

Simultaneous lightness contrast



www.physics.utoledo.edu/~lsa/color/mod20.htm

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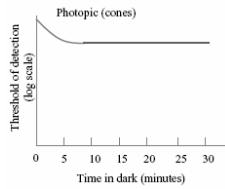
Sensitivity

- Two Types:
 - Rods
 - Cones
- Cones sensitive to high levels of light (photopic)
- Rods sensitive low levels of light (scotopic).
 - Rods "turn off" under photopic conditions
 - Cones do not respond under scotopic conditions
- **Eye adjusts sensitivity to varying light levels**
- Change of sensitivity to overall light level is **adaptation**

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Adaptation of Color Vision

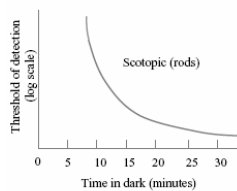


- The reason why you cannot see immediately after entering a movie theater from daylight
- Cone sensitivity increases for a few minutes
- Sensitivity increase reaches limit within 10 minutes

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Adaptation, rods



- Sensitivity of rods is nearly 0 (very high threshold) for first 10 minutes in darkness because they have been "bleached" in sunlight

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Question to Ponder

- Why do fighter pilots wear goggles with red lenses before departing on a night flight?

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Eye Movements

Your eyes are never stationary:

- **Drifts:** slow, smooth movements of about 1/60 of a degree per second (1 min of arc)
- **Tremors:** concurrent with drifts, these are rapid, jittery motions. (1/4 min of arc)
- **Saccades:** sharp, abrupt movements, may occur up to 4 times per second (5 – 10 min of arc)

While you read a paragraph your eyes skip to groups of words, and back to the beginning of each line by means of saccades.

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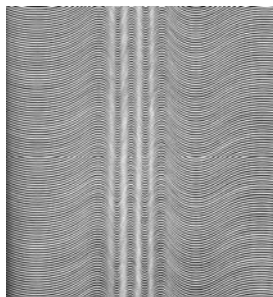
Eye Movements

- Eye is looking at detail only in a very small part of the field of view
- Brain constructs image of entire field, gives perception of high resolution over entire field

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Eye movements

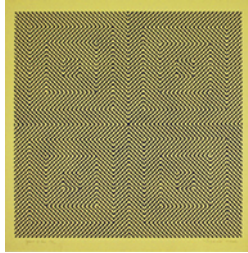


Bridget Riley, "Current"

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Eye movements



Reginald Neal, "Square of two"

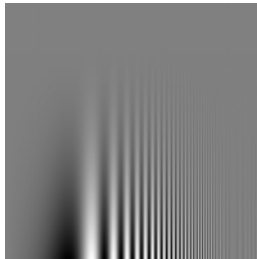
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Contrast sensitivity

Maximum at 6 cycles per angular degree, less sensitive to lower and higher spatial frequencies

- Due to lateral inhibition



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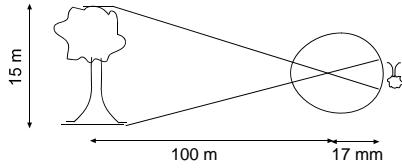
Vision

- **Accommodation:** (fine focusing) performed by crystalline lens
 - Suspended behind iris by ligaments connected to **ciliary muscles**
 - relaxed muscles pull "outward" to bring lens into fairly flat configuration
 - ▶ increased radius \Rightarrow longer focal length.
 - ▶ Completely relaxed muscles \Rightarrow light from object at infinity is focused on retina
 - As object moves closer, muscles *contract*
 - ▶ lens bulges \Rightarrow focal length is reduced
- **Near point:** closest point at which eye can focus
 - \approx 70 mm for teenager
 - \approx 120 mm for young adult
 - \approx 350 mm for middle age
 - \approx 800 mm at age 60

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Real Inverted Image on Retina



Size of retinal image: $15/100 = h/17 = 2.55 \text{ mm}$

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Imperfect Vision

- **Nearsightedness (myopia)**
 - Parallel rays brought to focus in front of retina
 - Power of lens is too large (focal length is too short)
 - Corrected by placing a negative lens in front of eye to place focal point of combined lens on retina
 - Corrective lens does not change focal length of total system
 - ▶ Image size does not change with glasses removed

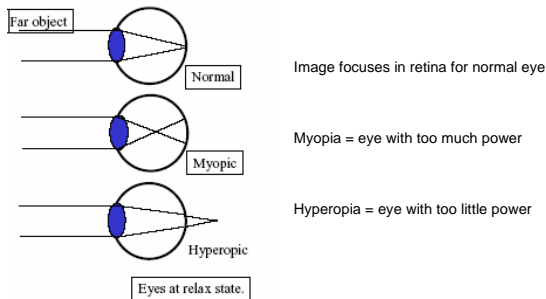
- **Farsightedness (hyperopia)**
 - Parallel rays focus behind retina
 - Power of lens is too small (focal length is too long)
 - Increase bending of rays by placing positive lens in front of eye
 - Moves near point farther away than normal.

- **Astigmatism:** due to uneven curvature of the cornea

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Refractive error



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Myopic eye

Far object: Myopic eye relaxed, Blurry. Distant objects look blurry because the eye cannot relax any farther \Rightarrow image is focused before the retina.

Near object: Myopic eye relaxed, In focus. Near object in focus without accommodation.

Far object: Myopia corrected with a negative lens. Corrected with a negative lens.

Virtual image from diverging lens appears to be "closer"

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Hyperopia

Far object: Hyperopic eye, Partially accommodated, In focus. Near object looks blurry because the eye cannot accommodate enough for near objects.

Near object: Hyperopic eye, Fully accommodated, Blurry. Far object in focus.

Near object: Hyperopia corrected with a positive lens. Corrected with a positive lens.

Virtual image from converging lens appears to be "farther"

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Astigmatism

The cornea is not spherical; Focal length different from one plane to a perpendicular plane.

Object: Image at F' Horizontal, Image at F' Vertical.

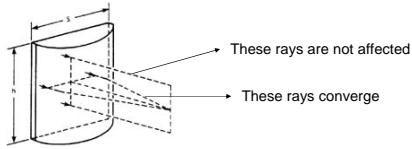
Direction of blur: F' horizontal, F' Vertical.

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Cylindrical correction

Astigmatism corrected with lens that corrects (converges or diverges) in one plane without affecting rays in perpendicular plane

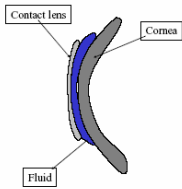
Cylindrical lens



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Contact lenses



Alternative to corrective lenses

In contact with cornea

Changes curvature of cornea by adhering to surface

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