

Lightness and Brightness

Presented by Gerwin Damberg, January 2011

Overview

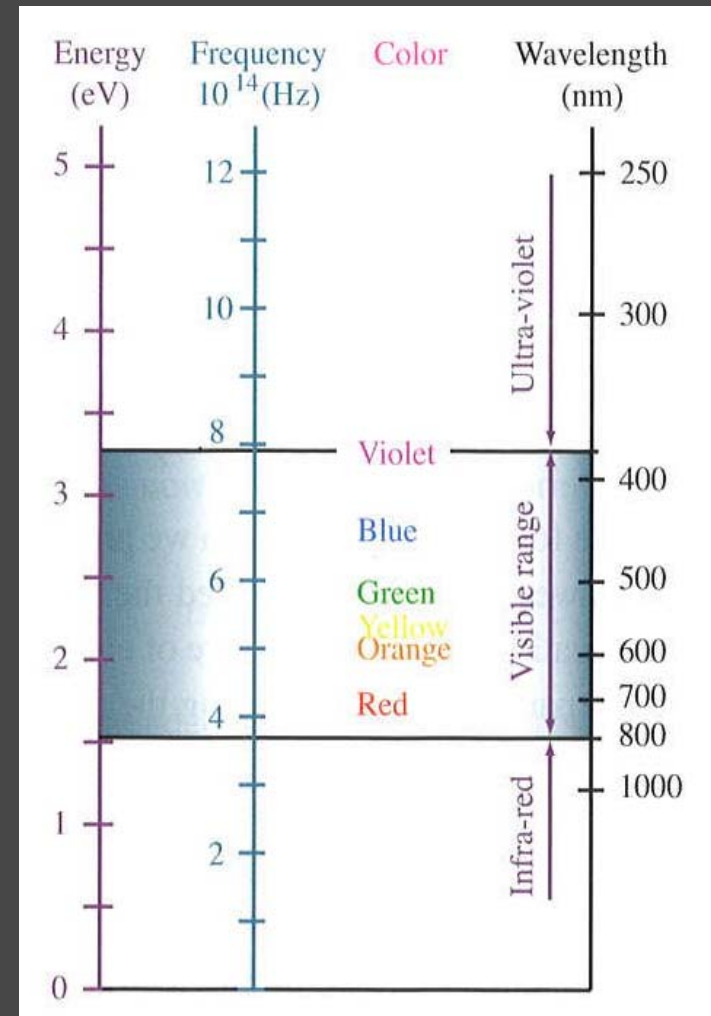
- Part I: Definitions
 - Radiometry
 - Photometry
 - Perception
- Part II: Perceptual effects and illusions
 - Low level vision
 - High level vision

Other related reads

- Color Imaging: Fundamentals and Applications
E. Reinhard et al.
- The reproduction of color
R.W.G. Hunt

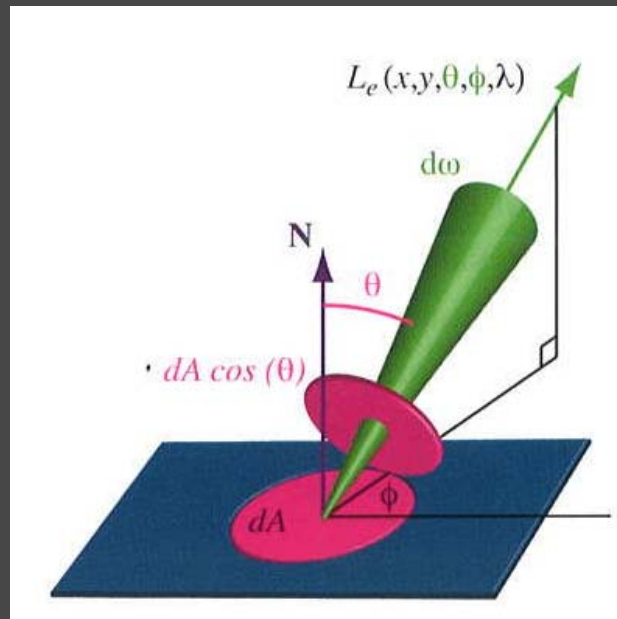
Radiometry: Physical quantities (measurable)

- Electromagnetic radiation: one form of energy; wave-like behavior. Examples: radio waves, micro waves, gamma rays.
- 'Light' is the aspect of electromagnetic radiation that is visible by humans
- The human visual system (HVS) responds to wavelengths between 390nm and 790nm



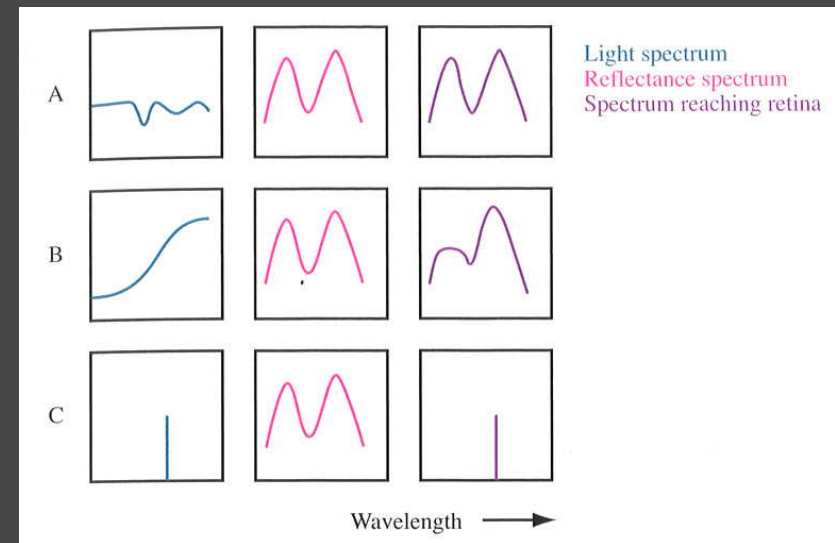
Radiance

- Radiance is a radiometric measure of energy emitted from a given surface area, traveling in a specific direction per solid angle. Unit: $\text{W}/(\text{sr} \cdot \text{m}^2)$



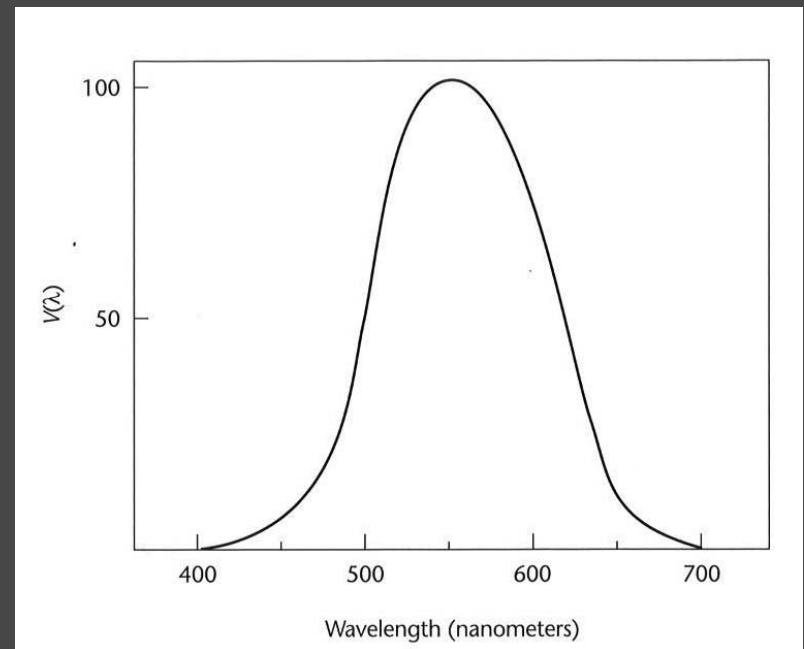
Object Reflectance

- Objects illuminated by light absorb and reflect parts of the spectrum
- The spectrum reaching the retina is a combination of the light spectrum and the reflectance spectrum



Photometry: perceptually weighted physical quantities (measurable)

- Luminance is a photometric measure of luminous intensity over a given area and direction. Unit: cd/m^2
- Luminance is the radiant energy weighted by the spectral sensitivity of the HVS

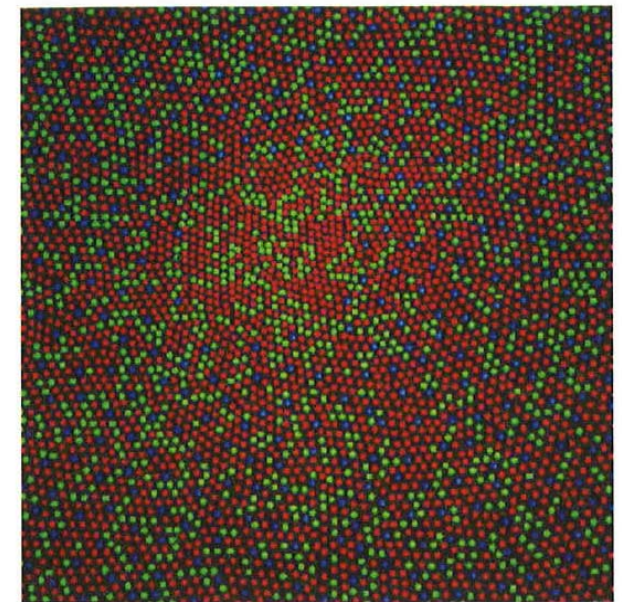
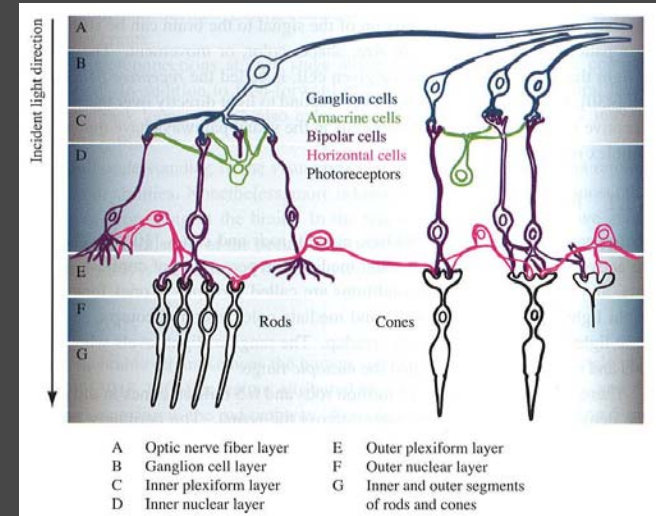


Perceptual quantities (not directly measurable)

- Brightness is an attribute of visual sensation according to which a given stimulus appears to be more or less intense or appears to emit more or less light. It ranges from 'dim' to 'bright'.
- Lightness is 'relative brightness'. It is an attribute of visual sensation according to which a visual stimulus appears to emit more or less light compared to a similarly illuminated area that appears white. Lightness ranges from 'dark' to 'light'

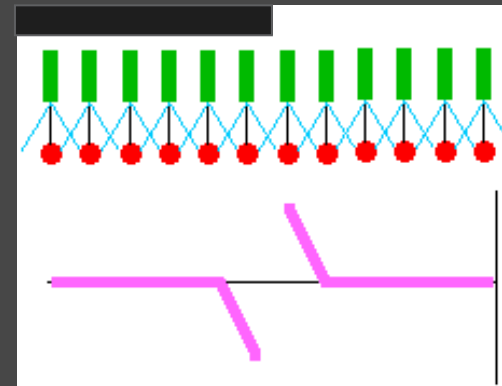
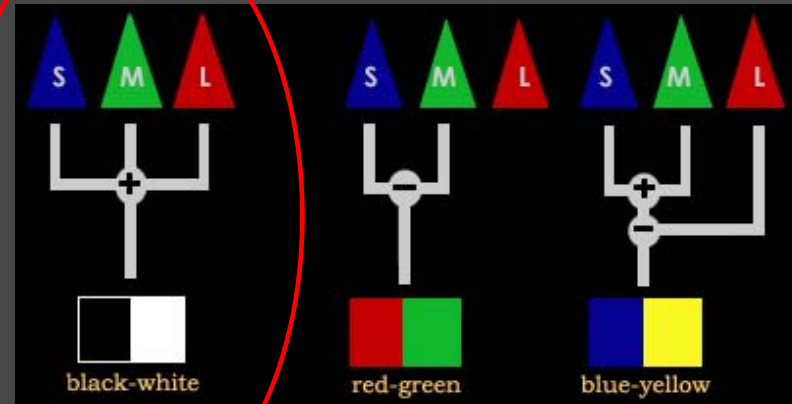
Low level vision

- The HVS can sense a very wide range from starlight to sunlight. Its 'sensors' are rods and cones.
- Rods are for night vision (one type), cones are for higher intensities (three types: **L**, **M**, **S**)
- Receptors are networked, first 'image processing' happens within the retina.



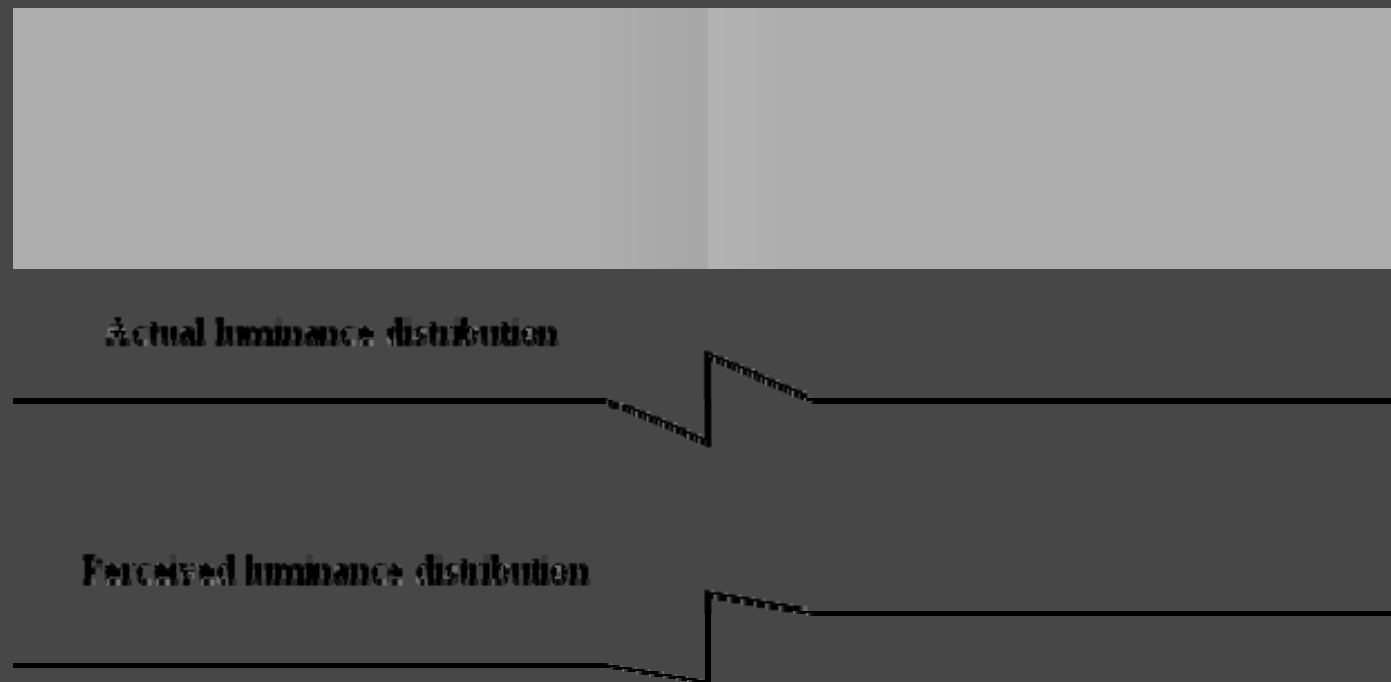
Opponent color model

- Three channels:
 - Red-green
 - Blue-yellow
 - Dark-bright
- Lateral inhibition
 - Each neuron (red) is excited by a overlaying photoreceptor and and inhibited by the neighboring receptors.
 - Simplified: we see differential (pink signal)



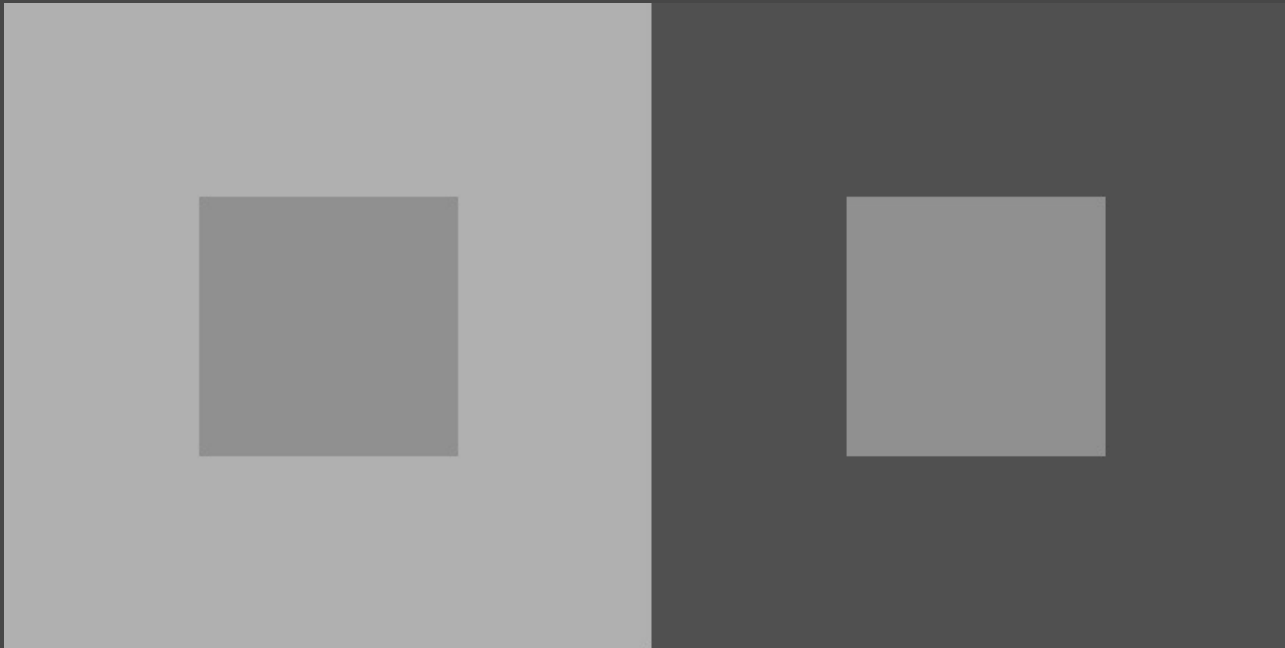
Example: Cornsweet Illusion

- If the HVS was a photometer, we would see the gradient



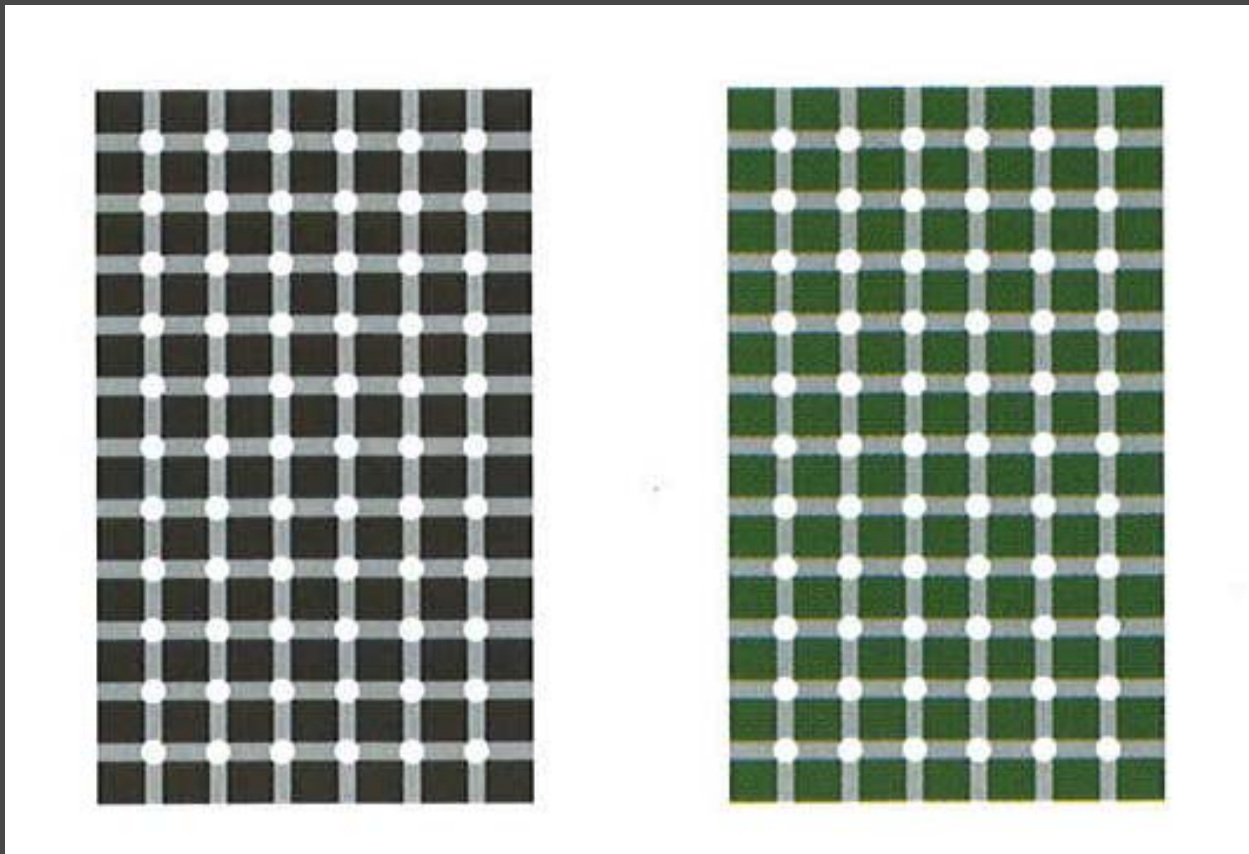
Example: Surround Luminance

- The left gray patch looks darker than the right



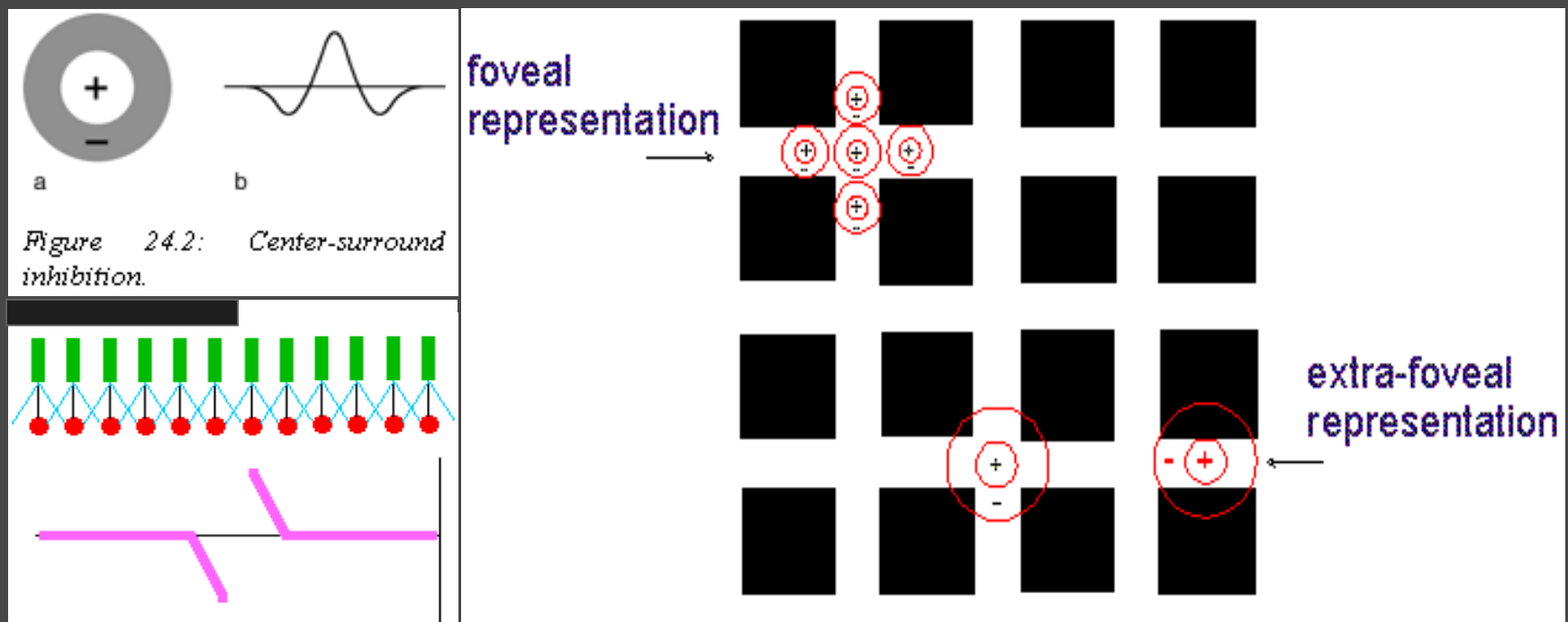
Hermann grid illusion

- 'Dots' appear in the periphery between boxes



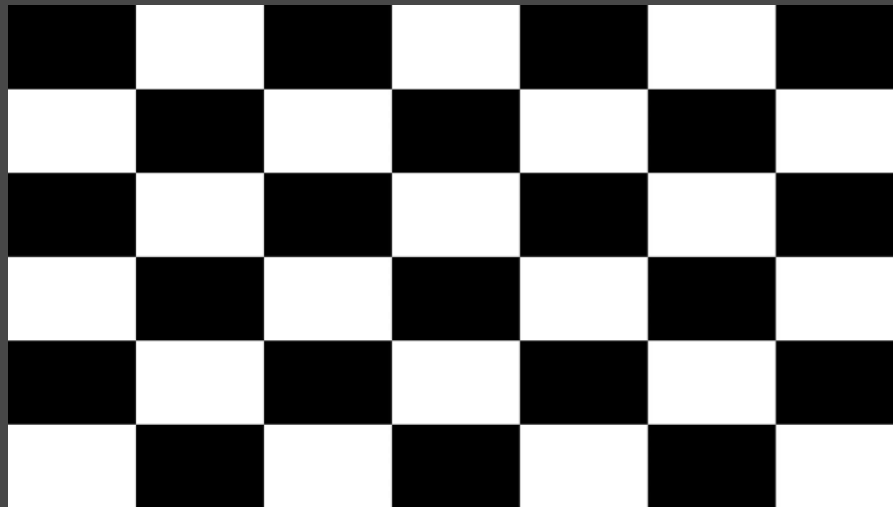
Hermann grid illusion: explanation

- Higher cone density at fovea



High level vision

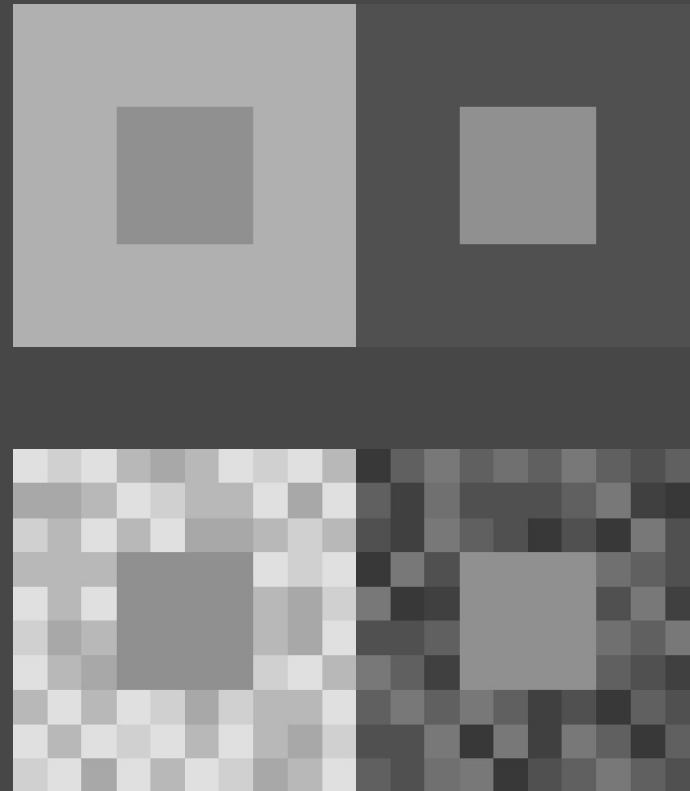
- Then why don't we see just edges?



- Brain 'fills in' uniform areas based on intensity change
- Complicated, but allows for adaptation, distinction between illumination and reflectance, etc.

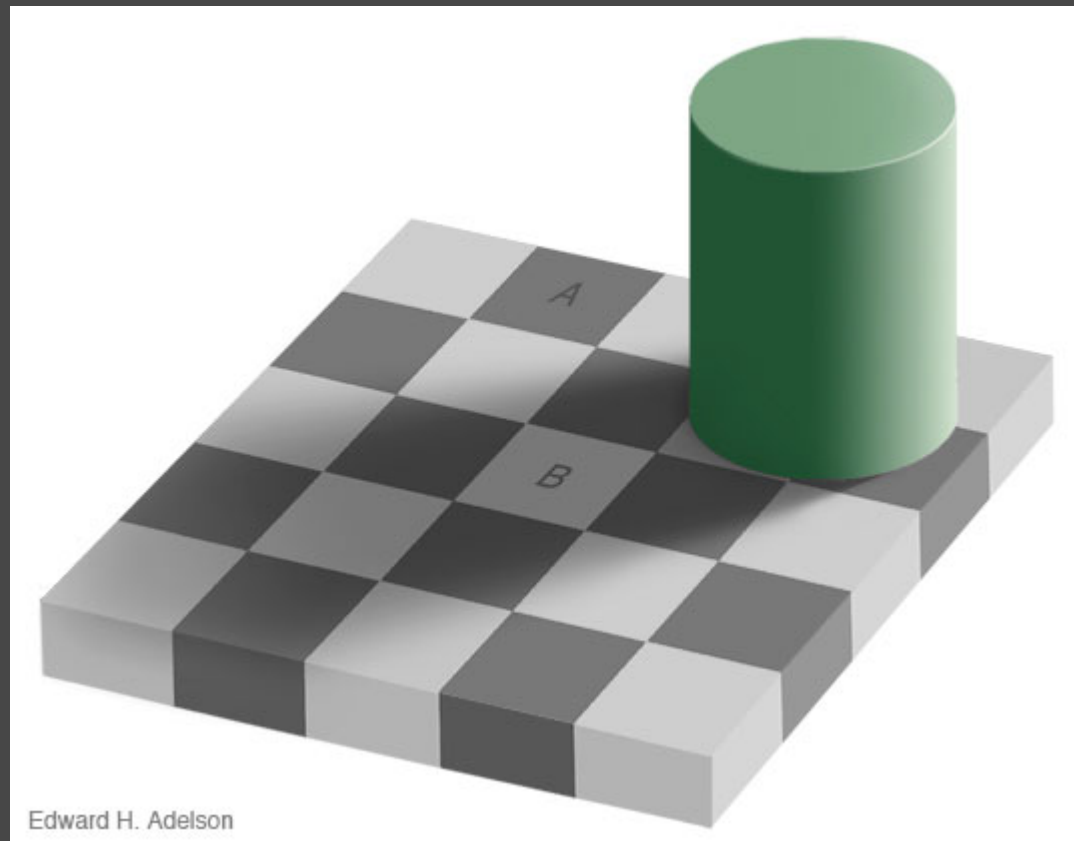
High level vision

- Same mean luminance top and bottom
- Effect is stronger at bottom
- Articulation: number of distinct surfaces in the surround of a stimulus
- Frameworks: local (direct surround) global (extended surround)



Checkersshadow Illusion

- $A = B$



Edward H. Adelson

- [Adelson, <http://persci.mit.edu/gallery/checkersshadow>]

Backups



Café house illusion (Bristol, UK)

