Photometry & vision

Physiology of the eye and glare assessment

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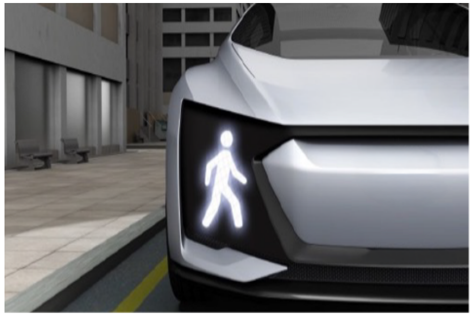
VUB ELECTROMOBILITY RESEARCH CENTRE

MOBI IS THE INNOVATIVE RESEARCH HUB FOR ELECTROMOBILITY IN EUROPE

- Electric and autonomous driving
- Innovative batteries
- Intelligent drive systems
- Energy management
- Power Electronics
- Design for Sustainability
- Charging infrastructure
- Lighting for transport

MERLIN lighting research



- V2X communication with visual light (Jan)
- Metrology of clusters of LEDs (Guillaume)
- Visual communication / DRLs (Li Ru & Yan)

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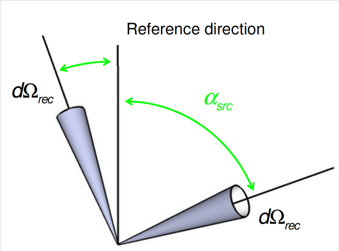
- Applications of LED arrays (Pooria)
- Measurement protocols for Light pollution (Arjen, Leonard)
- Impact on health&wellbeing (Iris, Siman)
- Lighting for the arts (Caroline, Maarten)

A broad overview of terminology

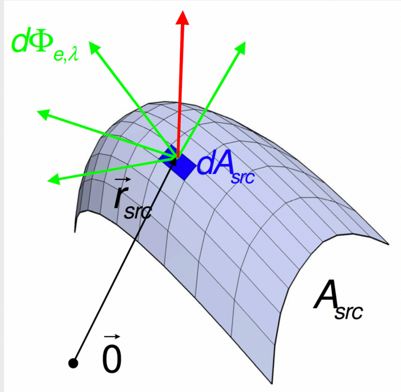
$I\ [cd]$

Luminous intensity (distribution)
Luminous flux from a point source in a given direction



$M\ [lm/m^2]$

Luminous exitance
Luminous flux from an emitting surface



$\phi\ [lm]$

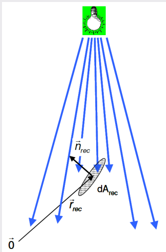
Luminous flux

$L\ [cd/m^2]$

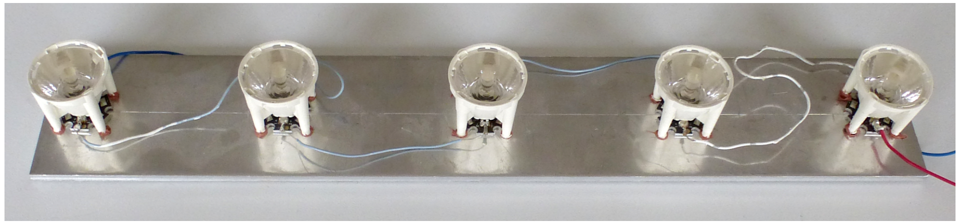
Luminance
Luminous flux from an emitting surface in a given direction

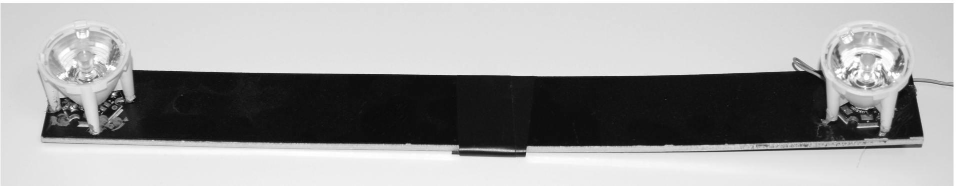
$E\ [lm/m^2 := lx]$

Illuminance
Luminous flux on a receiving surface

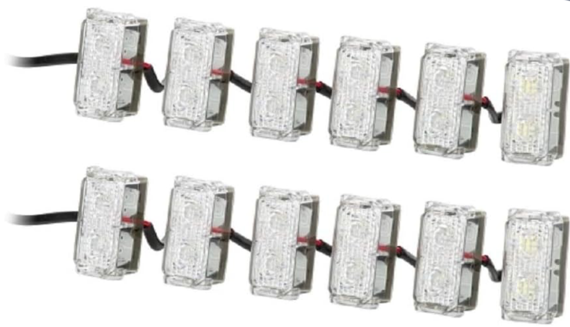


Near-field and far-field goniophotometry of LED arrays



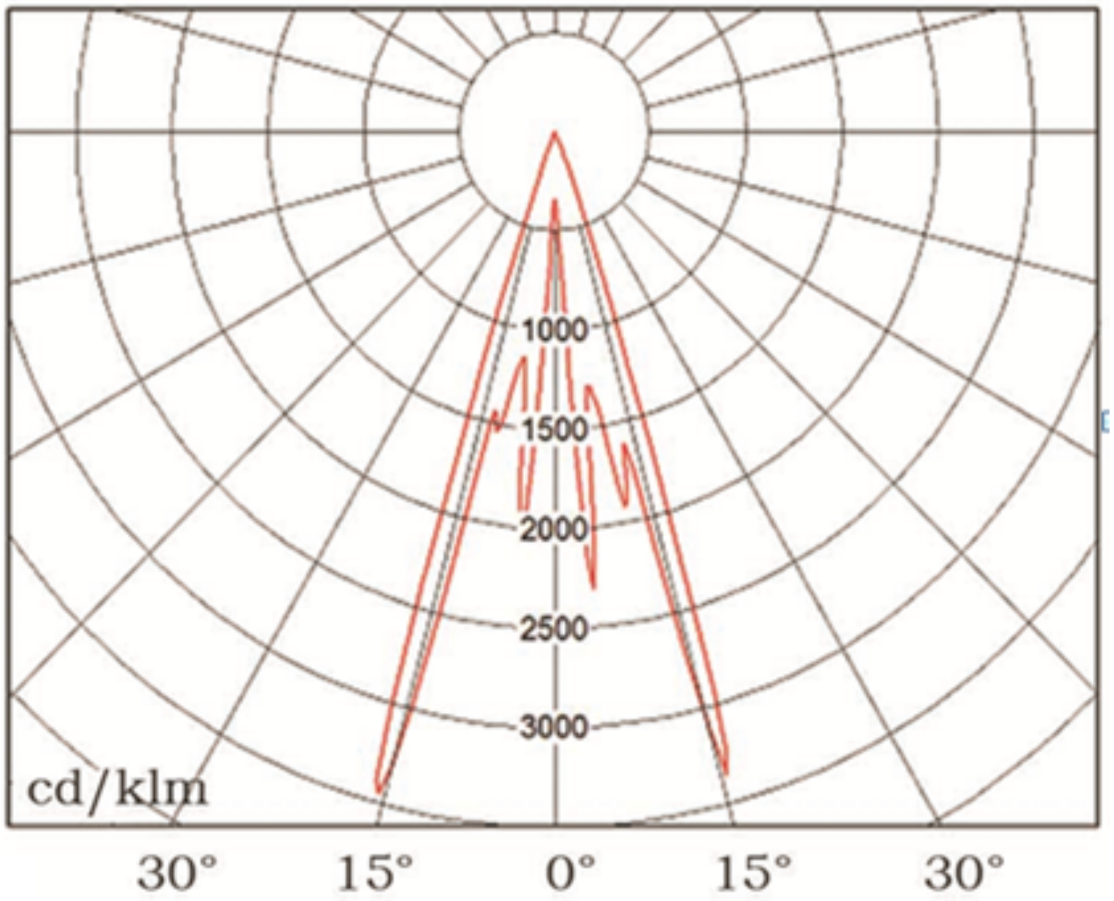


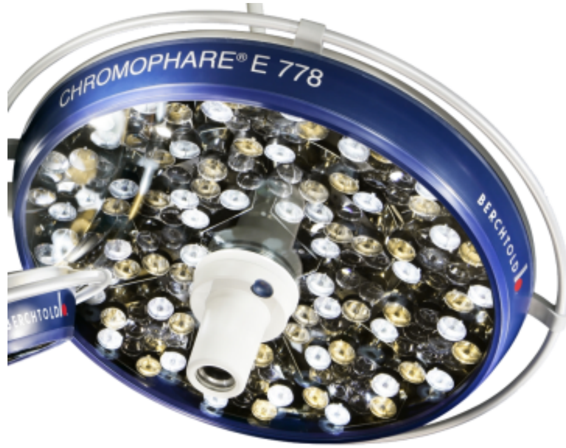
Focused and parallel LED arrays



Berchtold Chromophare E778 Surgical luminaire, Hella LEDayFlex II – Rectangular DRL, , Schréder Ampera Road Lighting

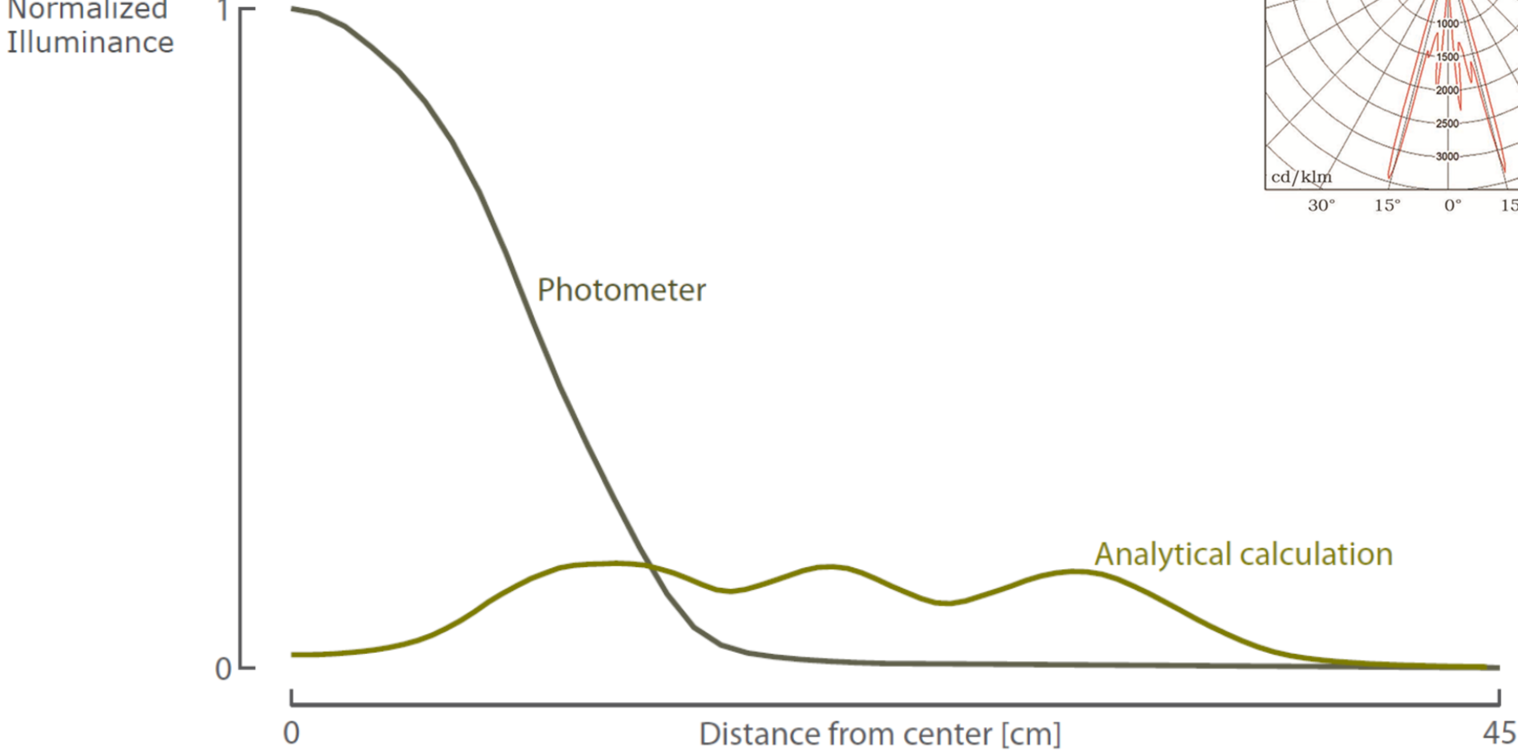
An example of how wrong things can get

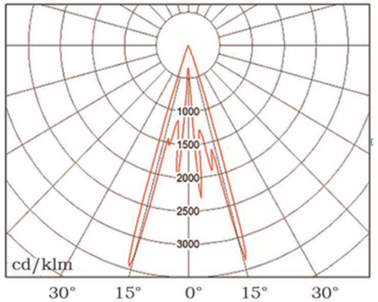


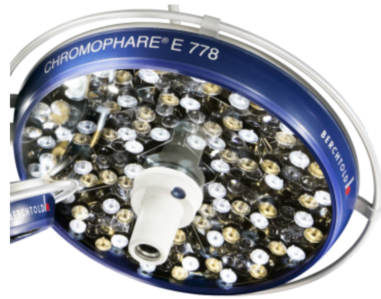


$$E = \frac{I \cdot \cos \alpha_{rec}}{R^2}$$

An example of how wrong things can get

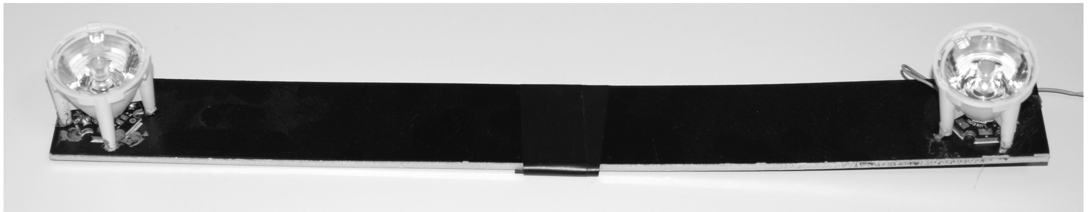


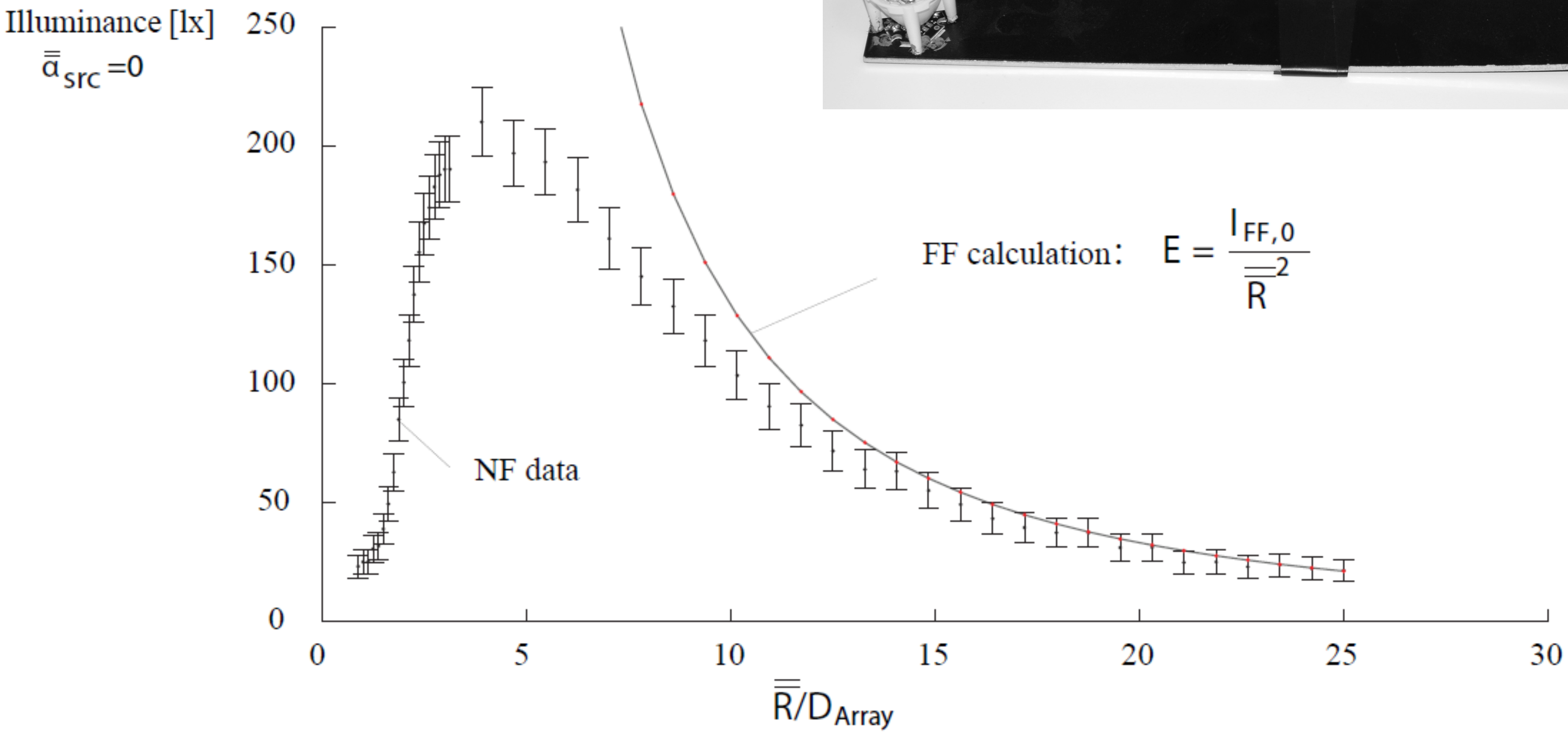




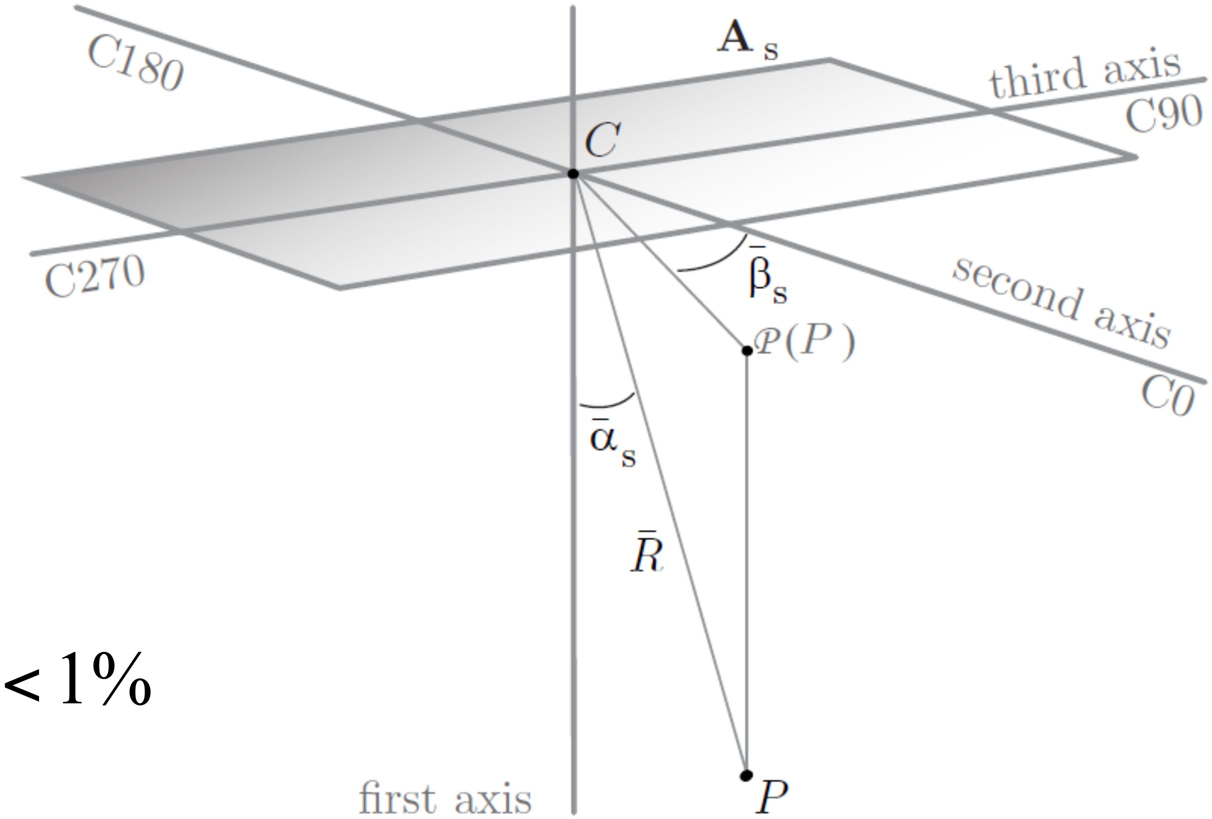
$$E = \frac{I \cdot \cos \alpha_{rec}}{R^2}$$

Similar problems exist near smaller LED arrays



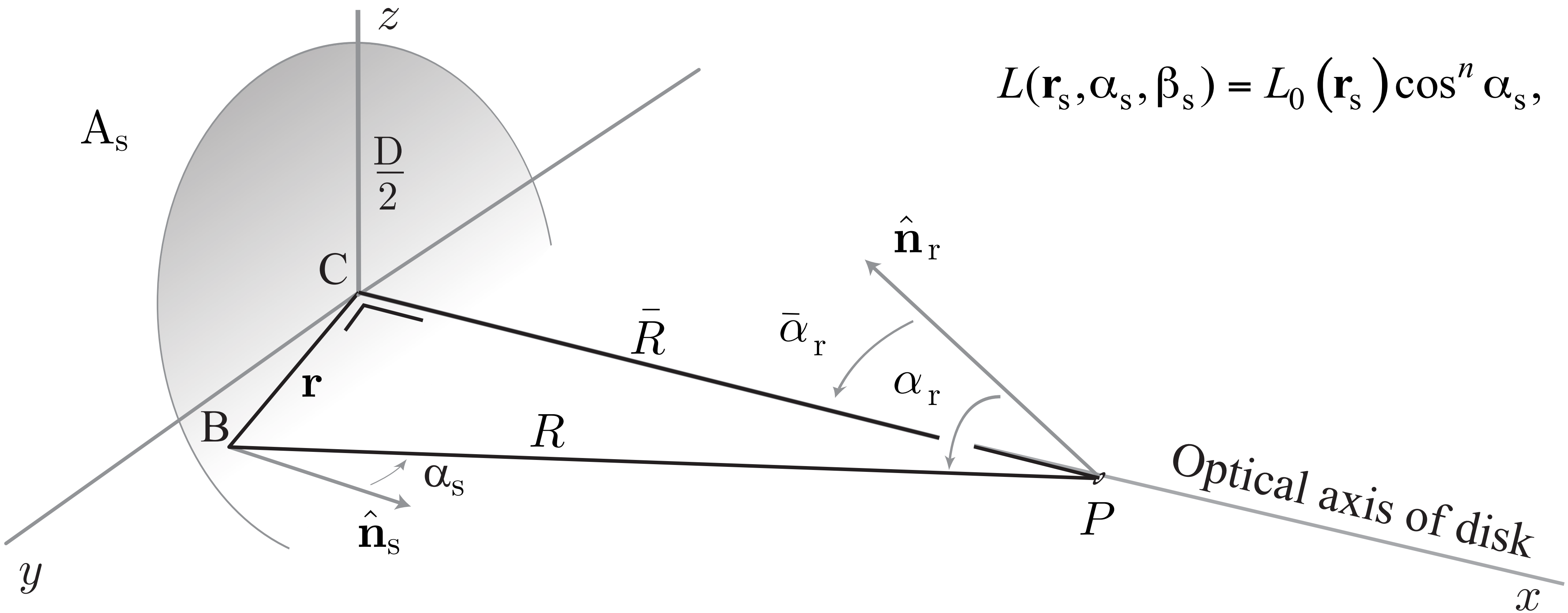


The "limiting photometric distance" (LPD) is defined as the distance from which the inverse square law is valid



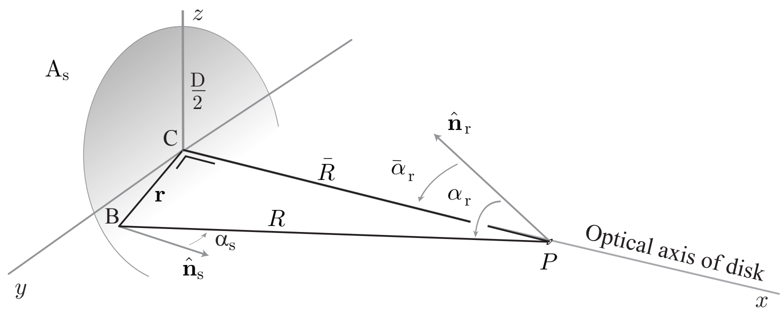
$$\bar{R} \quad \Big| \quad 1 - \frac{I_{app}(\bar{R}, \bar{\alpha}_s, \bar{\beta}_s)}{I_{FF}(\bar{\alpha}_s, \bar{\beta}_s)} < 1\%$$

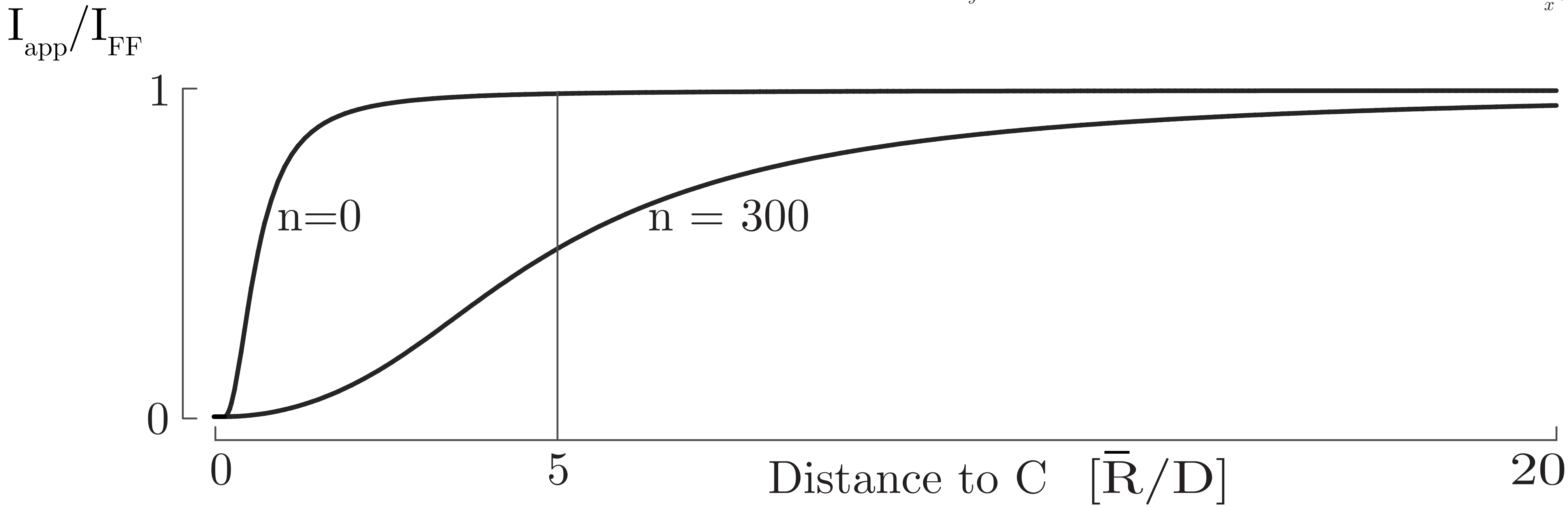
A disk source can model an LED with focusing optics creating a narrow beam



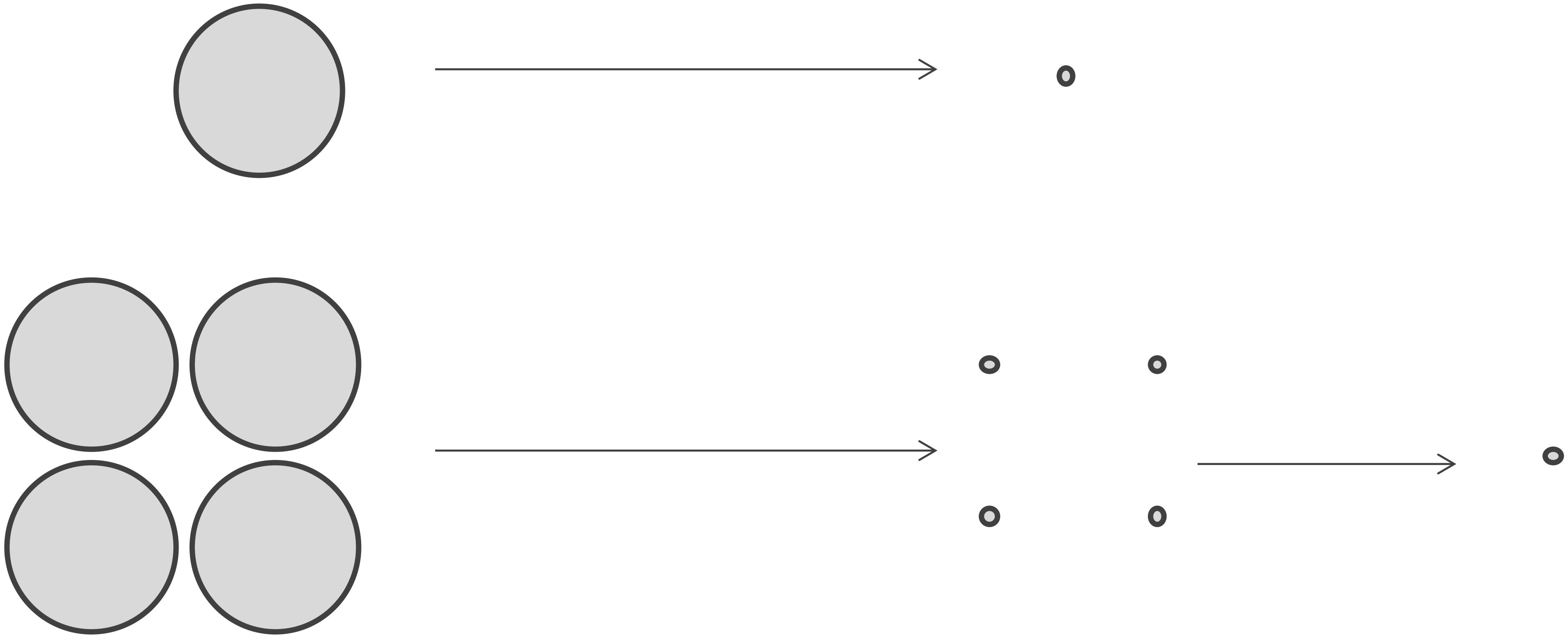
$$L(\mathbf{r}_s, \alpha_s, \beta_s) = L_0(\mathbf{r}_s)\cos^n \alpha_s,$$

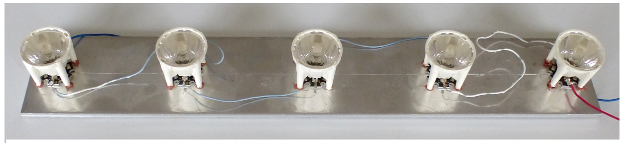
Far larger measurement distances are needed for narrow beam sources, which is experimentally shown for LEDs and LED arrays

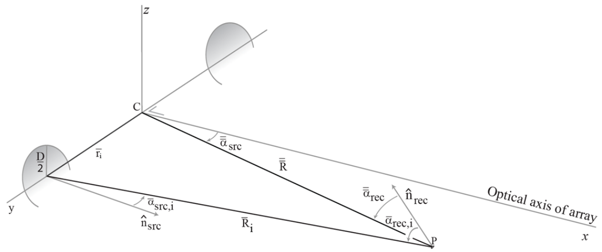




From what distance, do we reach the FF of an Array?







Simulations

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Measurements

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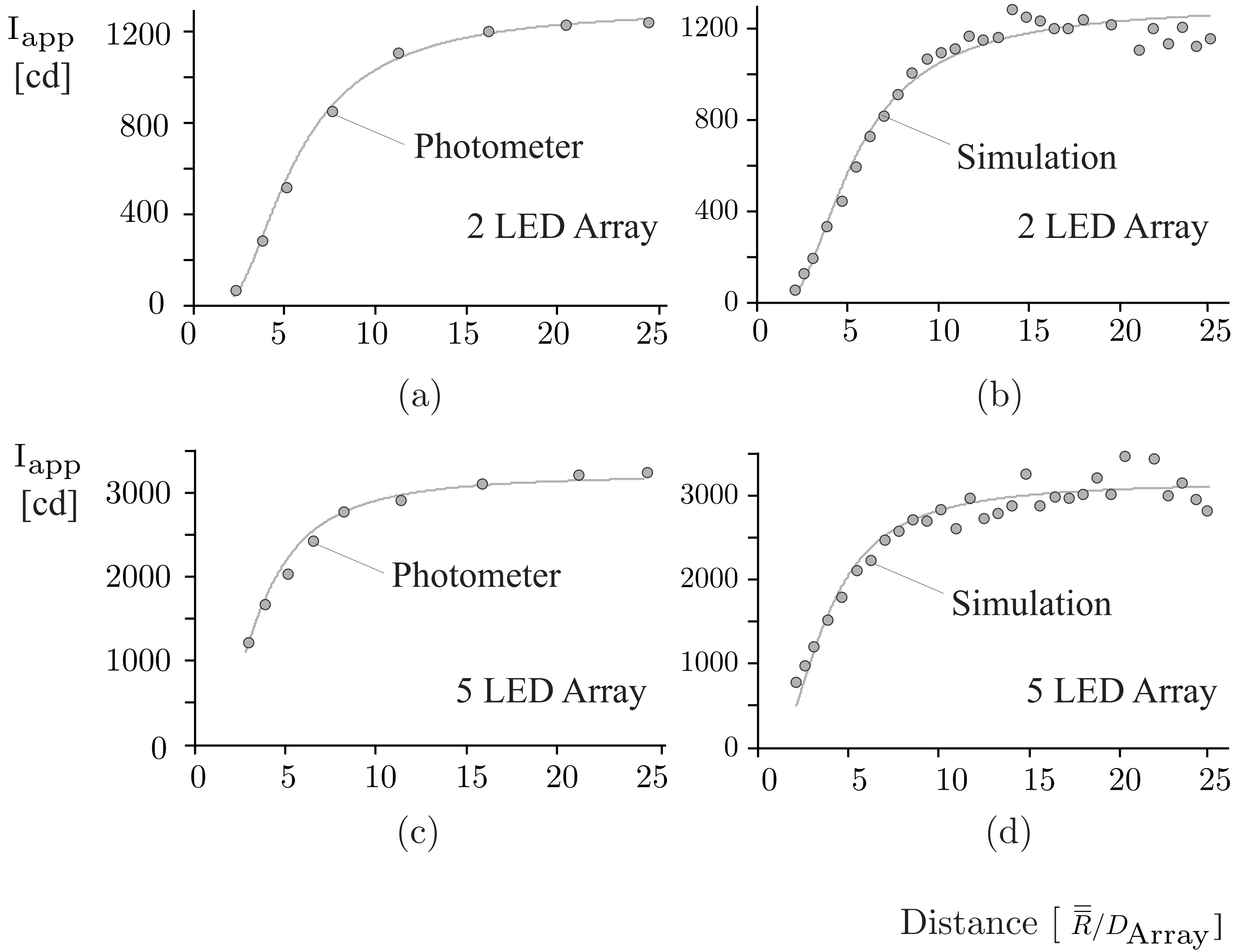
Theoretical model



The human eye as a lens system with imaging plane

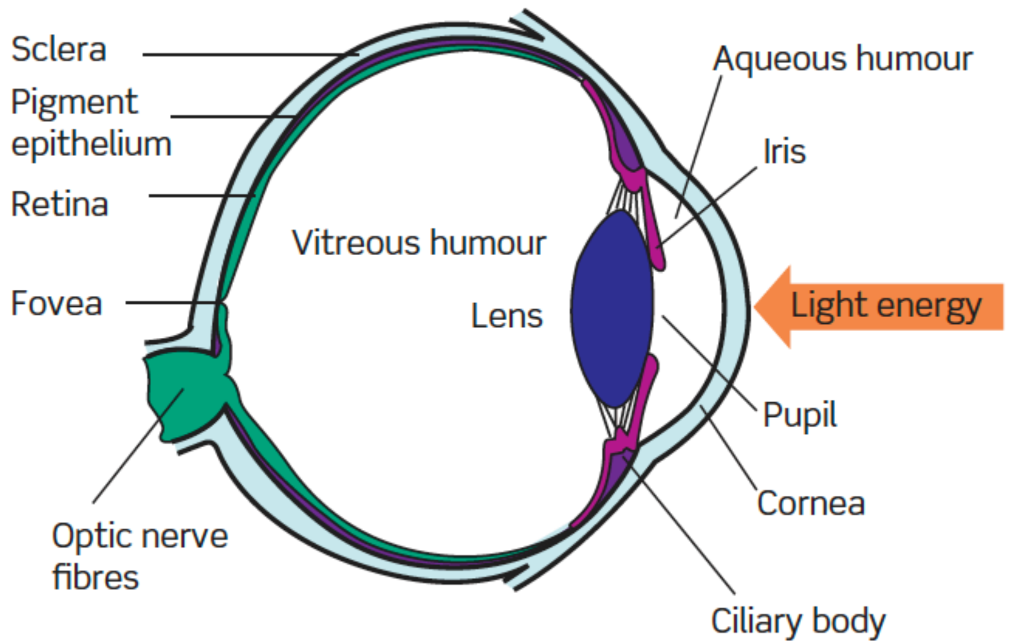
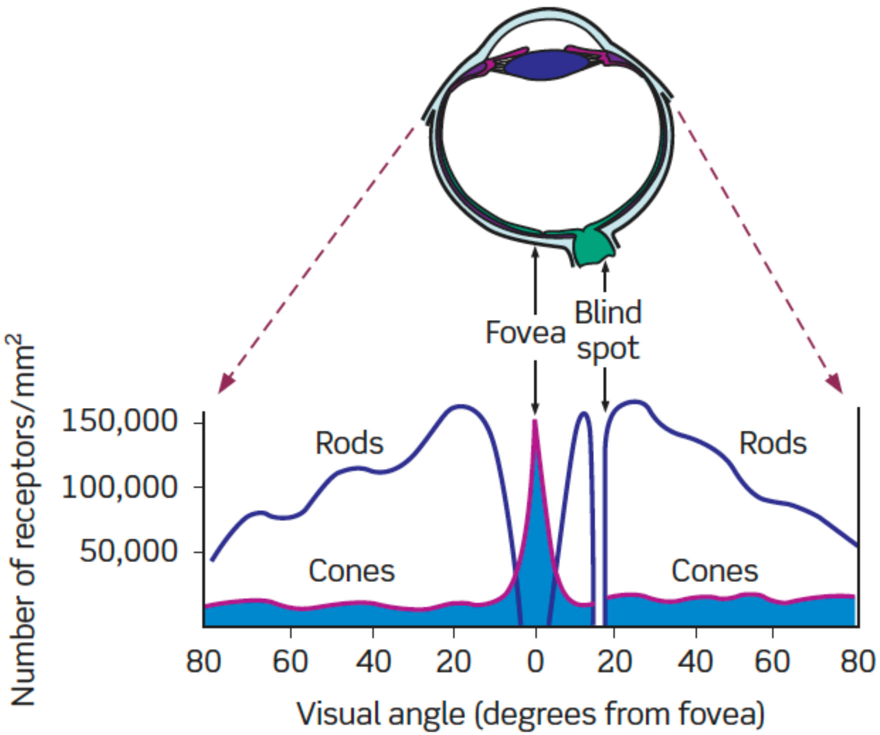


Figure from Basic Vision An Introduction to Visual Perception by Robert Snowden, Peter Thompson, Tom Troscianko

The optical detectors of the human eye



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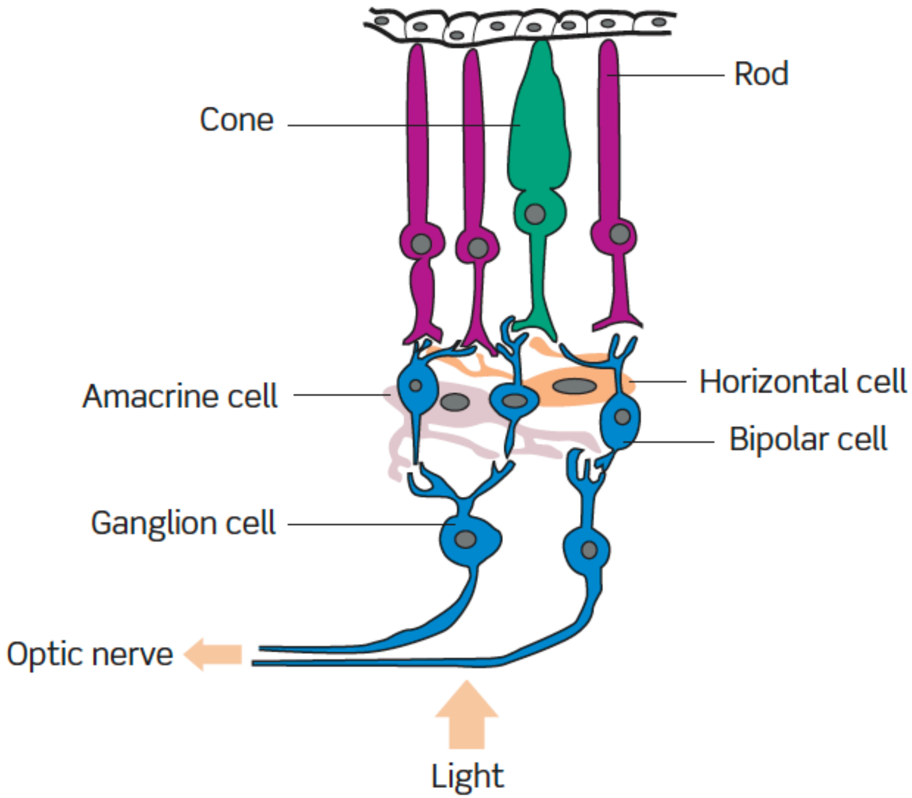
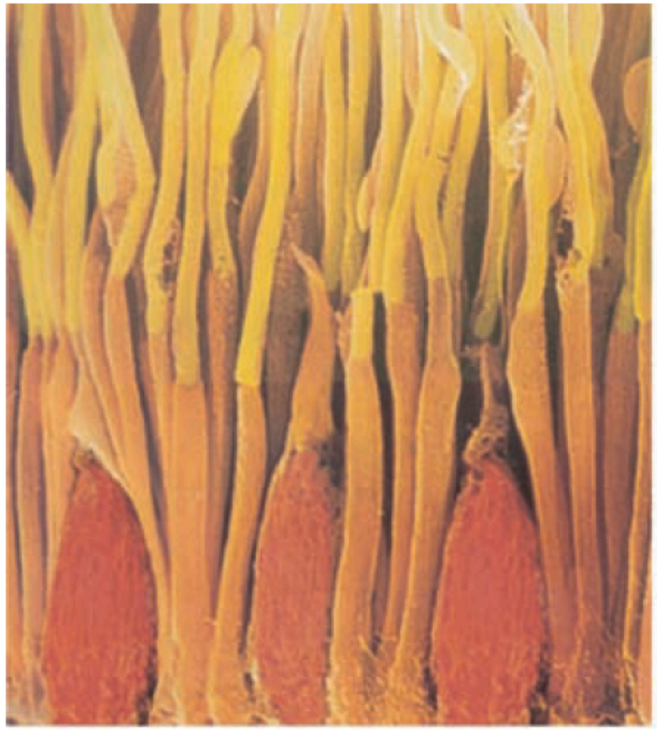
A cross-section of the retina of the eye

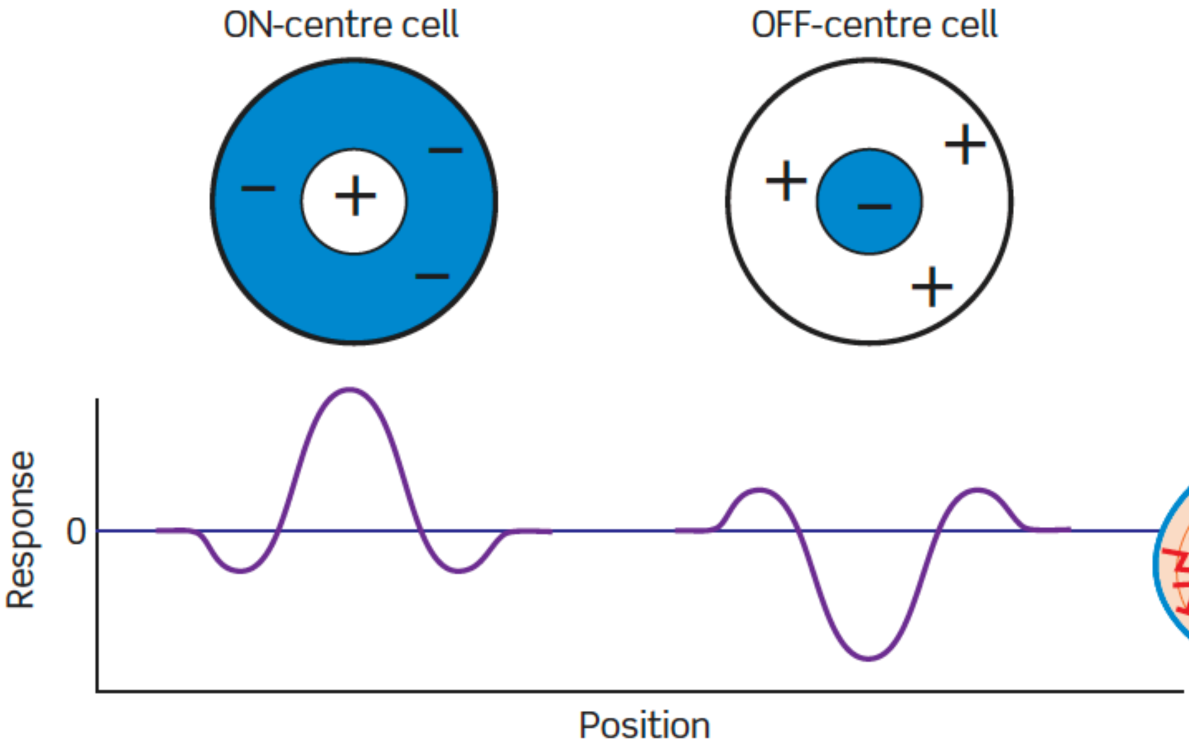


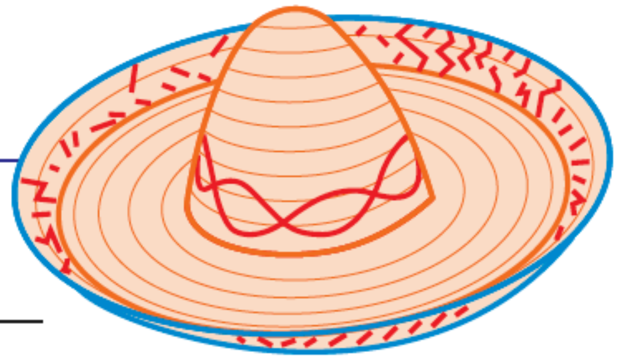


The photo, a scanning electron micrograph of a primate retina, shows what the rods and cones really look like.

Figure from Basic Vision An Introduction to Visual Perception by Robert Snowden, Peter Thompson, Tom Troscianko

On-centre and off-centre receptive fields





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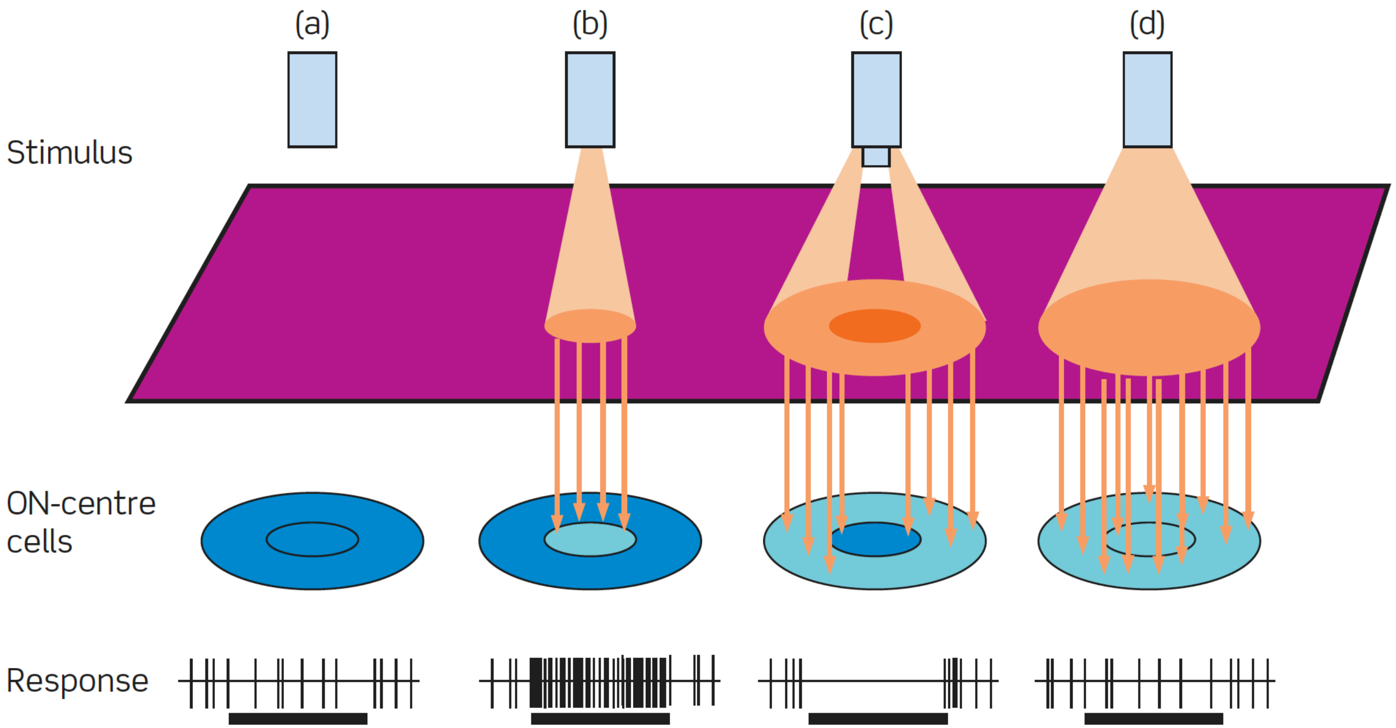
The response of on-centre ganglion cells to light



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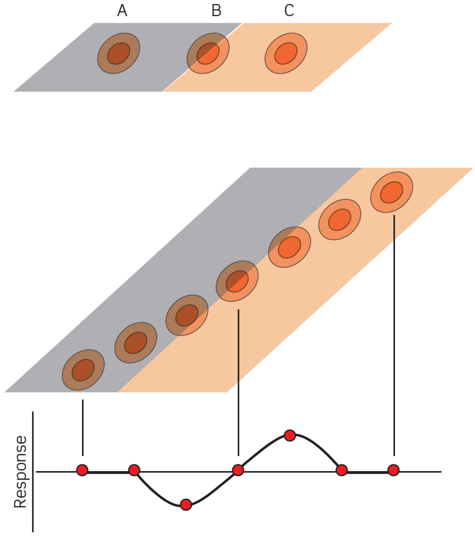
Edge filtering is performed by the ganglion cells



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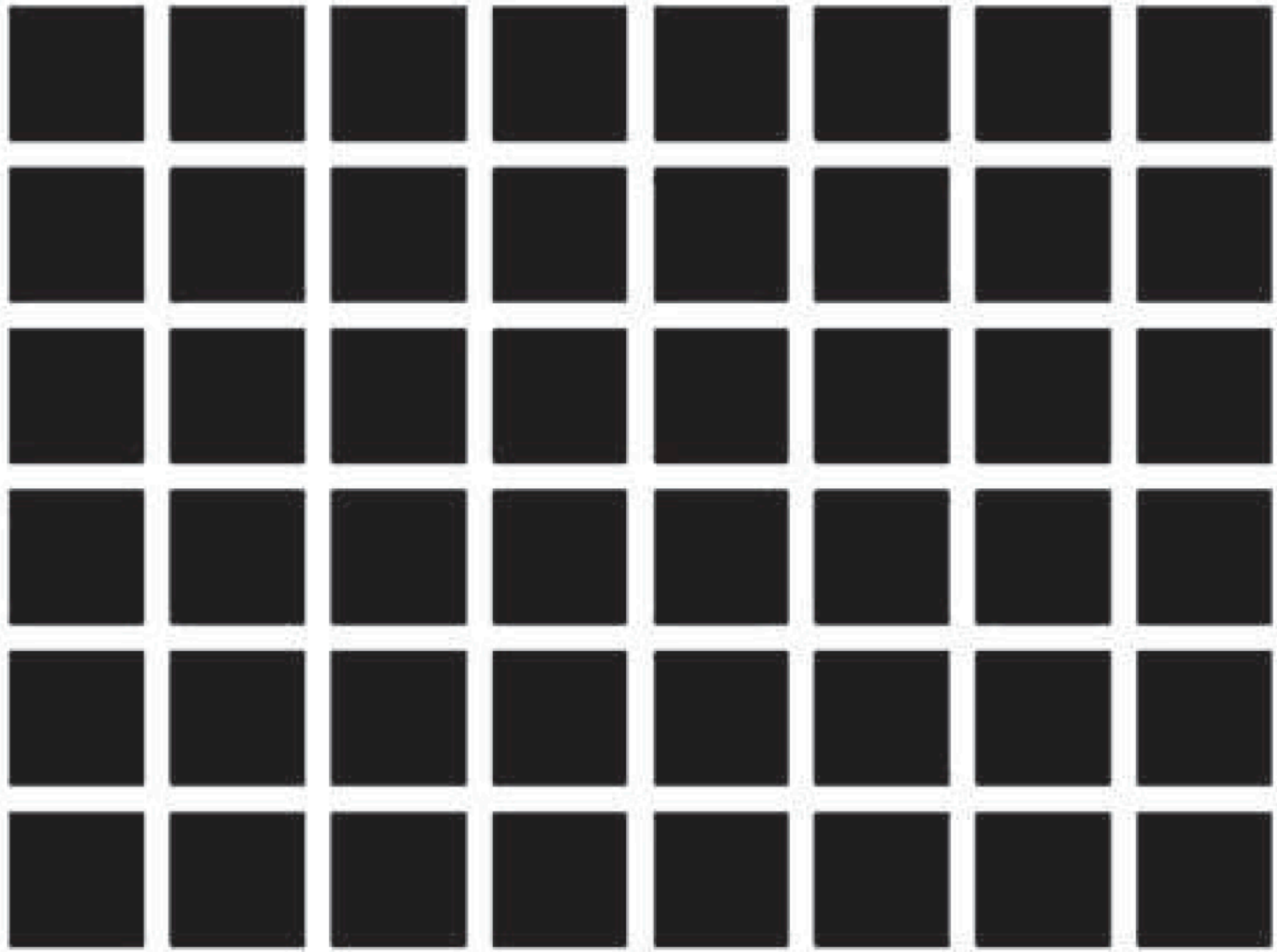


The Hermann grid (or Hering grid)

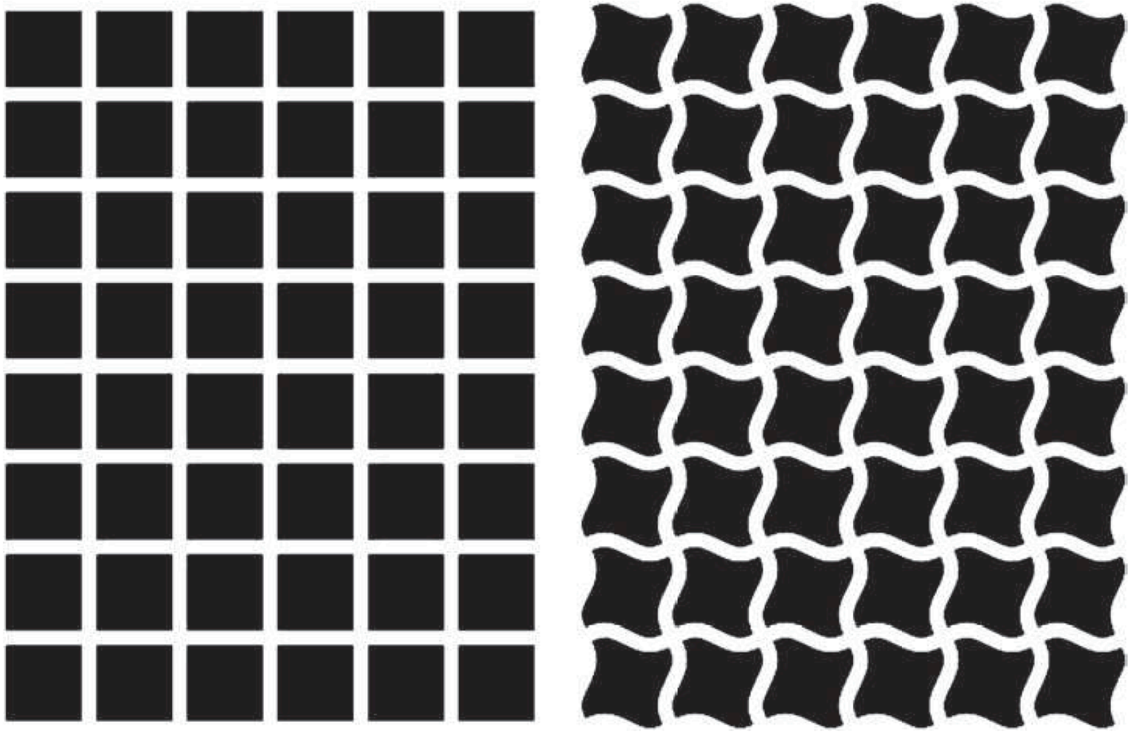
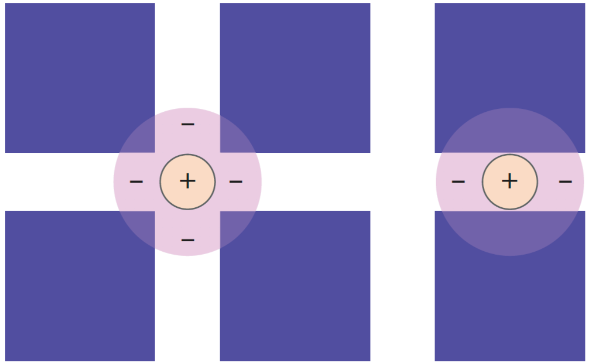


Figure 2.9 (a) The Hermann grid and (b) the version by **Geier et al. (2008)** which challenges the Baumgartner model. Why should the wiggles make the illusion disappear?



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The scintillating grid

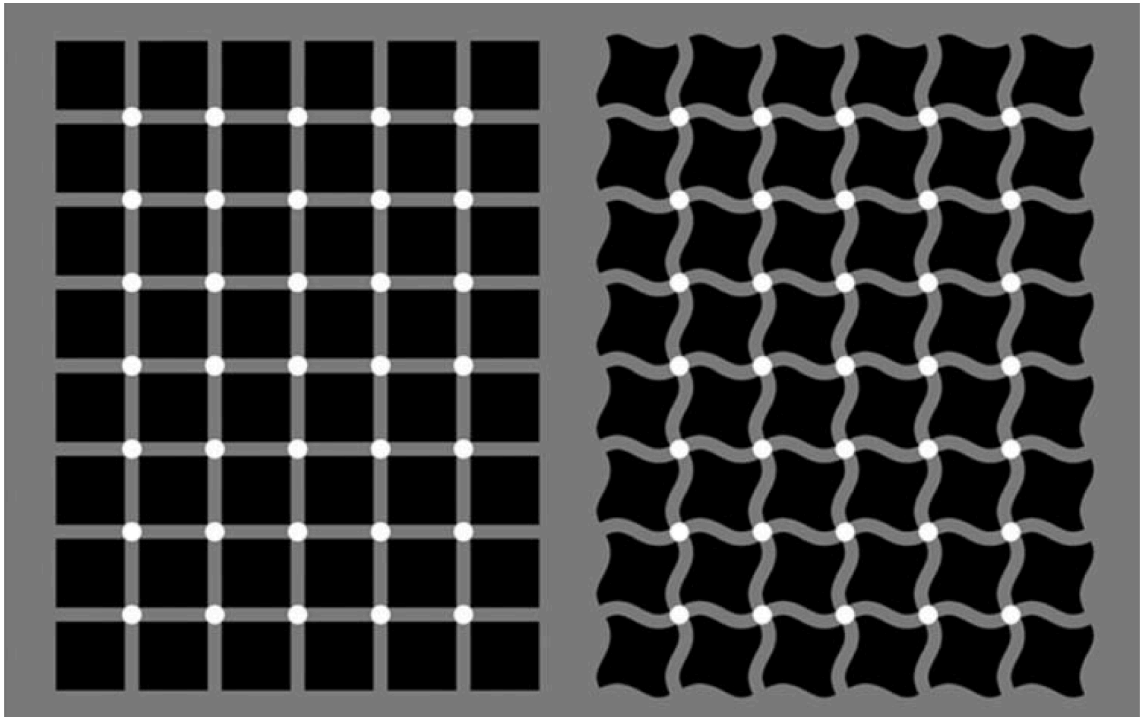

Figure 2.11 The scintillating grid. As you move your eyes around (a), you should see black spots flashing in the middle of the white spots. Why should this happen? It is clearly a different effect from the Hermann grid. Or is it? Just like the Hermann grid, making the lines a bit wiggly abolishes the illusion, as shown in (b).

Figure from Basic Vision An Introduction to Visual Perception by Robert Snowden, Peter Thompson, Tom Troscianko