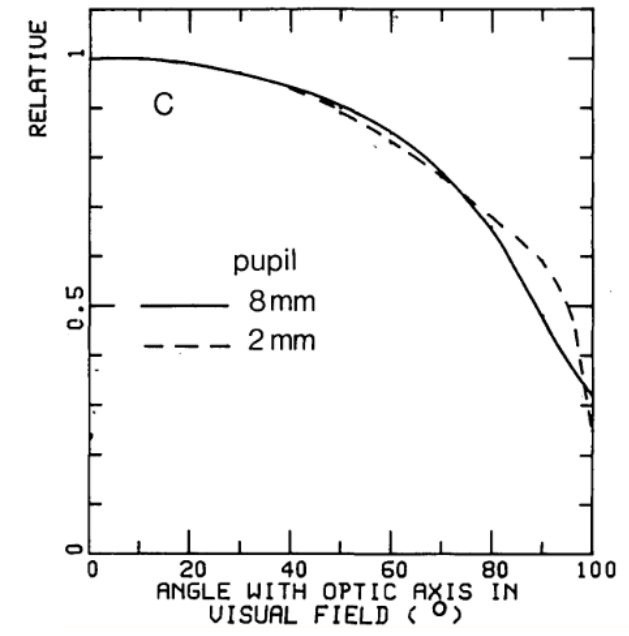
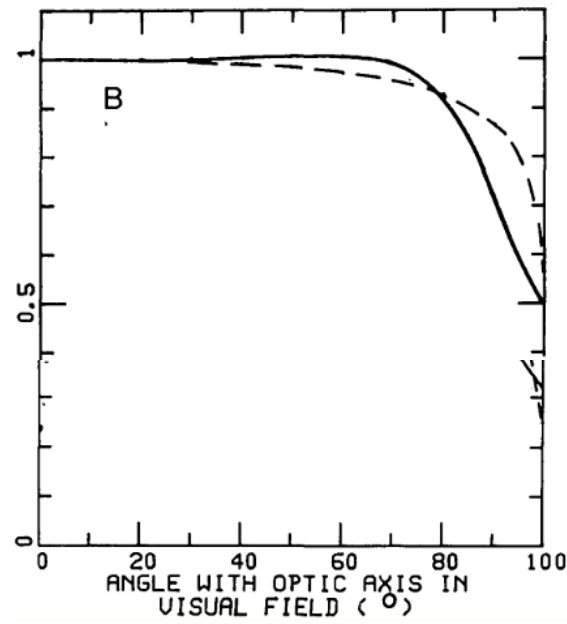
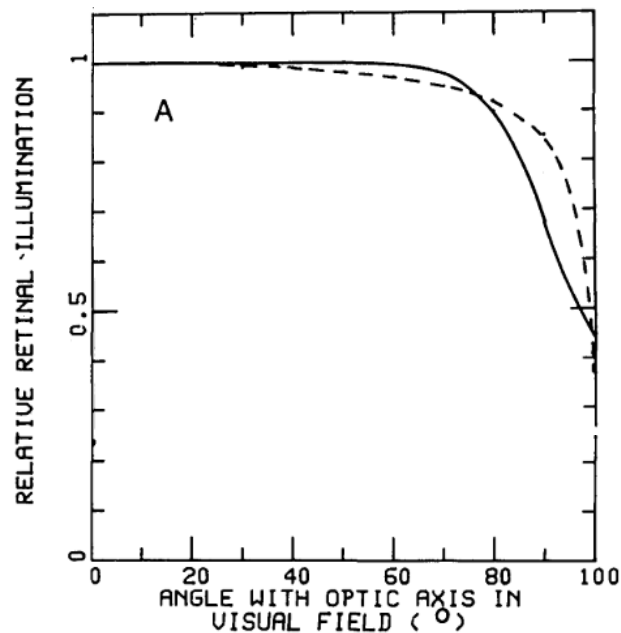


$9.5 \times 9.5 = 90.25 \text{ m}^2$
6 occupant (15.04 m^2 per occupant)



Human visual system sensitivity to light

- Potential changes in sensitivity to light with retinal eccentricity [4-5]



[6]

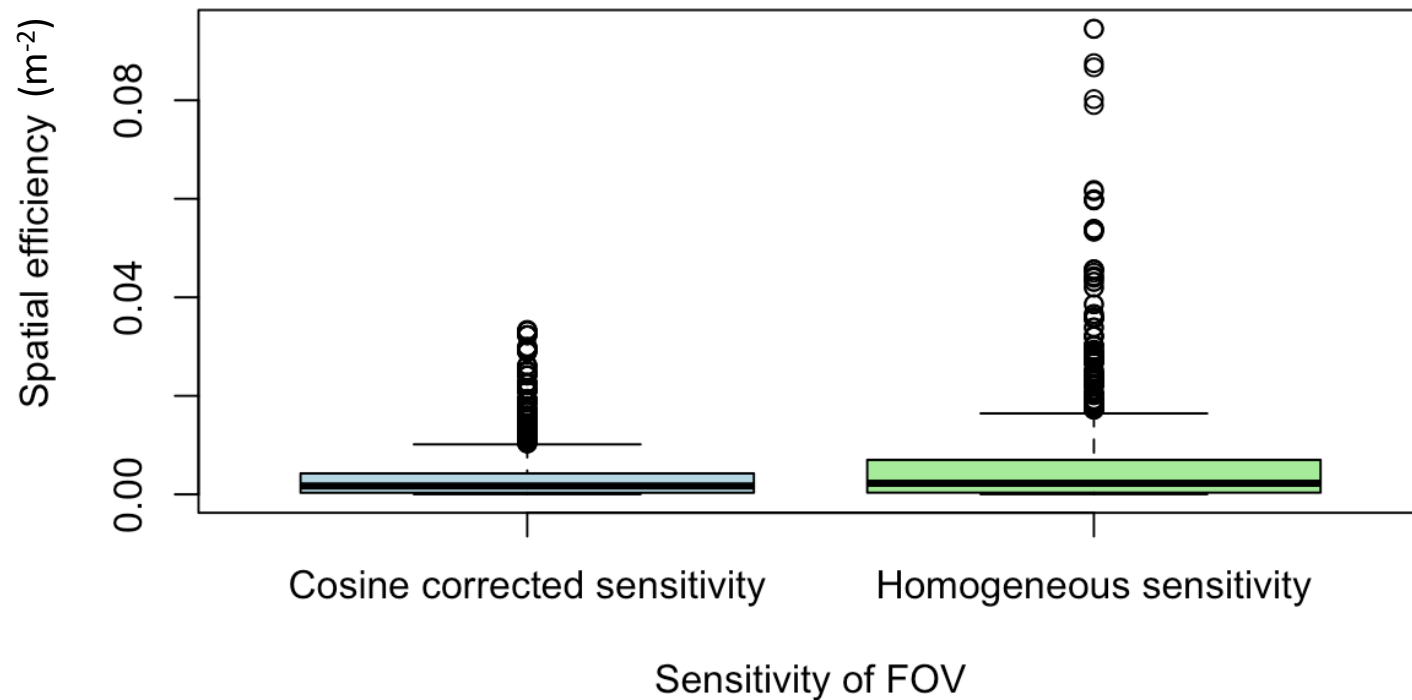
[4] Marks, L. E. (1966). Brightness as a function of retinal locus. *Perception & Psychophysics*, 1, 335-341.

[5] Sampson, D. M., Roshandel, D., Chew, A. L., Wang, Y., Stevenson, P. G., Cooper, M. N., ... & Chen, F. K. (2021). Retinal differential light sensitivity variation across the macula in healthy subjects: importance of cone separation and loci eccentricity. *Translational vision science & technology*, 10(6), 16-16.

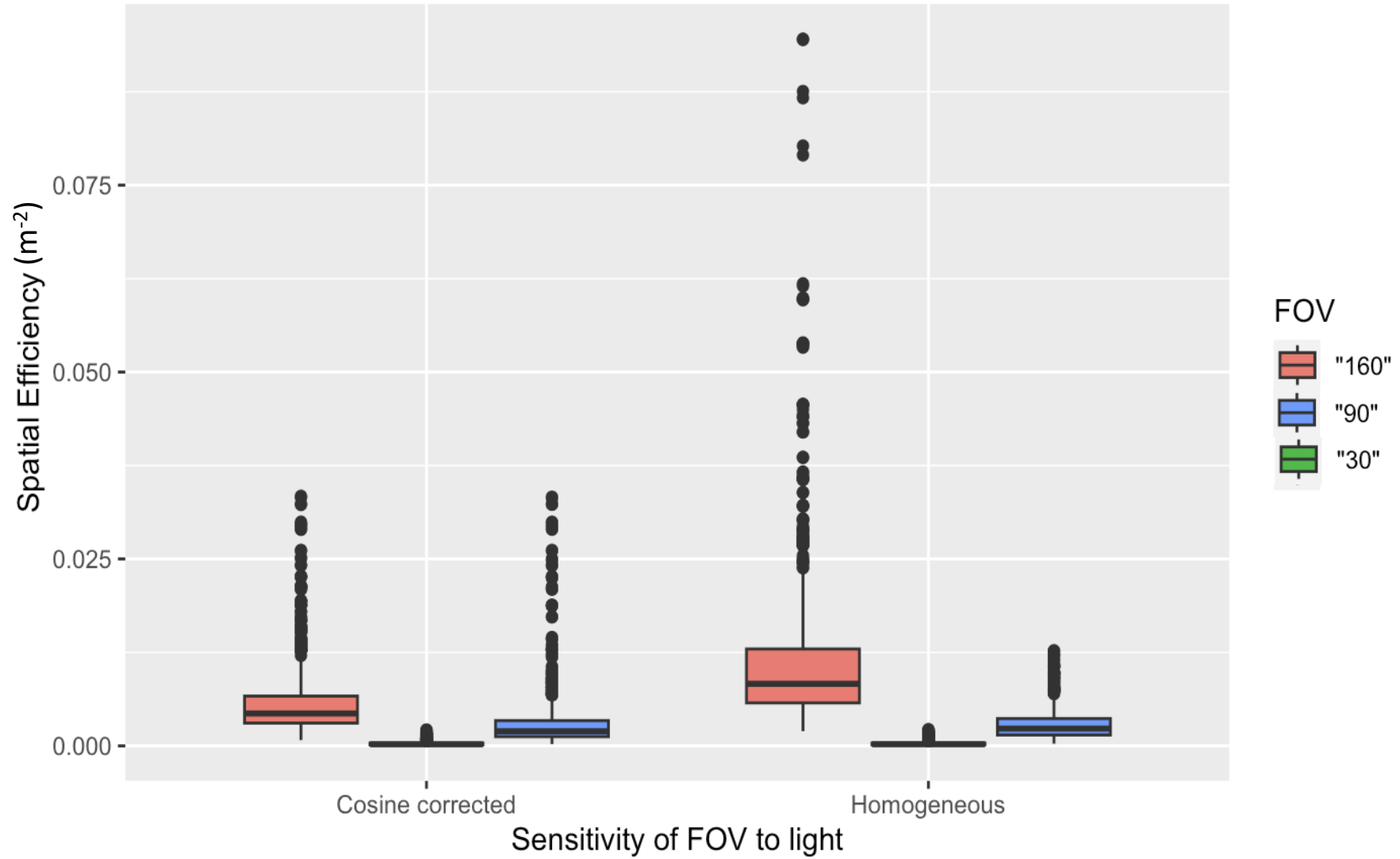
[6] Kooijman, A. C. (1983). Light distribution on the retina of a wide-angle theoretical eye. *JOSA*, 73(11), 1544-1550.

Results

- Significant difference between the spatial efficiency values with homogeneous sensitivity and spatial efficiency values with cosine corrected sensitivity ($p < 0.001$)



Results



Conclusion

- The LAE framework's versatility for adaptability
- Spatial efficiency variations with corrections/modifications
- Application-dependent potential for further enhancing lighting design efficiency
- Acknowledging the importance of tailored approaches for optimized outcomes
- Emphasizing the significance of continuous improvement and adjustment

Future research



Take aways

- Recognizing the power of **customized lighting efficiency calculations** based on **design** and **application**.
- Inspiring the need for **continued research** and collaboration among researchers to build upon the knowledge and expand the possibilities.

Thank you!
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