Game Over UGR

An alternative physiological model for discomfort glare

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Glare

- Disability

Impairs the vision of objects

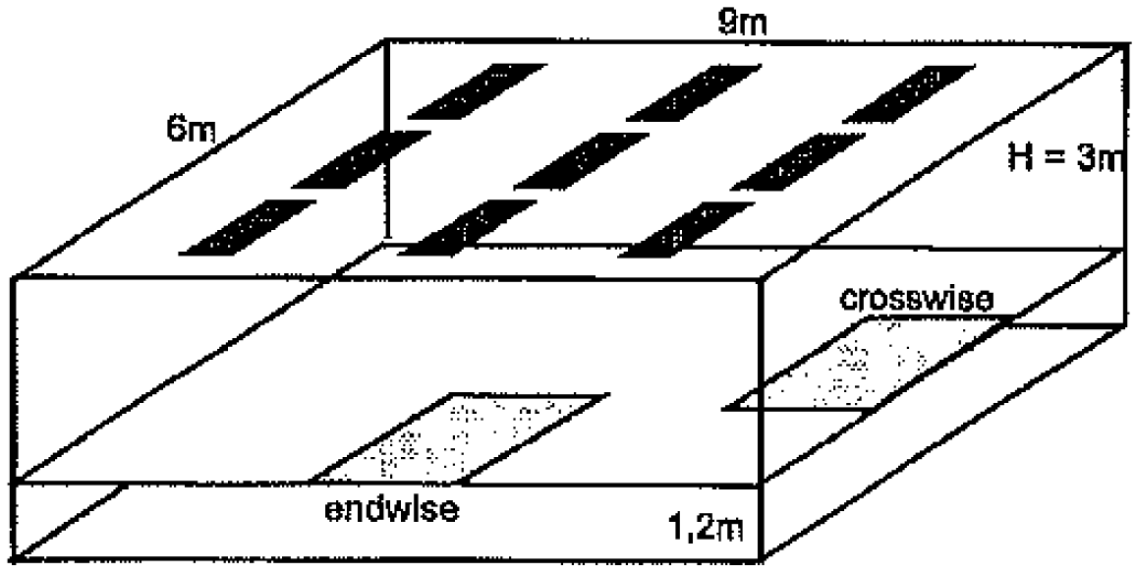



- Discomfort

Causes annoyance or pain



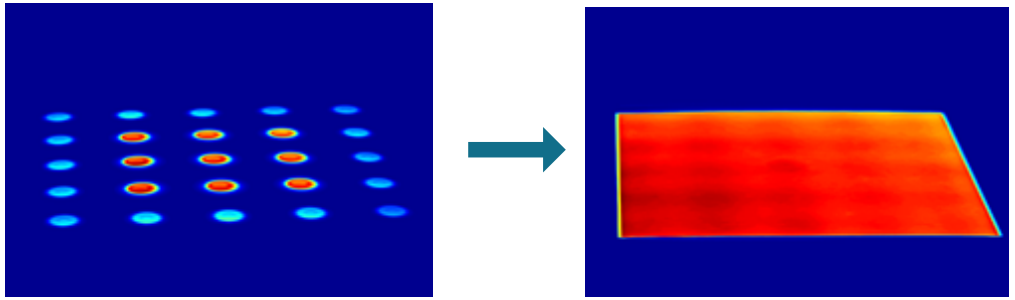

Unified Glare Rating



$$UGR = 8log\left[\frac{0.25}{L_b}\sum\frac{L^2\omega}{p^2}\right]$$

- Light source luminance
- Solid angle
- Background luminance
- Position index

Each luminaire one term
=> **uniform** approximation



UGR < 10 => No glare
UGR > 40 => Unbearable glare

Problem non-uniform light sources

‘Old’ lamps

’Old’ glare metrics valid for ‘new’ lamps?

‘New’ lamps

Game Over UGR?

'Your reporter has referred to UGR as a "leaky boat". Is it time, therefore, to develop a new system rather than to try further patch the "leaks".'

Solutions

Option 1: UGR for non-uniform sources

Quickfix

CIE JTC7
Discomfort caused by glare from luminaires with a non-uniform source luminance

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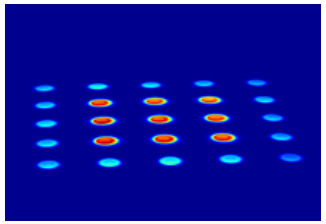
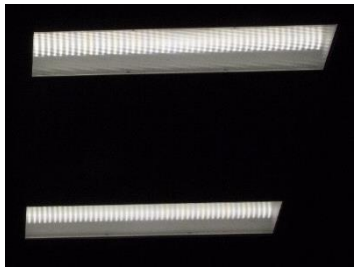
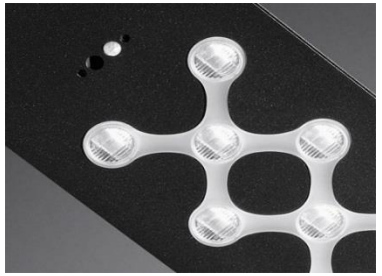
Defining the Actual Luminous Surface in the Unified Glare Rating. Leukos, 13 (4), 1-10.







Option 2: New discomfort glare index

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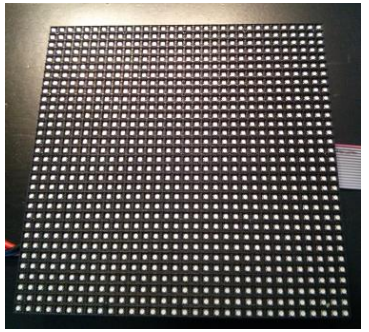
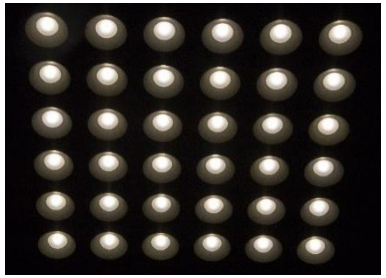




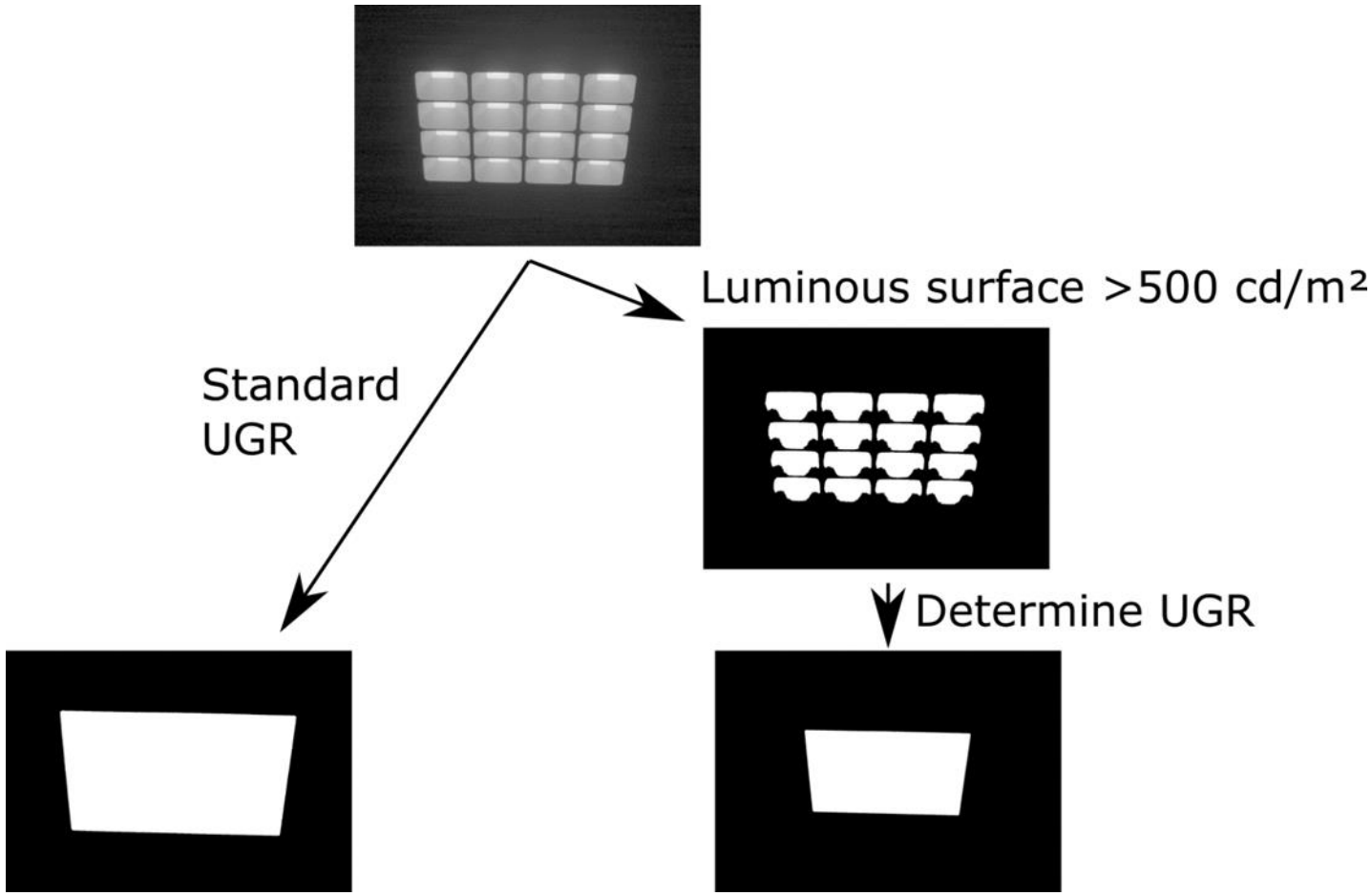
Quickfix UGR

As in CIE 117-1995, appendix C3: “Luminiare size and shape data”

luminous area > 500 cd/m

⇒Reduce solid angle

⇒Increase average luminance



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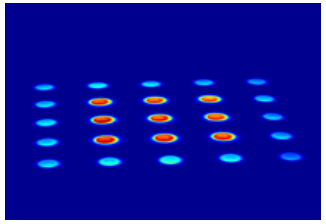

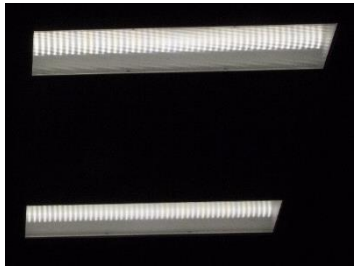

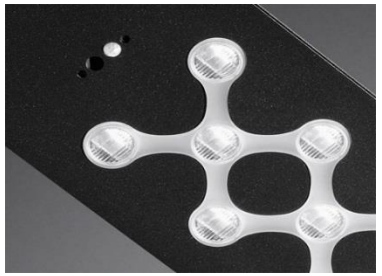

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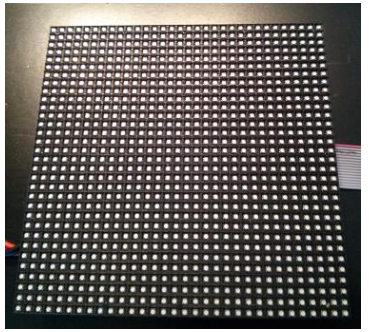
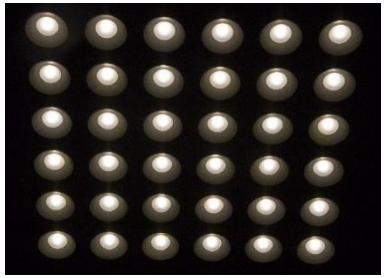
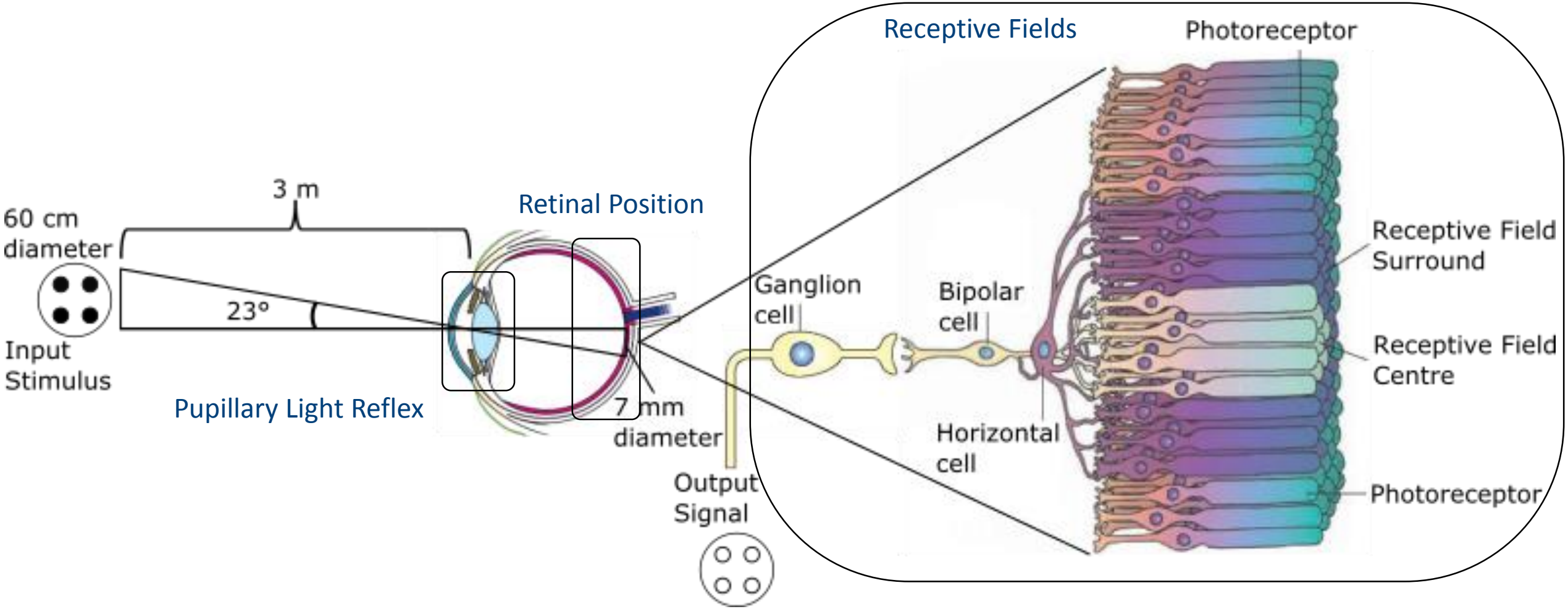




Human Visual Perception System



Hubel, 1988. Eye, Brain and Vision

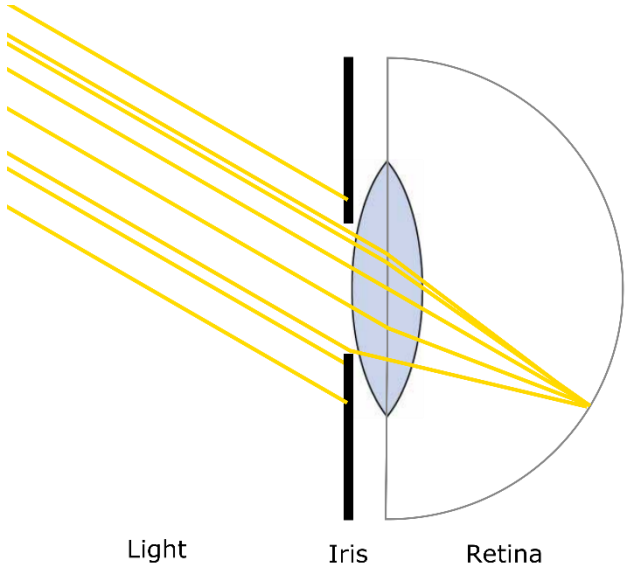
Pupillary Light Reflex

Dim environments: pupil dilation

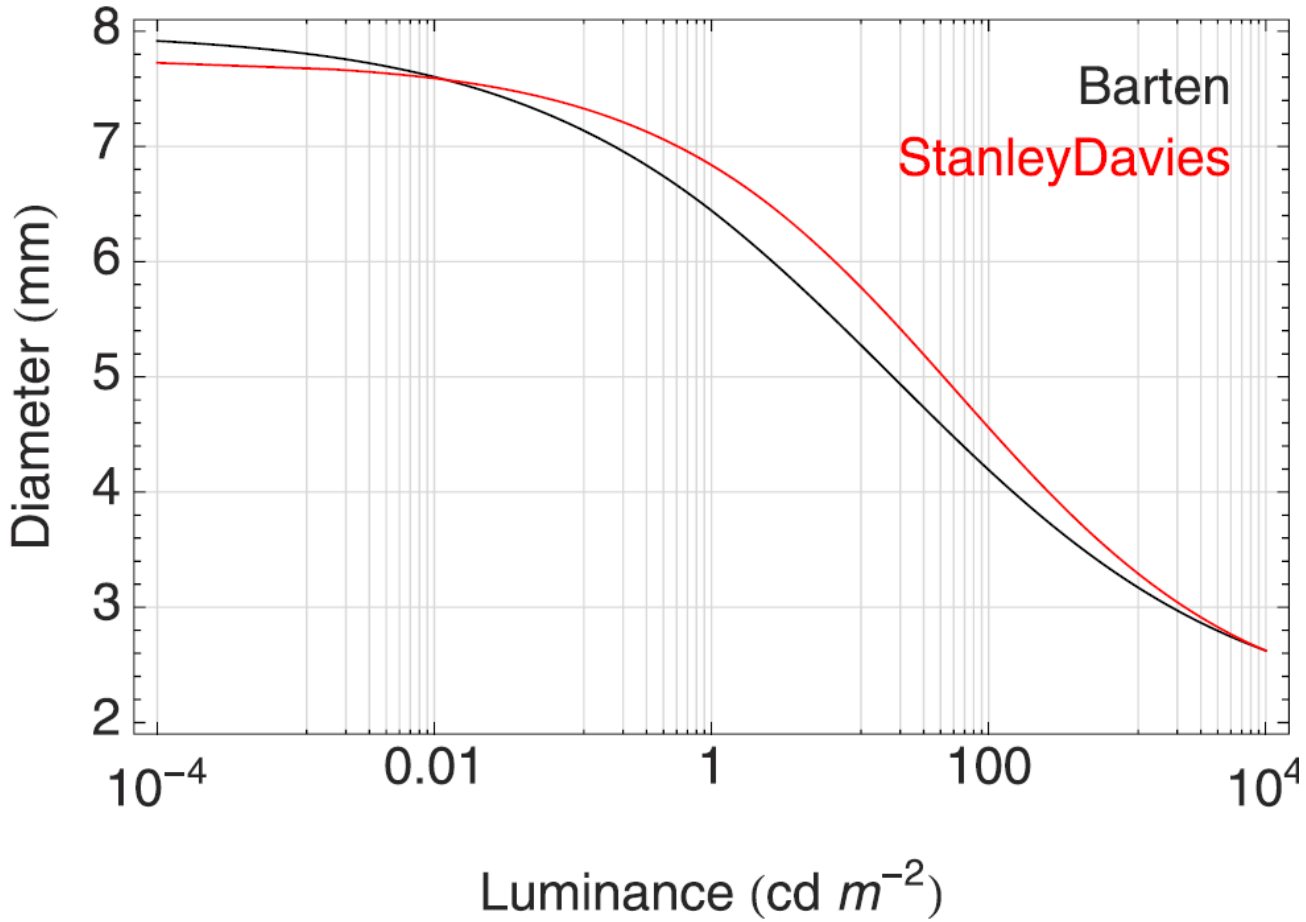
Bright environments: pupil constriction

$$D_{Barten}D = 5 - 3\ tanh\left(0.4log\frac{L_s a}{40^2}\right)$$

$$D_{StanleyDevies} = 7.75 - 5.75\left(\frac{L_s a/846^{0.41}}{L_s a/846^{0.41} + 2}\right)$$



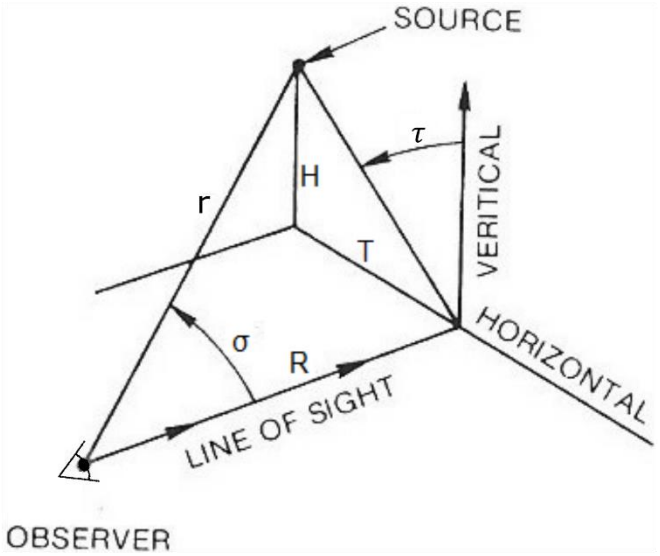
$$E_{ret} \sim L_{object} \cdot A_{pupil}$$



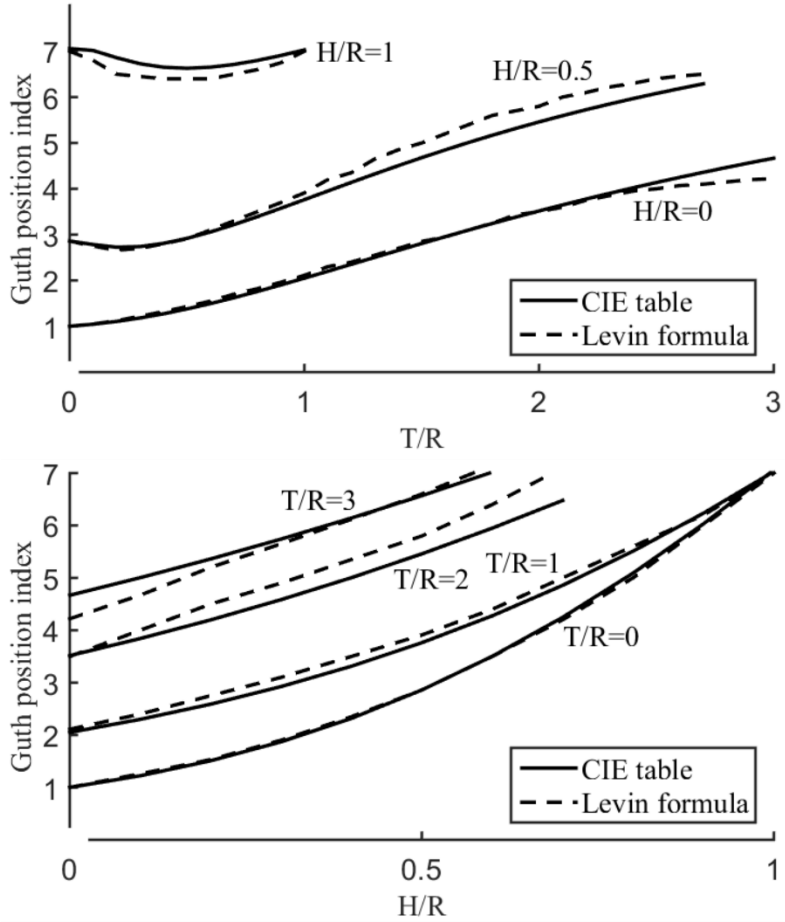
Watson, 2012. A unified formula for light-adapted pupil size

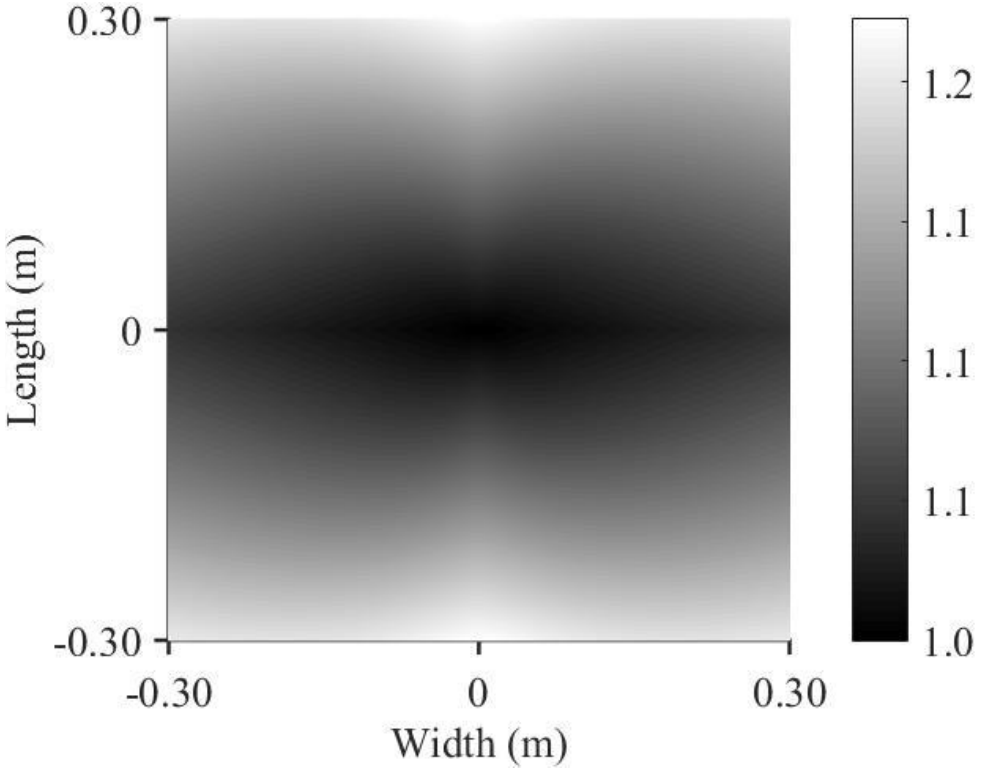
Retinal position

more away from the line of sight => lower brightness perception

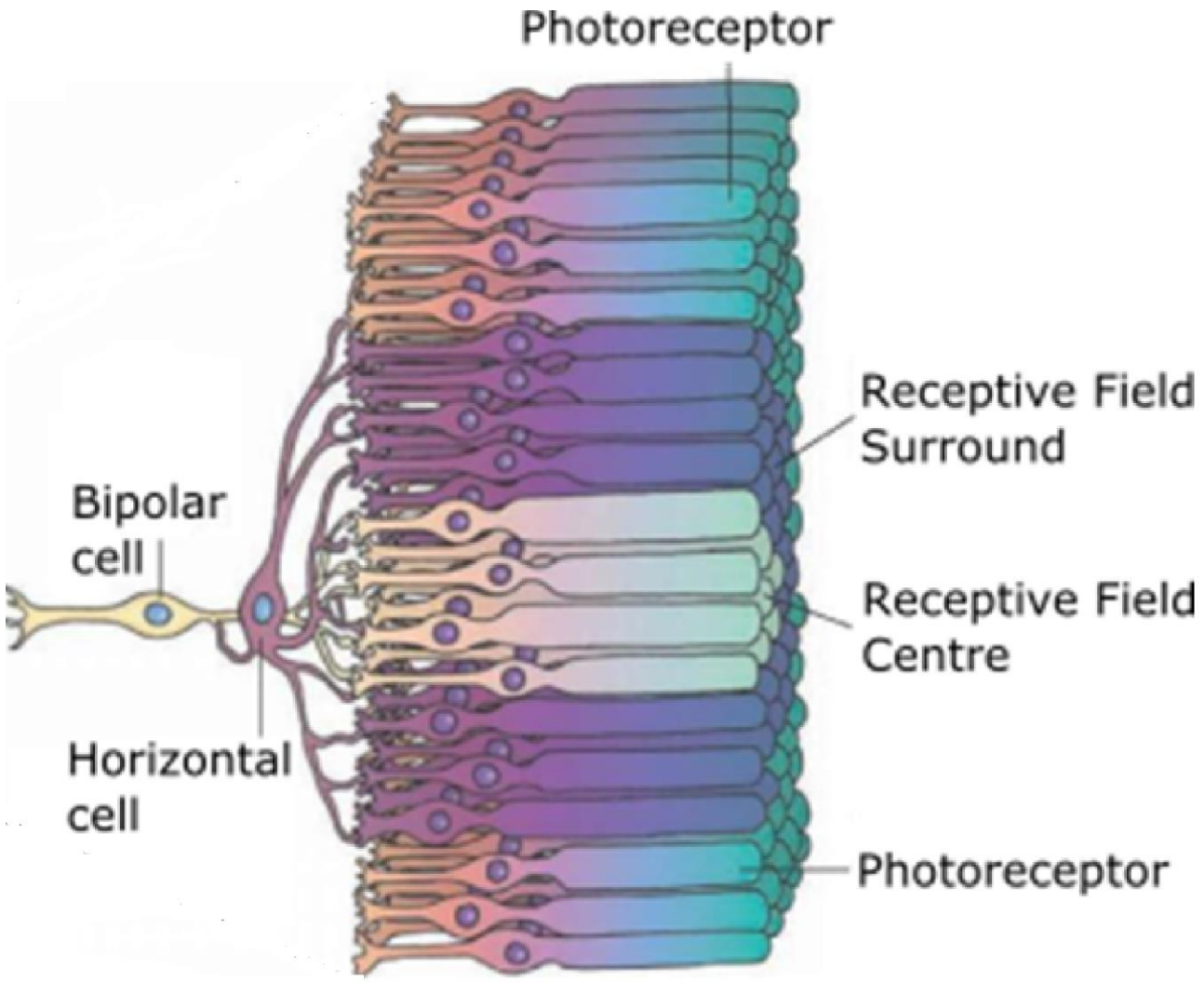


$$E_{ret} \rightarrow E_{p,ret}$$





Centre-Surround Receptive Fields

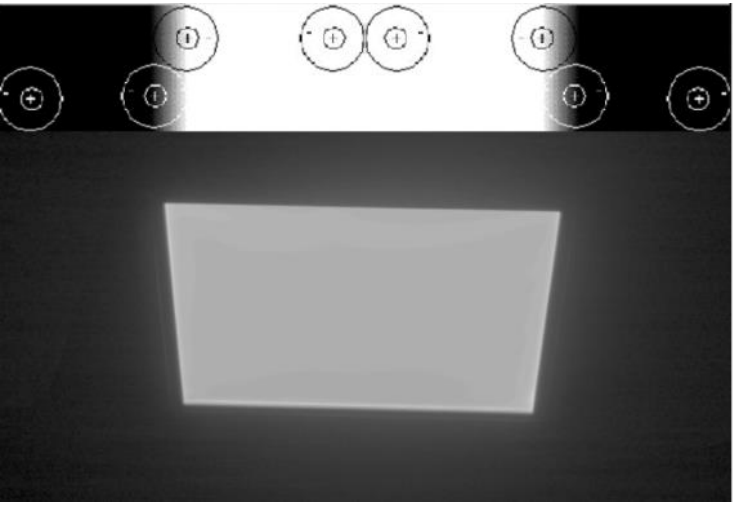


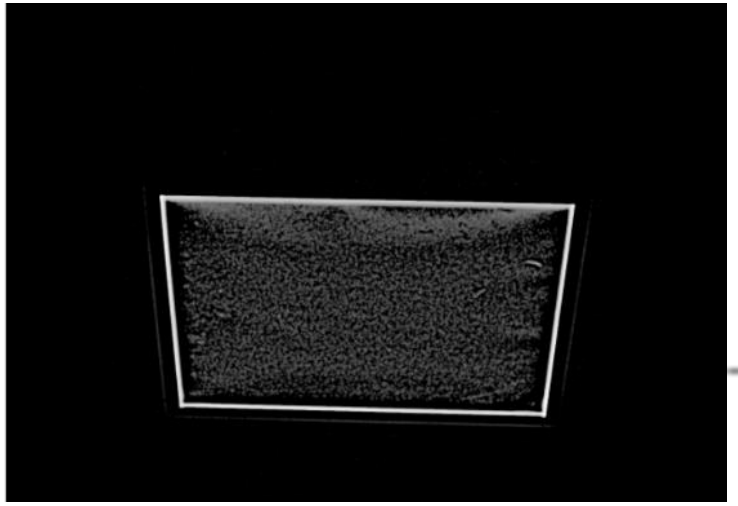
- Centre:
  - direct path
  - link to bipolar cells
- Surround:
  - indirect path
  - via horizontal cell to bipolar cell

- Bipolar cell to ganglion cell

- Ganglion cell to brain

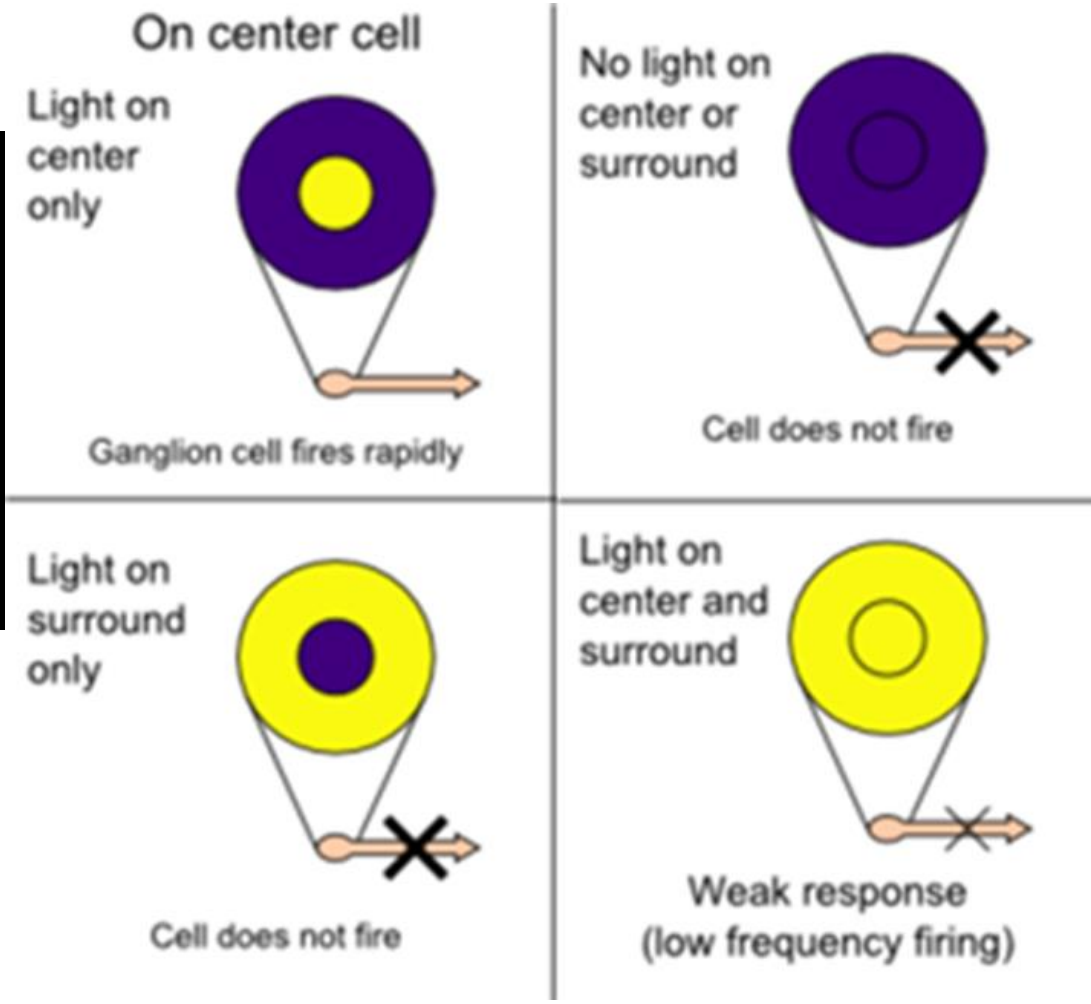
Receptive Field convolution: Edge detection



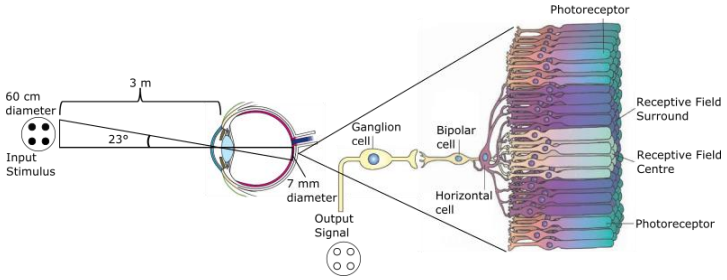


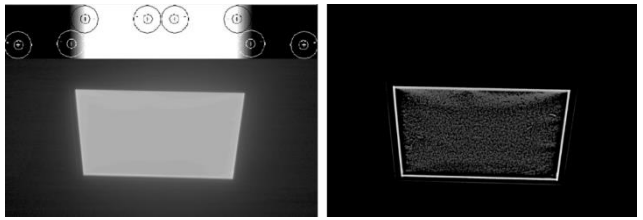
$(C - WF.S)$

Edge length
Edge height
Edge sharpness



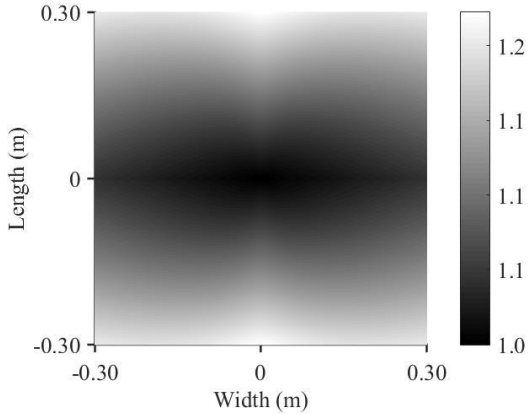
Receptive field model

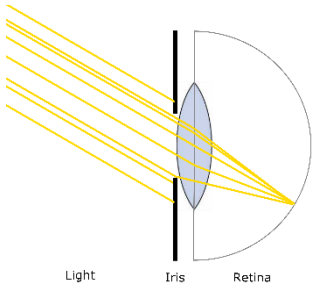




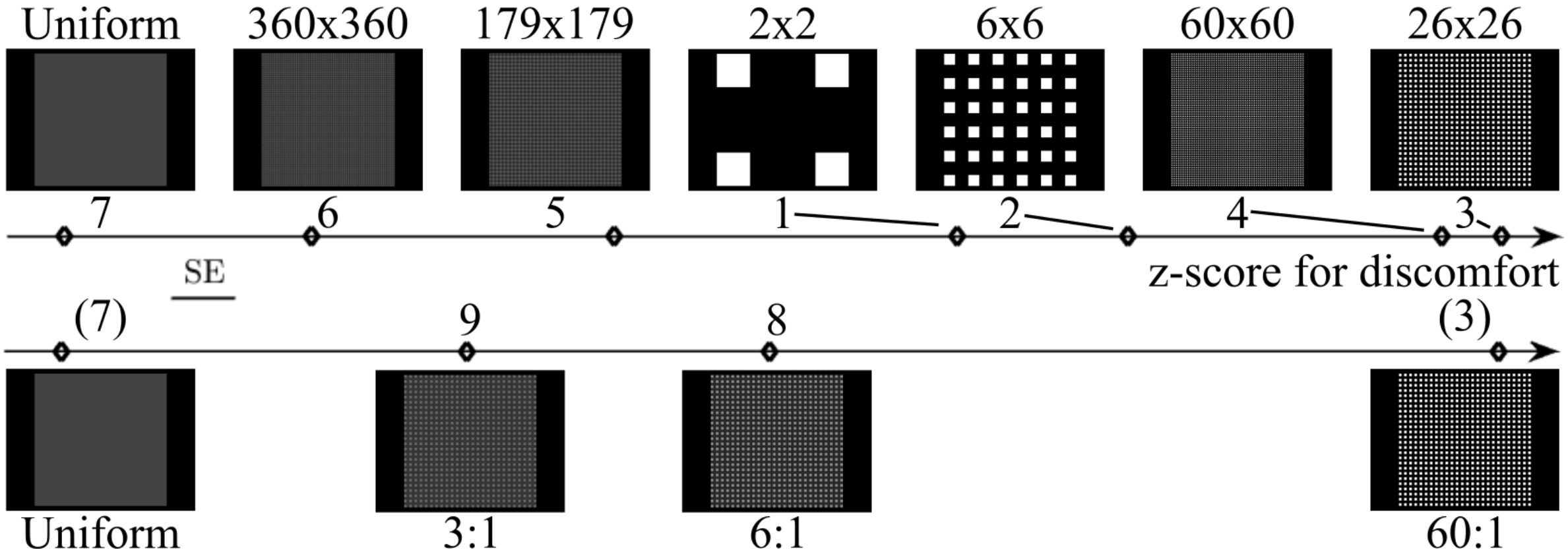
Convolution: to model ALL ganglion cell signals

$$\text{Discomfort } Glare = ln \sum_{pix} \omega_{pix} . \left| \underbrace{(C - WF.S)}_{\text{Receptive Field Kernel}} * \underbrace{E_{p,ret}}_{\text{Retinal illuminance map, correted for position}} \right|$$

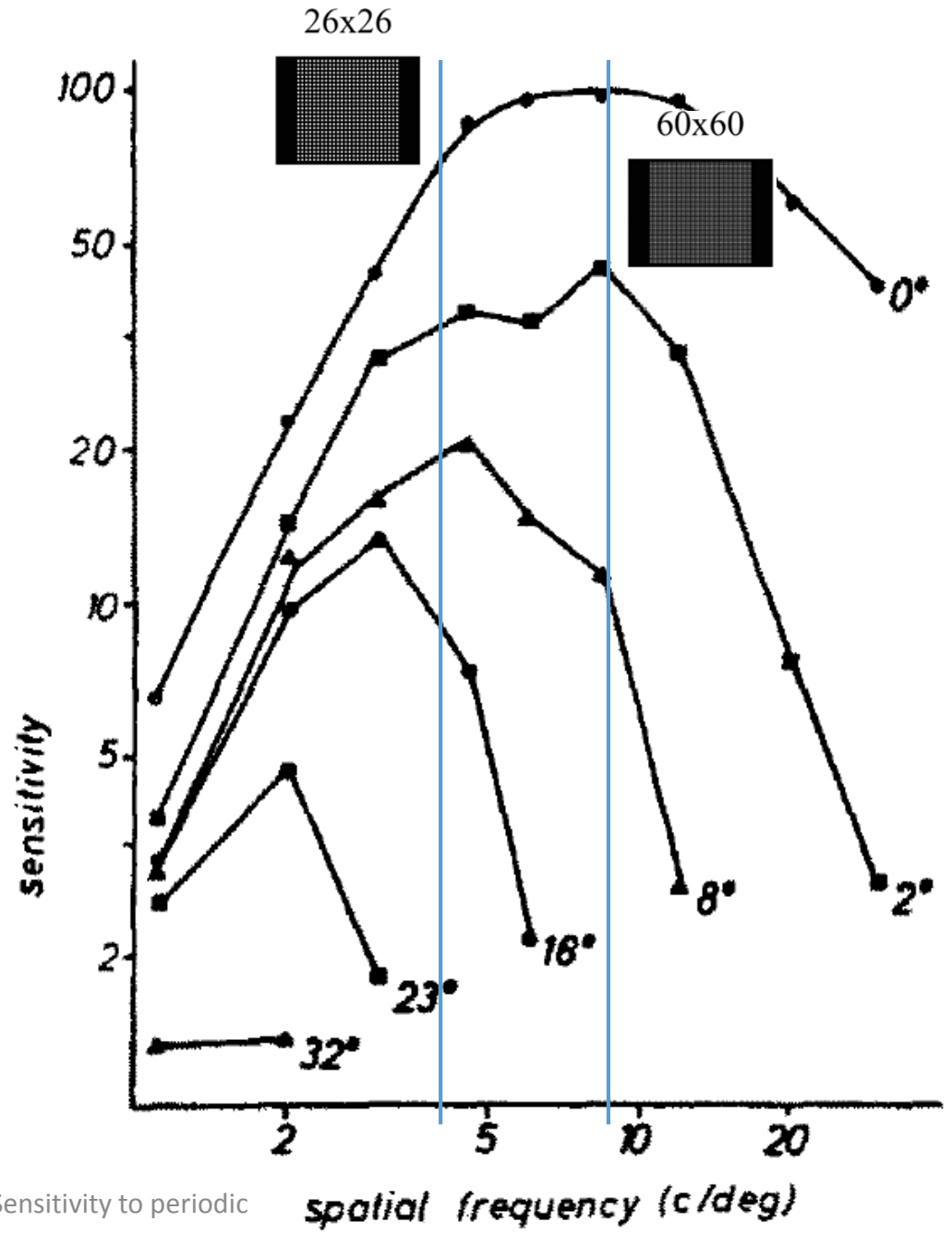




Paired Comparison Experiment

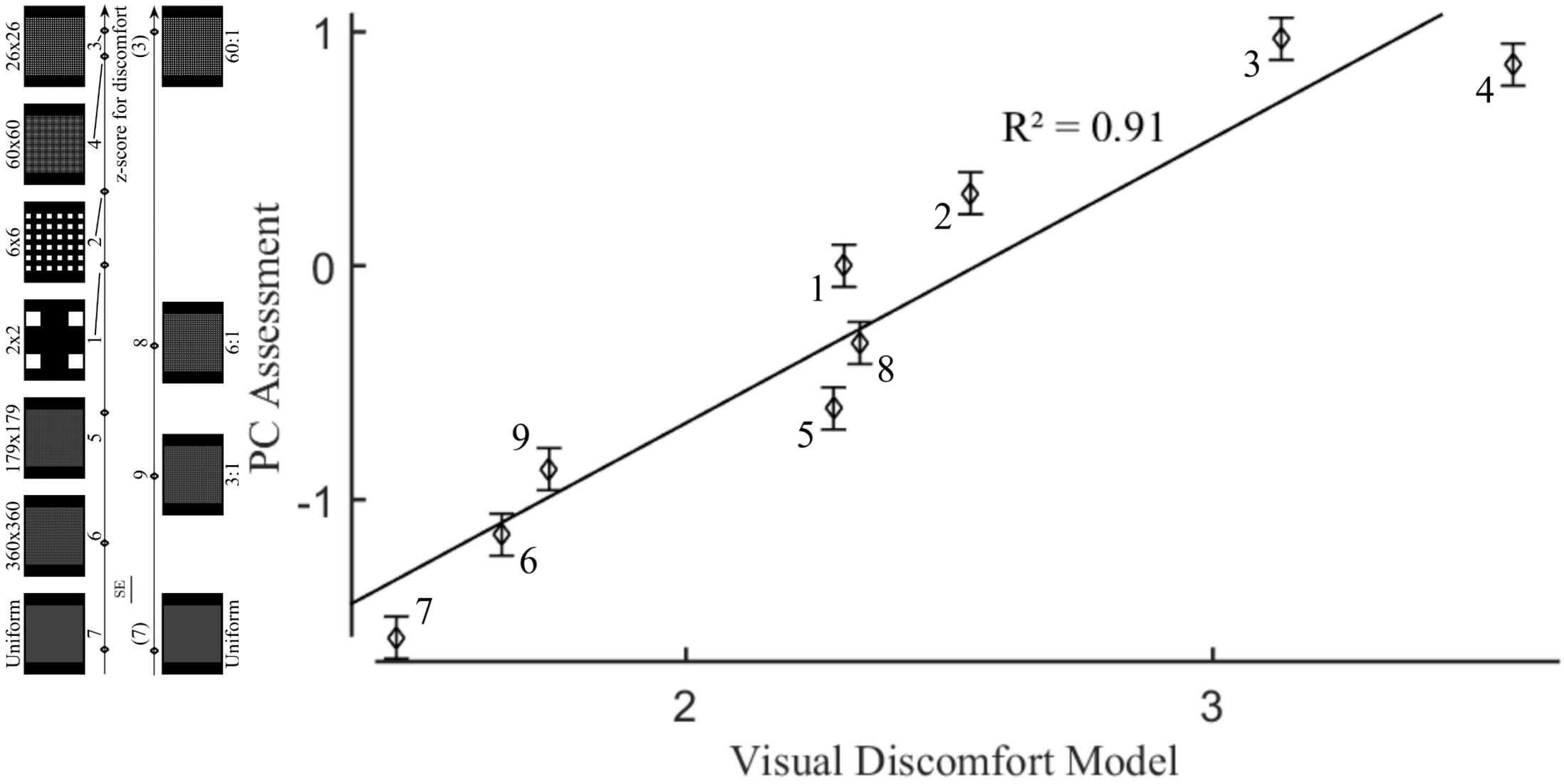


Contrast Sensitivity Function



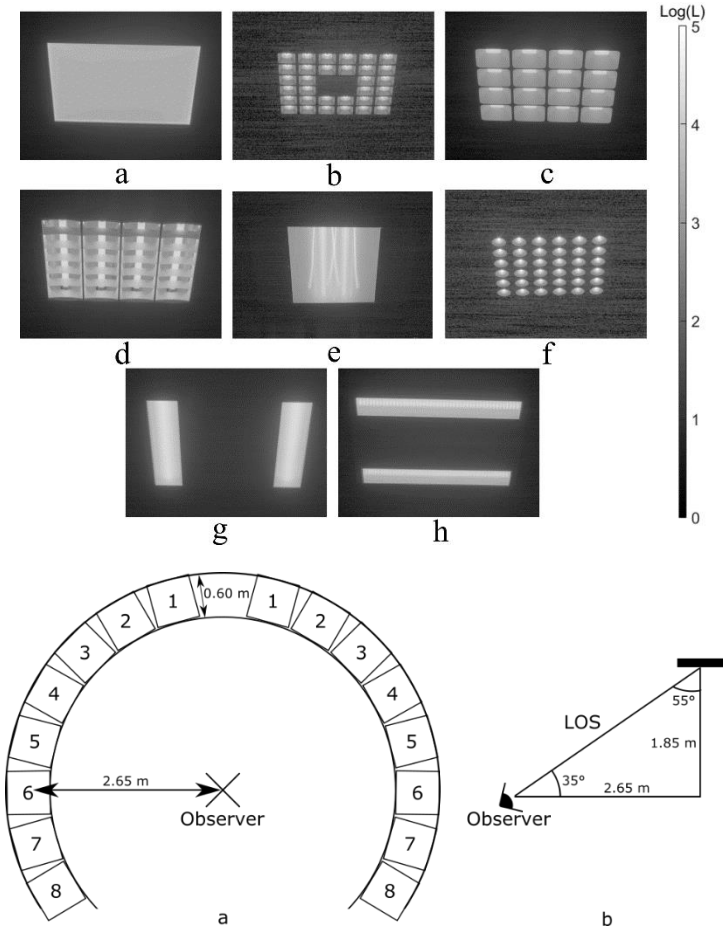
Hilz & Cavonius, 1974.
Functional organization of the peripheral retina: Sensitivity to periodic stimuli

Visual discomfort model Performance

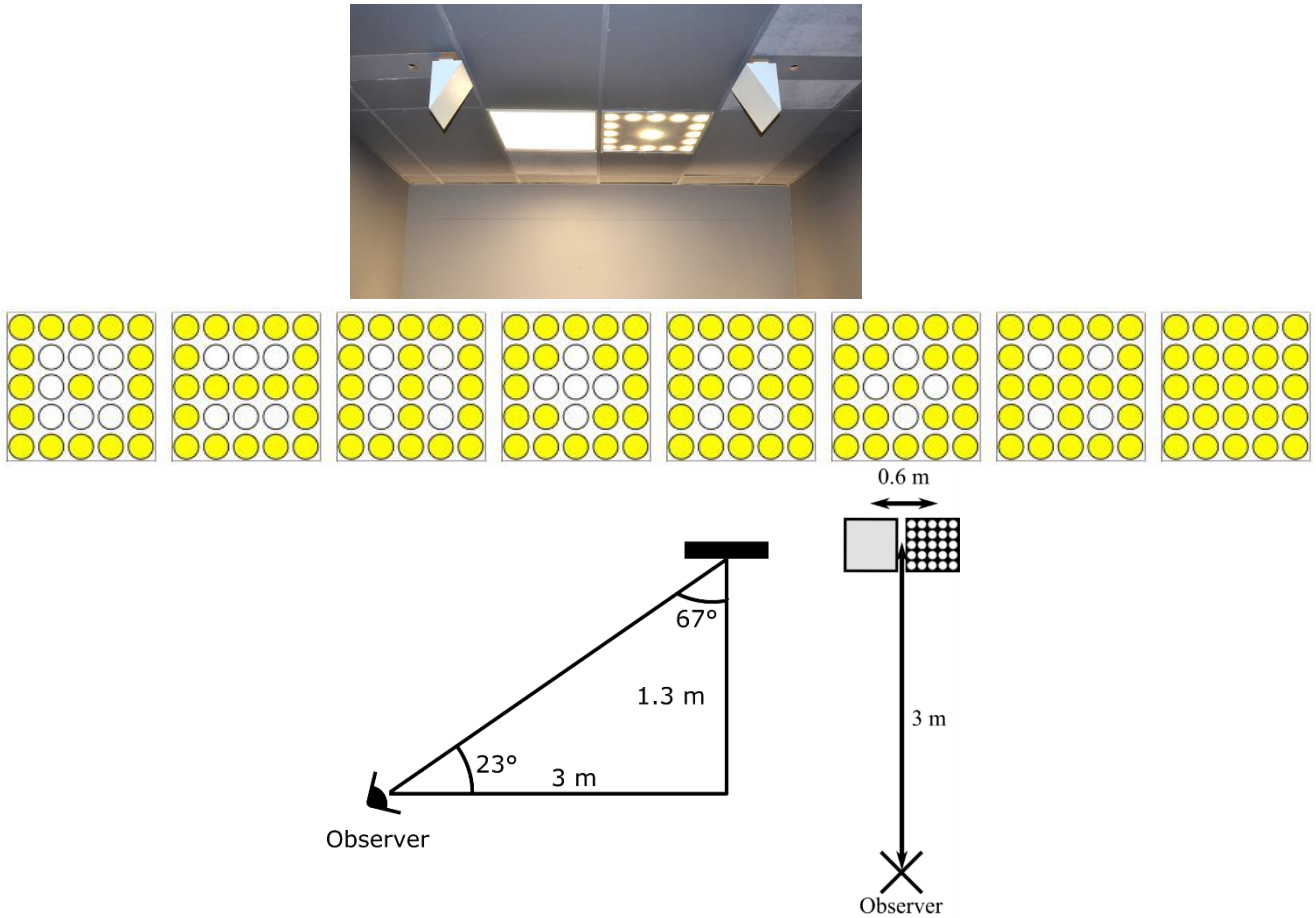


Validation experiment

Office luminaires test



Diffusor luminaires test



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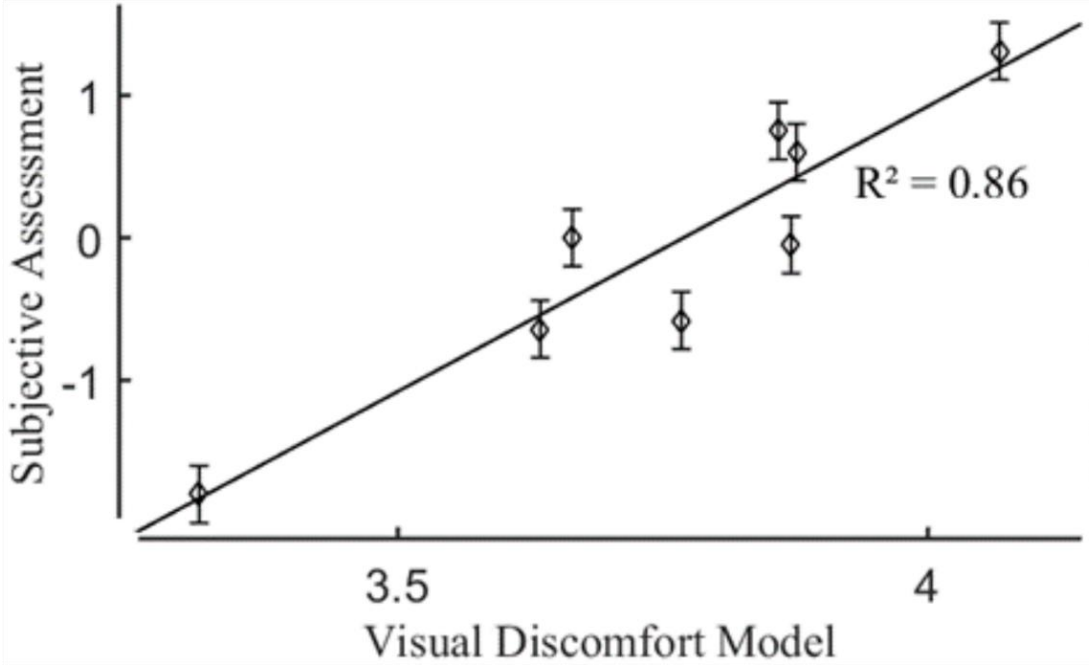

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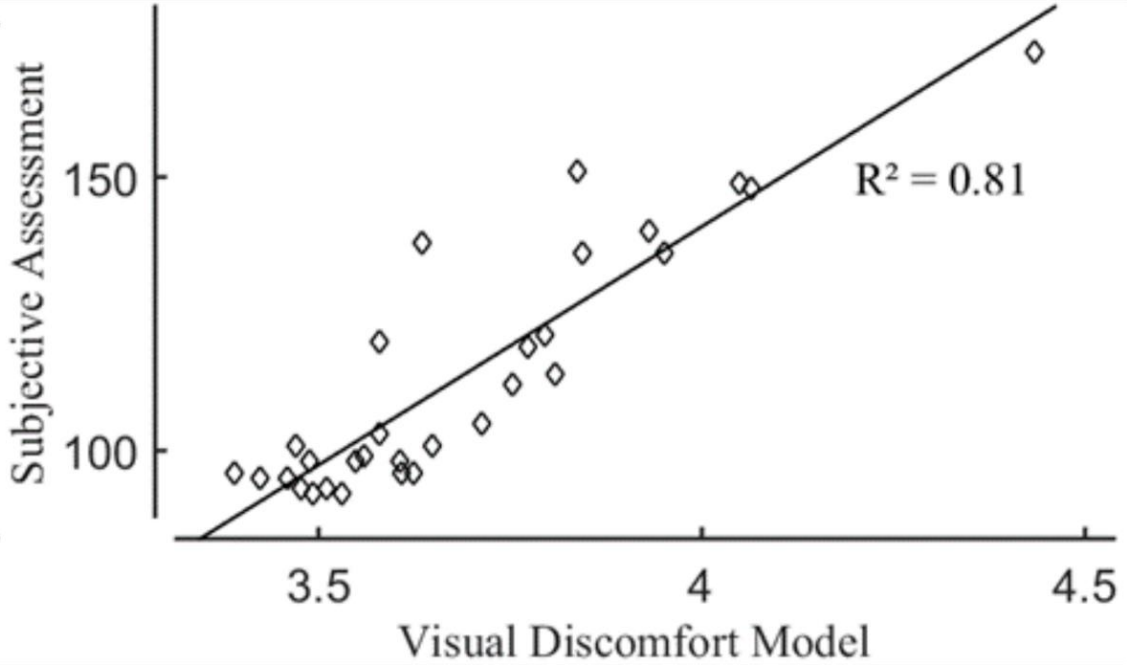
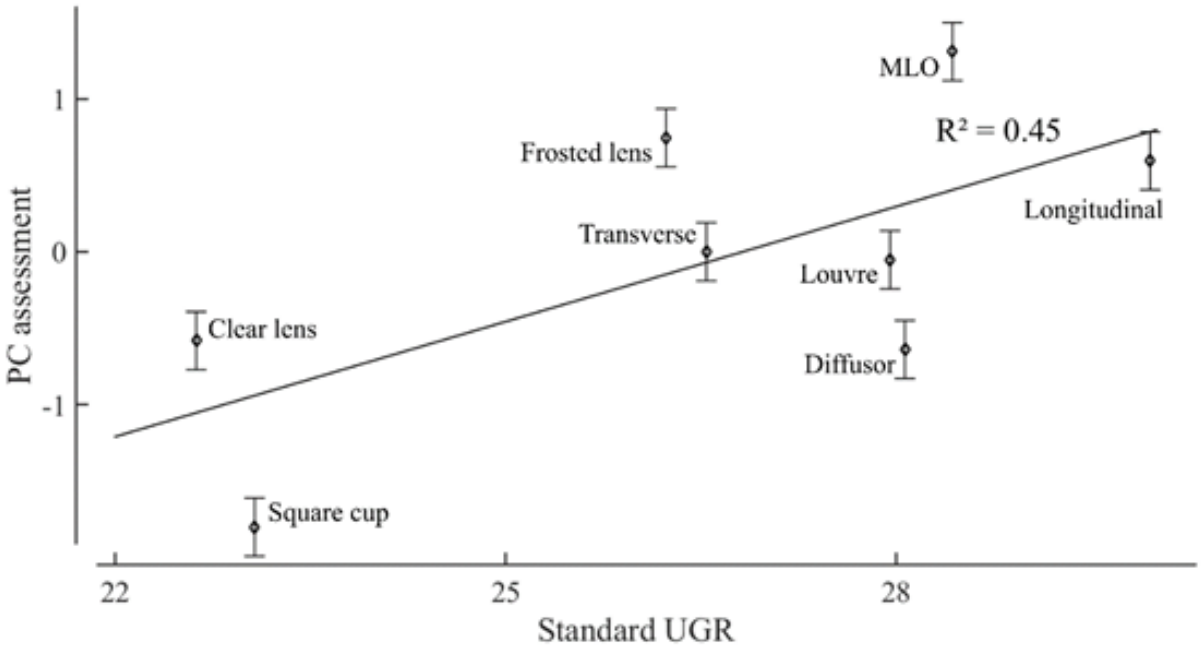


Comparison with standard UGR

Office luminaires test



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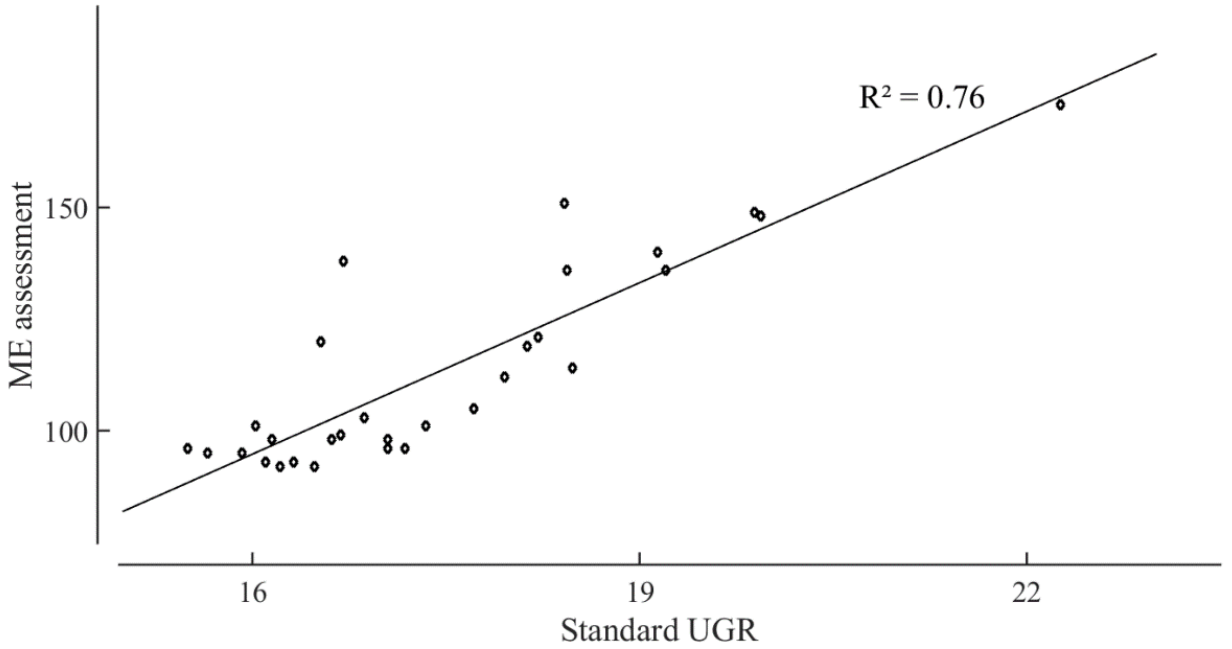
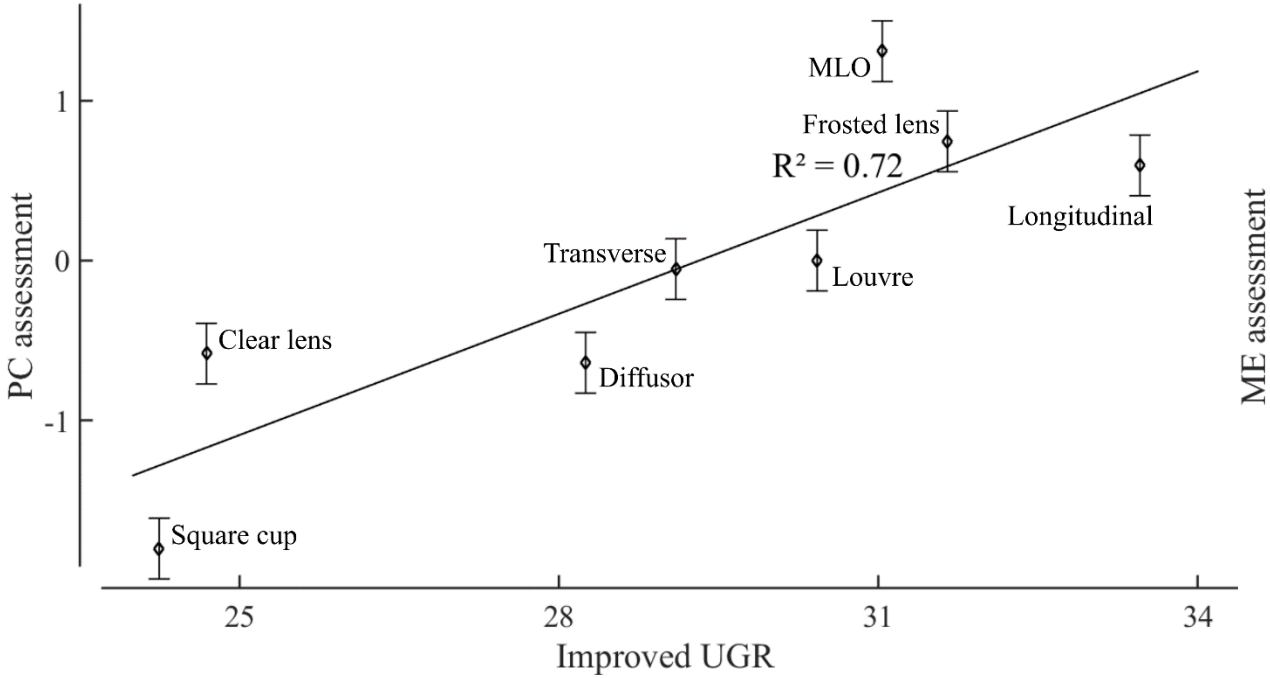
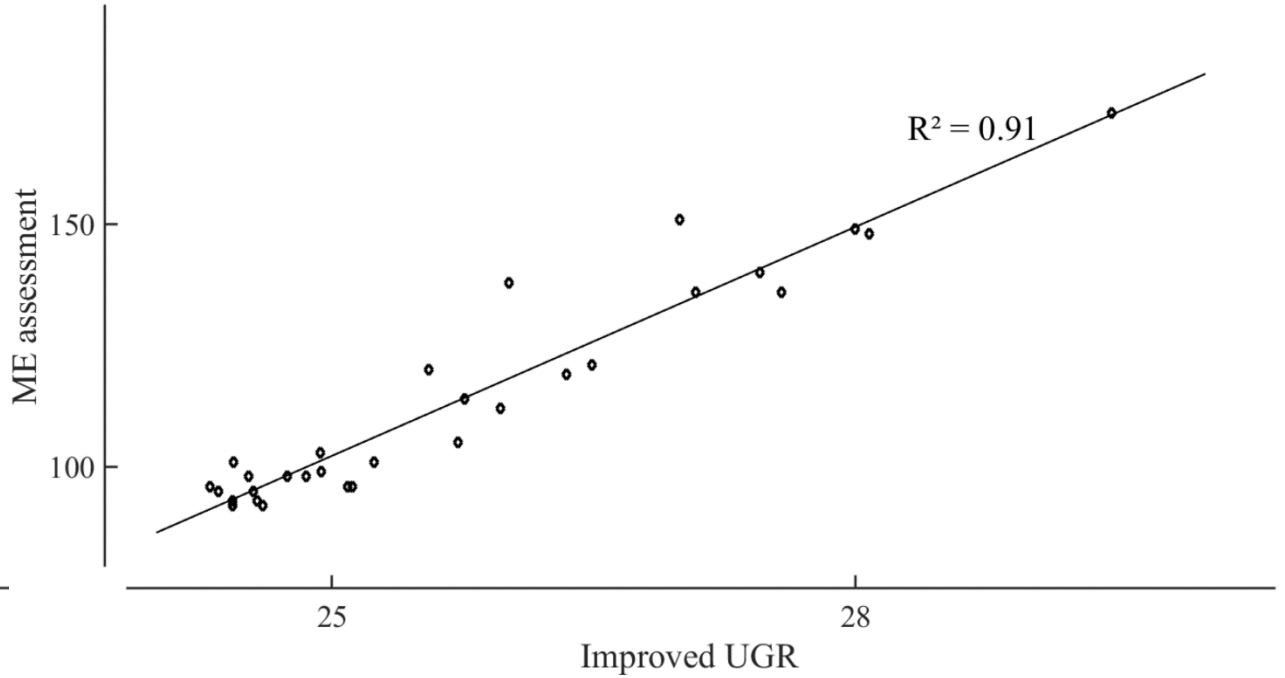


Comparison with Quickfix UGR

Office luminaires test

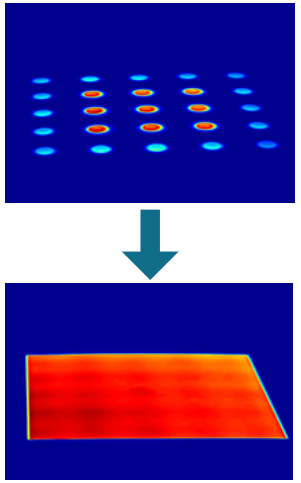


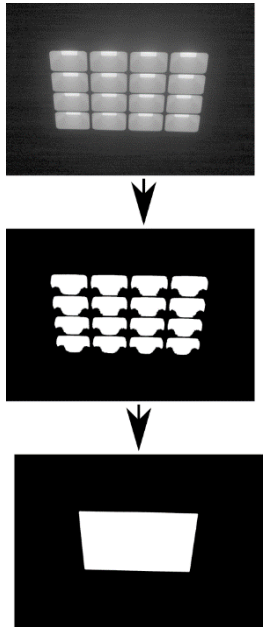
Diffusor luminaires test

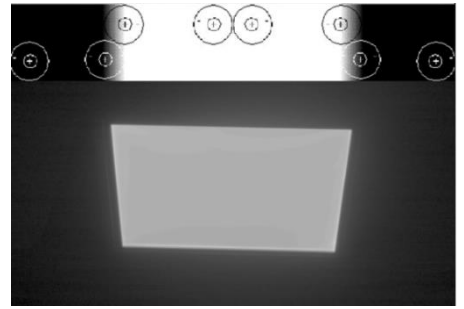


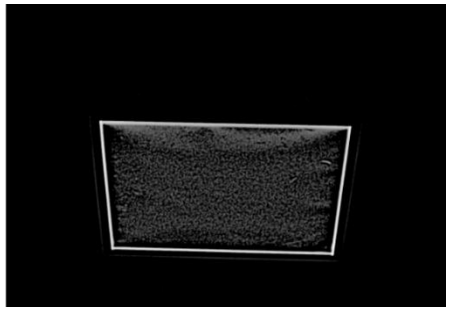
Overview results

R^2	Standard UGR	Quickfix UGR	Physiological Model
Office Luminaire Test	0,45	0,72	0,86
Diffusor Luminaire Test	0,76	0,91	0,81



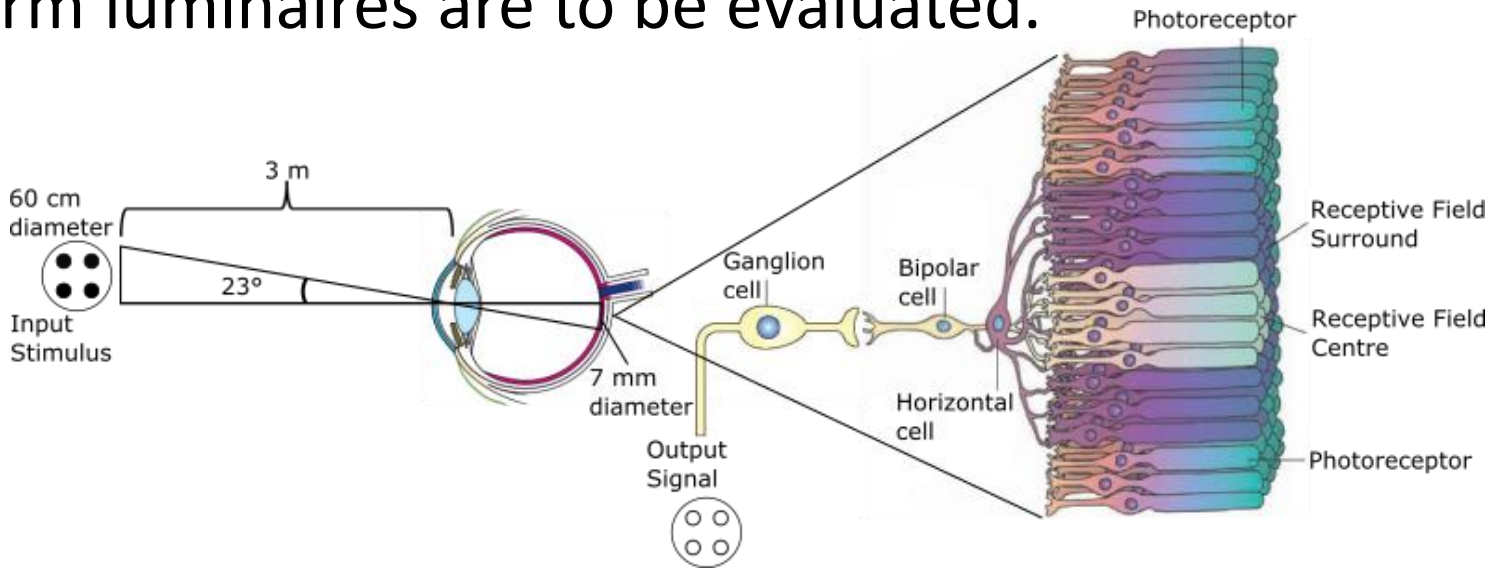






Game Over UGR?

- Short term: not really! Patches keep the UGR floating: Use the Quickfix!
- Long term: The model including the receptive field mechanism and the pupillary light reflex is able to predict the visual discomfort and is promising to replace current standard glare metrics, specifically when non-uniform luminaires are to be evaluated.



LED EVENT
2017 BE 29-11-17
NL 30-11-17

Thank you!

Questions?
Remarks?
Suggestions?