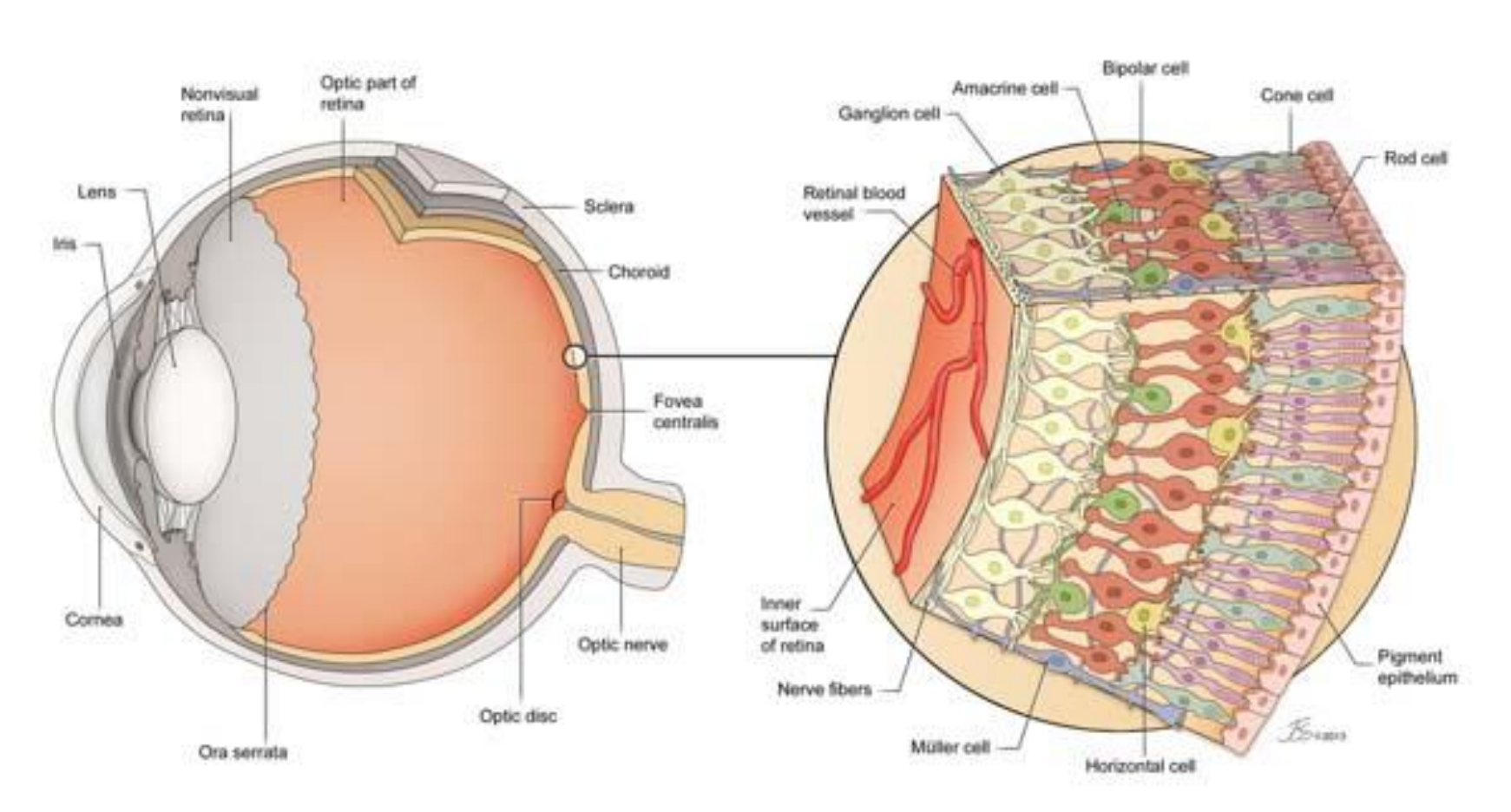
Visual Imaging and the Electronic Age

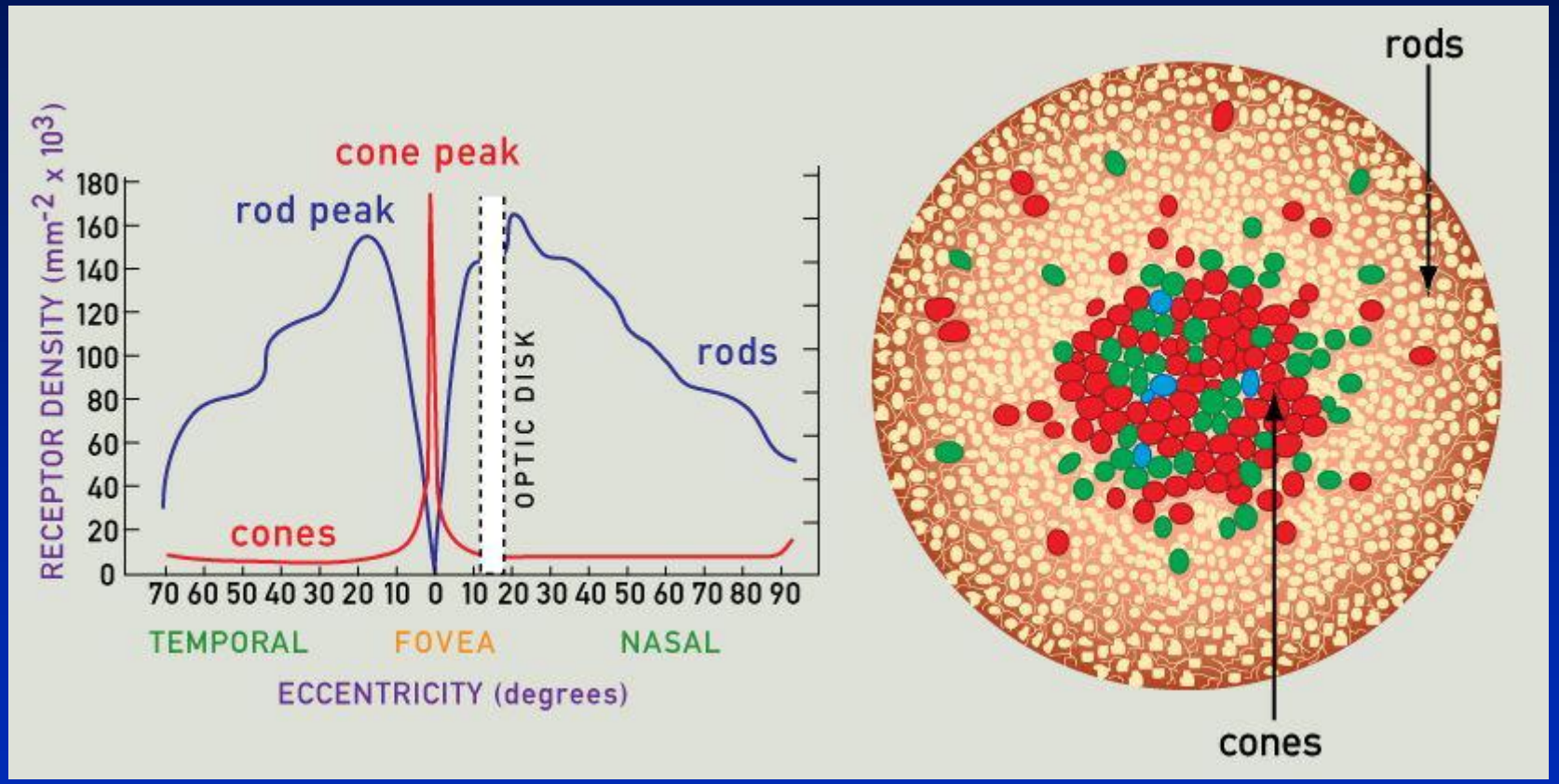
Fundamentals of Human Perception

Lecture #9
October 1, 2020
Prof. Donald P. Greenberg

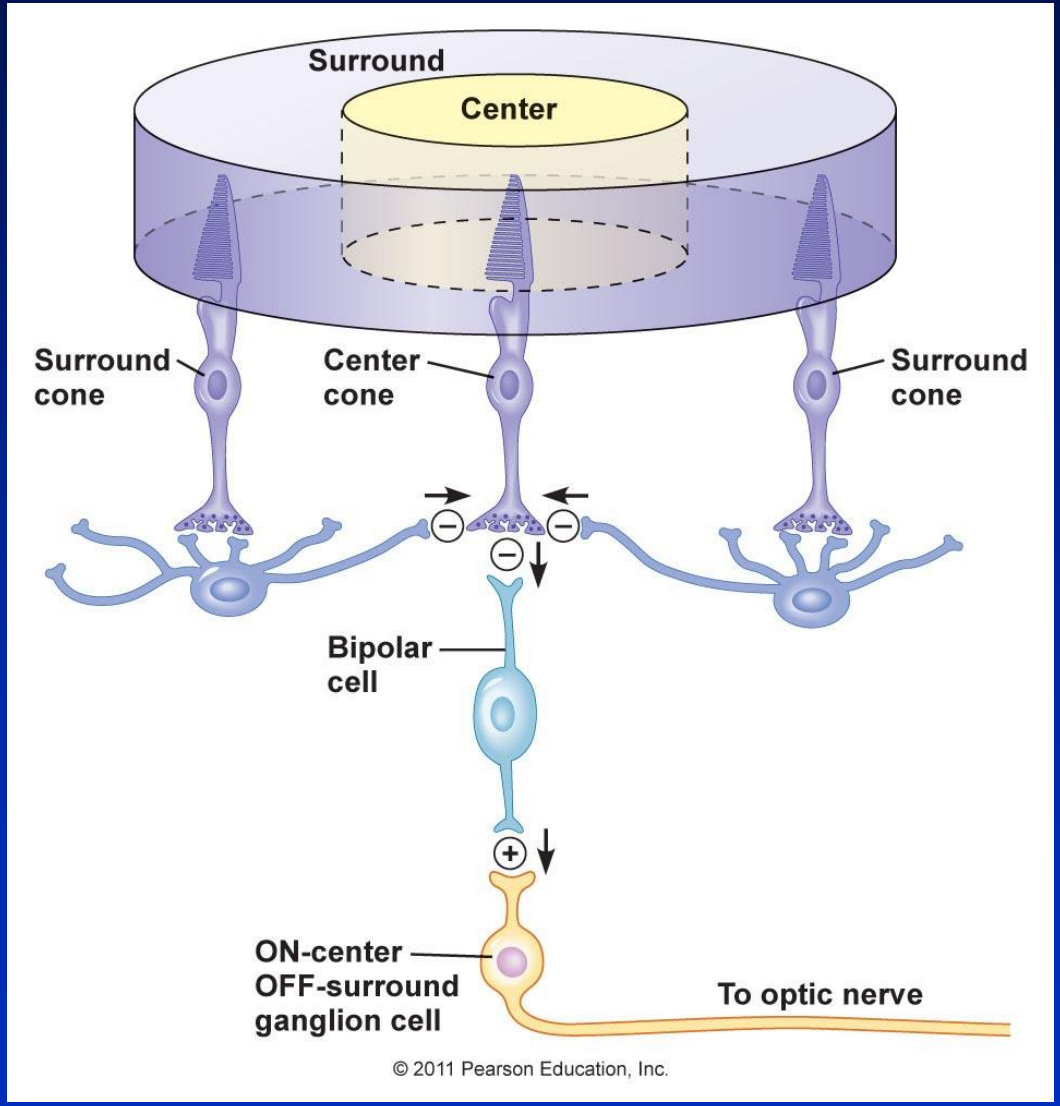
Rods and Cones



Receptor Distribution



Receptive Fields



- http://droualb.faculty.mjc.edu/Course%20Materials/Physiology%20101/Chapter%20Notes/Fall%202007/figure_10_39_labeled.jpg

Opponent Color Theory

Hering 1892

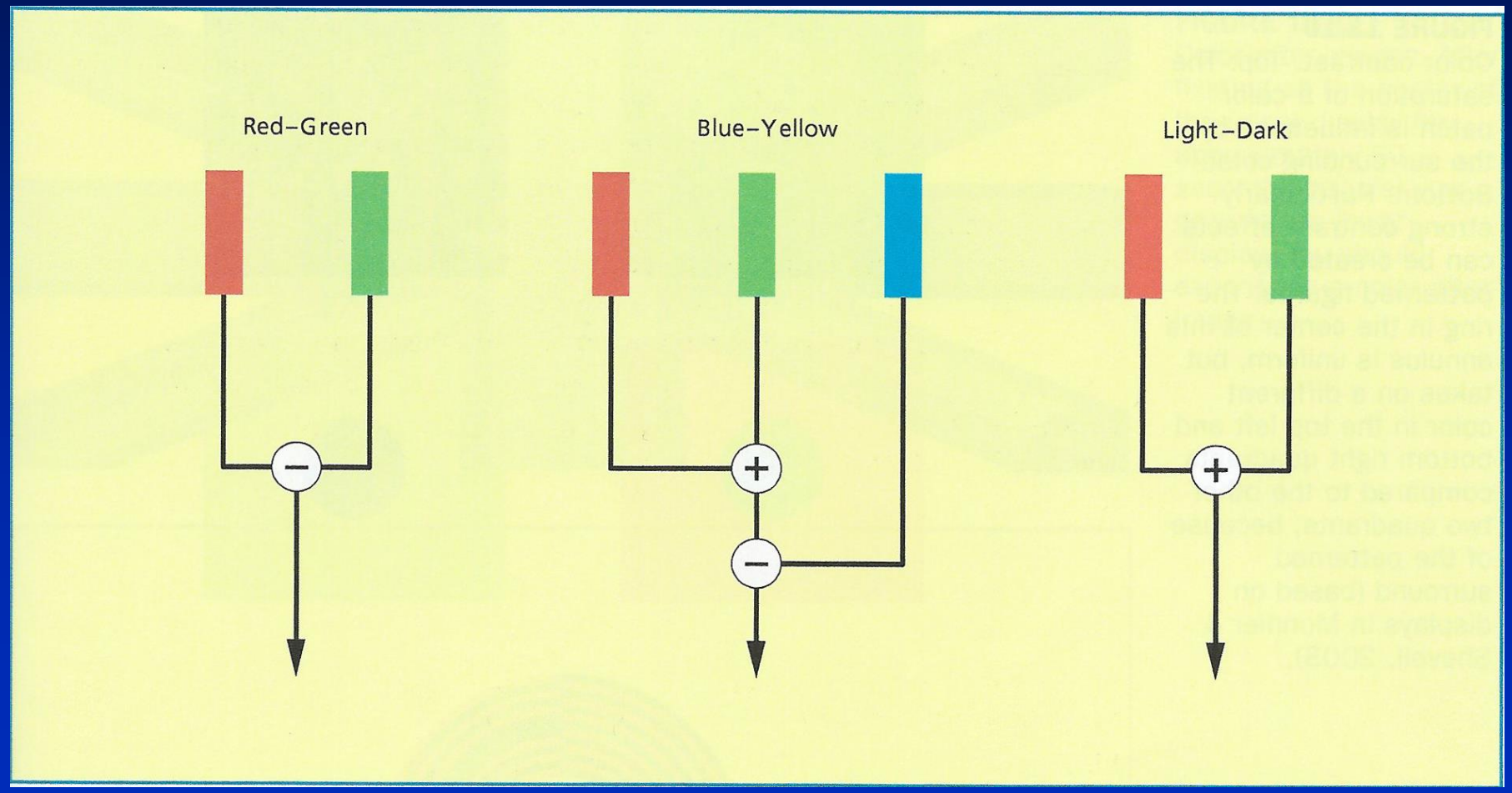
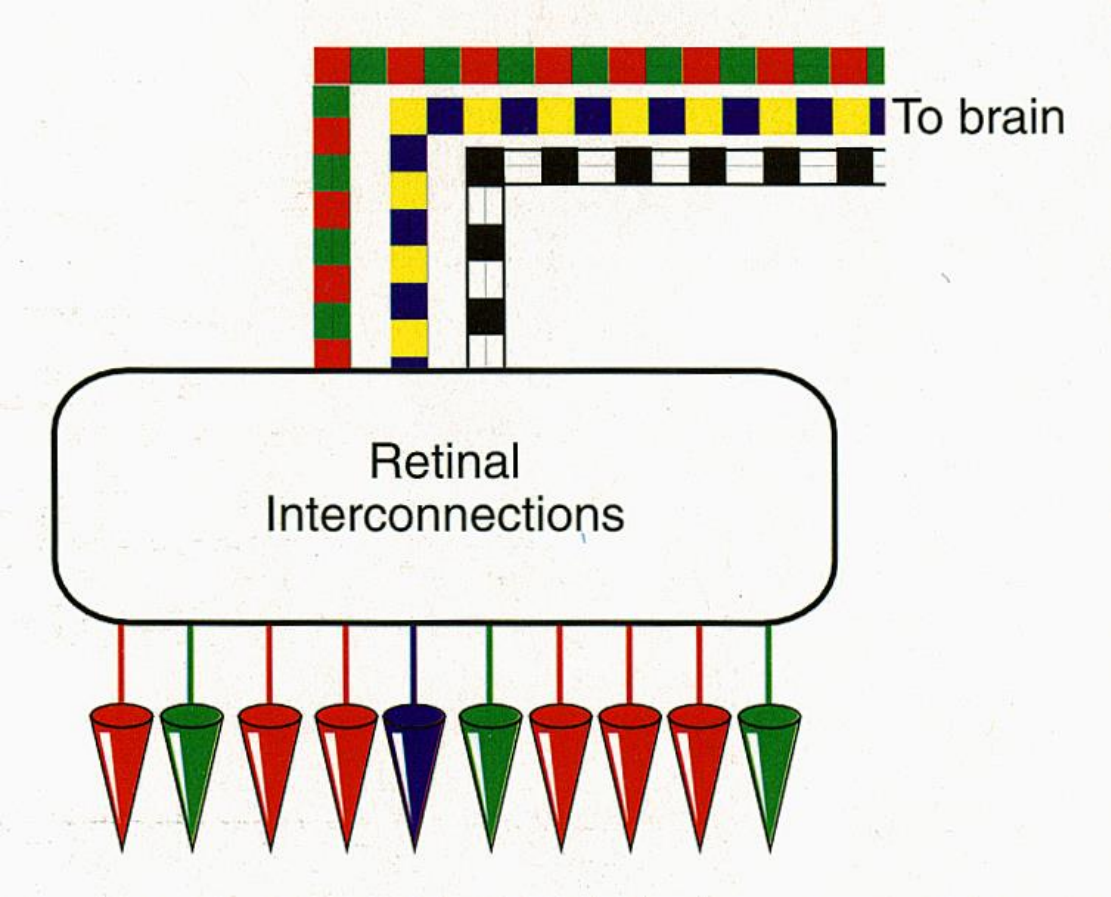


Figure 12.9– Foundations of Sensation and Perception, George Mather

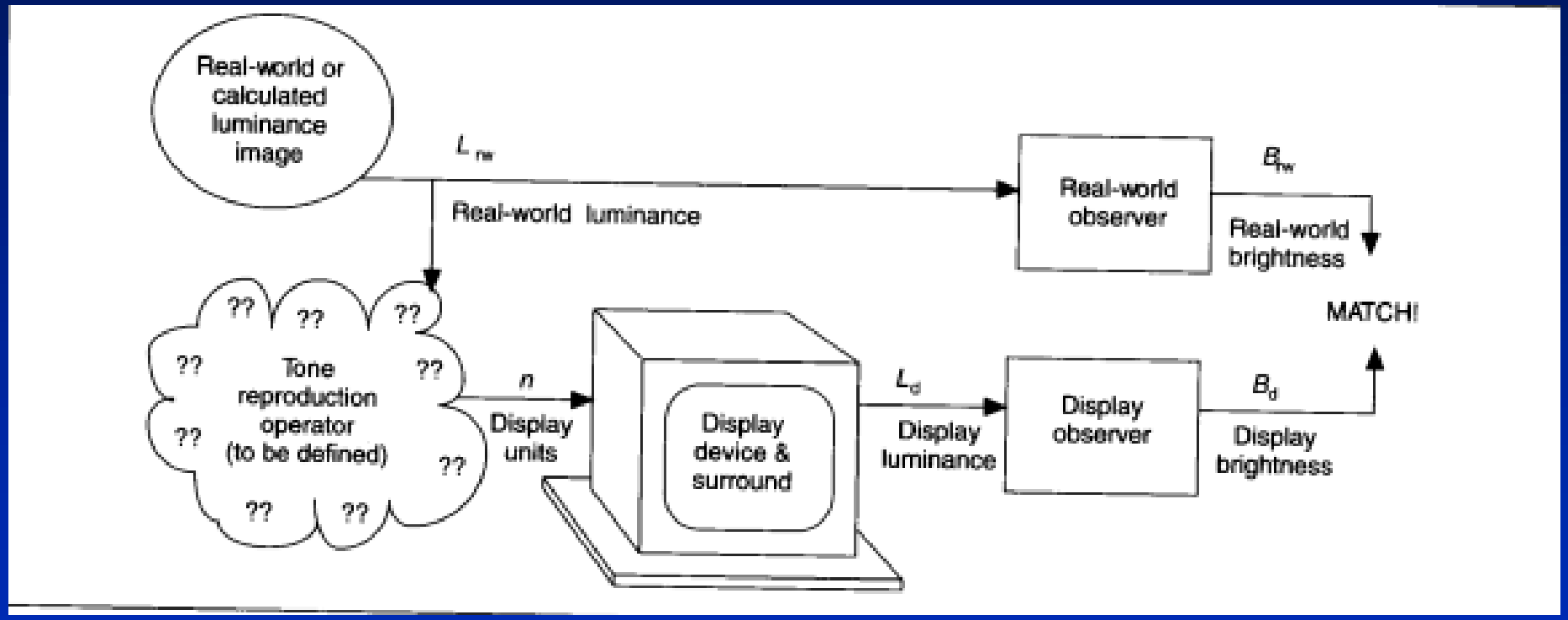


Cones interconnect in the retina, eventually leading to opponent-type signals.

Roy S. Berns. “Billmeyer and Saltzman’s Principles of Color Technology, 3rd Ed. 2000, John Wiley & Sons, Inc. p. 16.

End of Review

From Real World to Display



Tumblin, Jack & Rushmeier, Holly. (1993). Tone Reproduction for Realistic Images. Computer Graphics and Applications, IEEE. 13. 42-48. 10.1109/38.252554.

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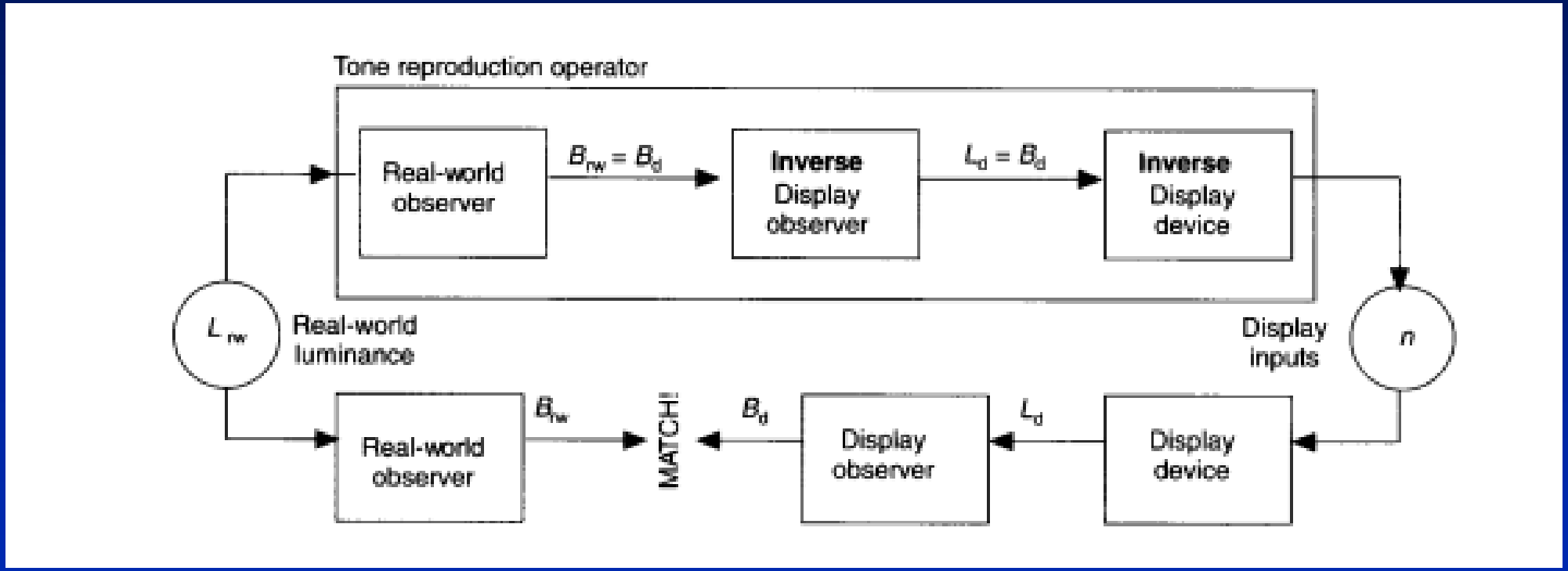


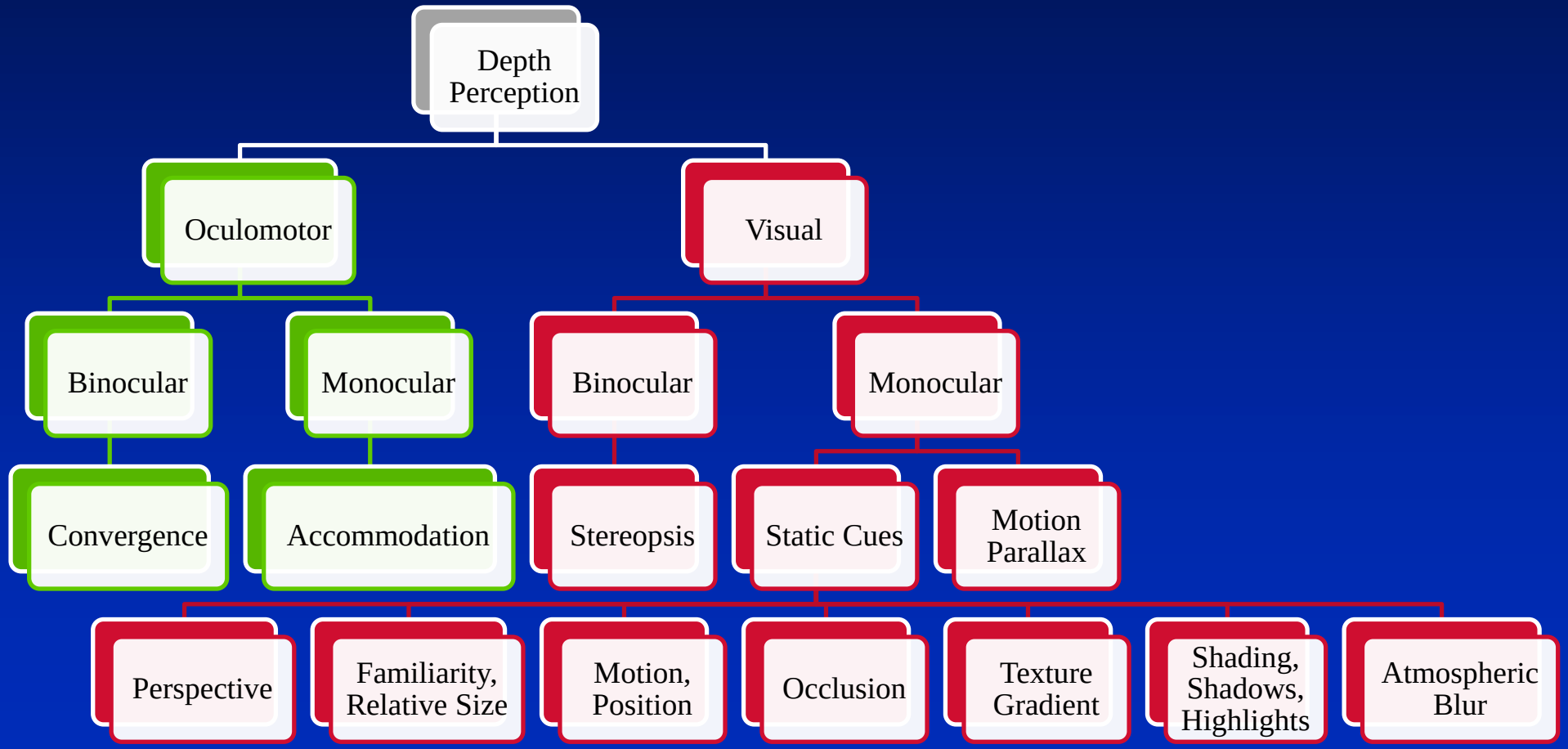
Tumblin, Jack & Rushmeier, Holly. (1993). Tone Reproduction for Realistic Images. Computer Graphics and Applications, IEEE. 13. 42-48. 10.1109/38.252554.

Fundamentals of Human Perception

- Retina, Rods & Cones, Physiology
- Receptive Fields
- Depth Perception

Depth Perception

Human Depth Perception

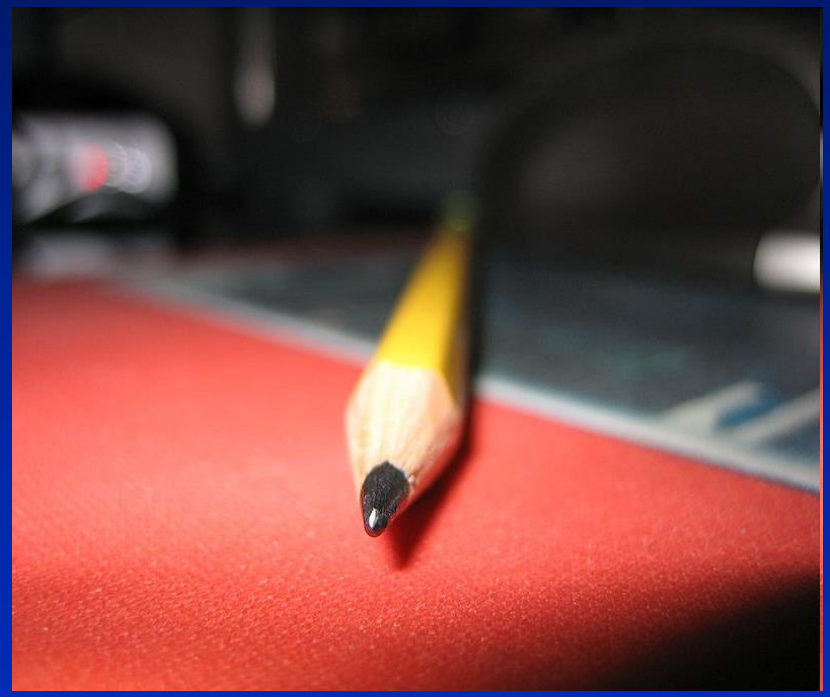


Monocular Vision

- Sixty to seventy degrees have no binocular vision (because only one eye can see those portions of the visual field)

Monoscopic Depth Cues

- Perspective
- Depth from Motion, Relative Size, Position, Familiarity
- Occlusion
- Texture Gradient
- Parallax from Motion
- Shadows and Specular Highlights
- Atmospheric Blur



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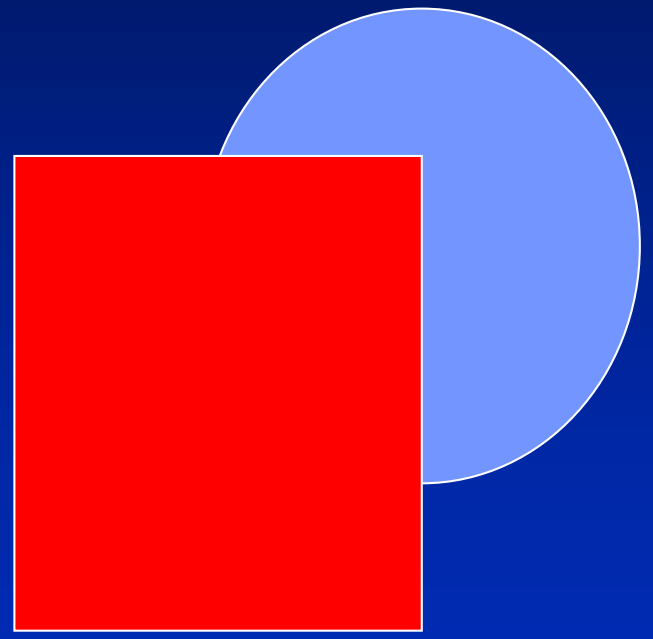

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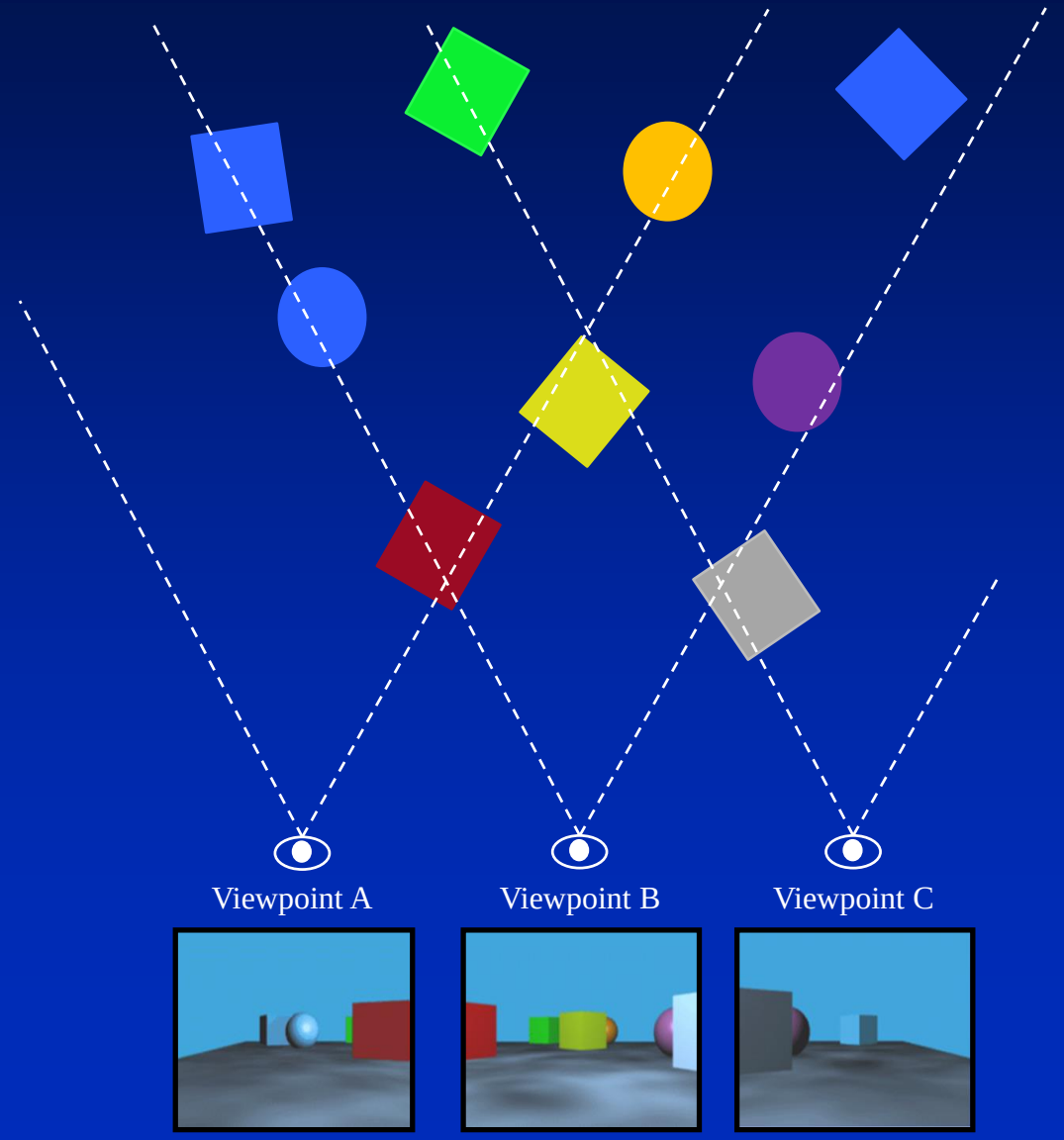

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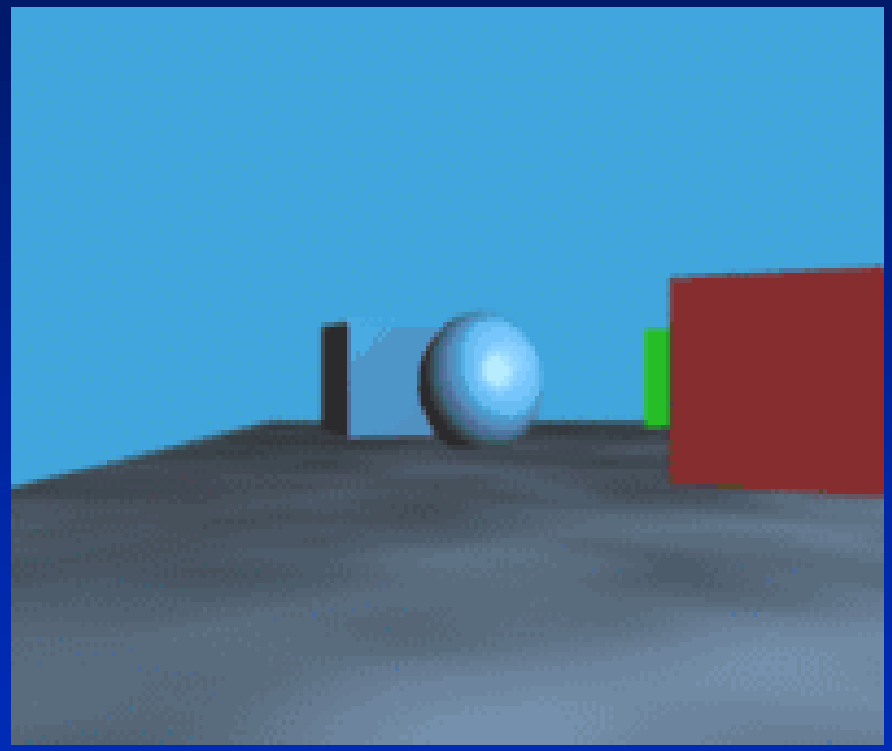

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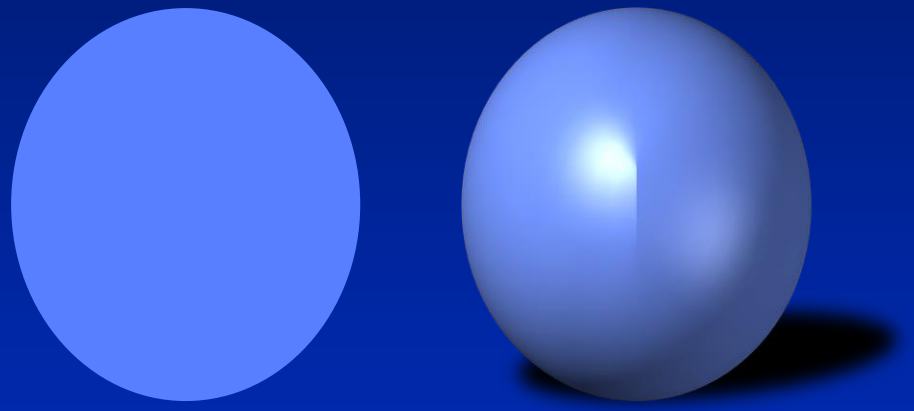

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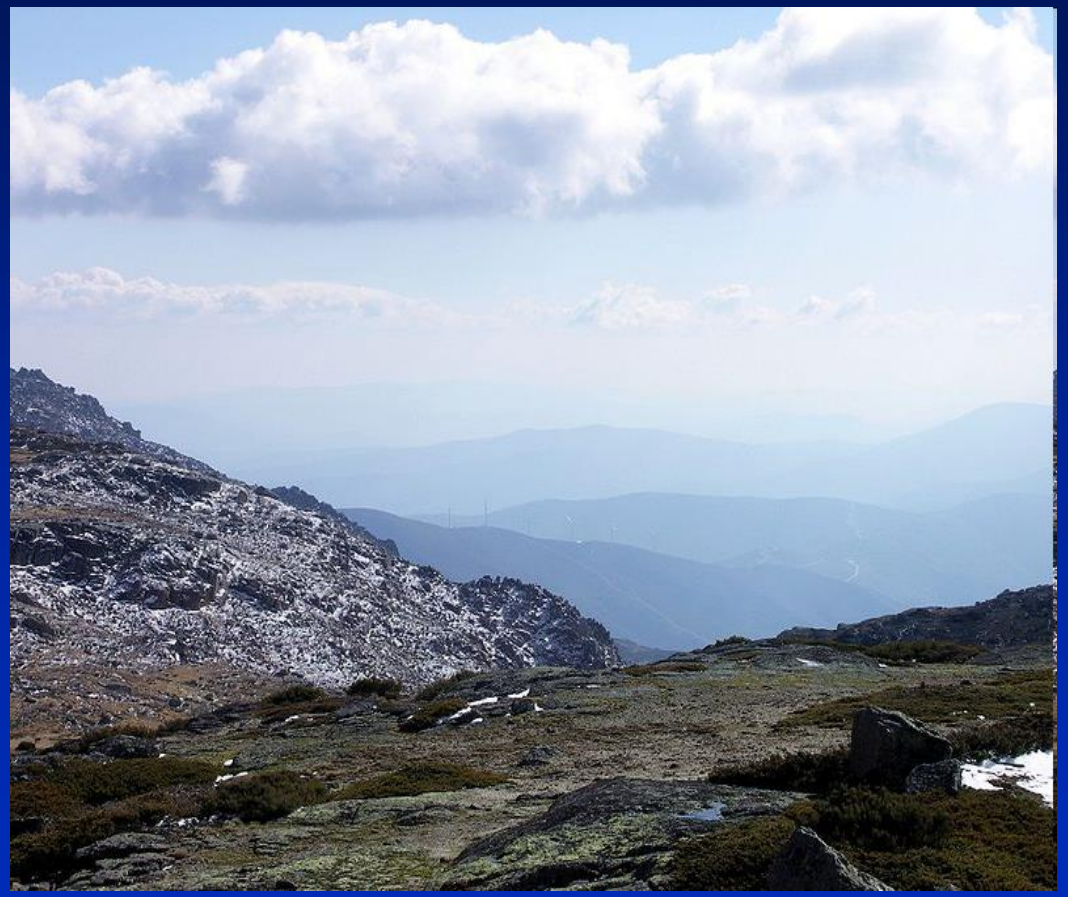
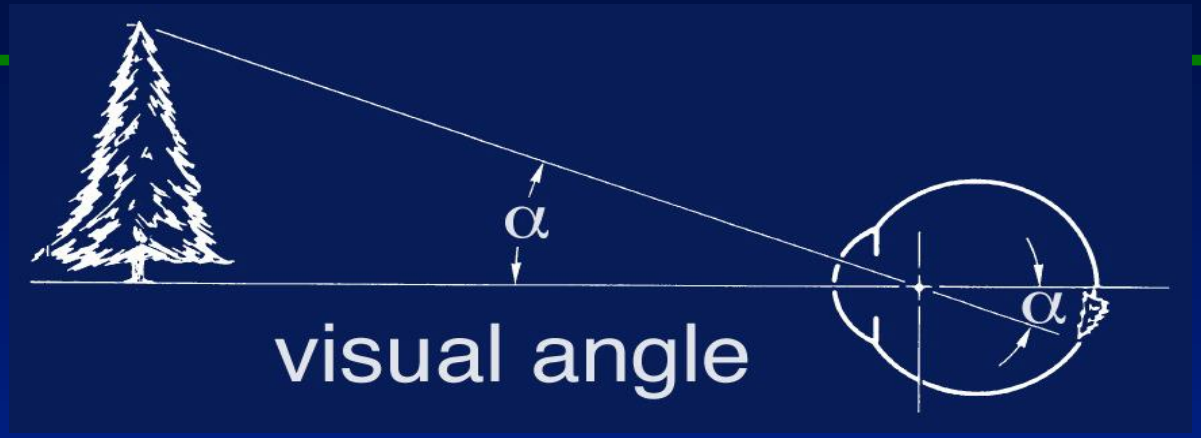


- Resolution
- Dynamic range
- Contrast ratio
- Contrast Sensitivity Function
- Vergence Accommodation Conflict

Visual Acuity

- Visual acuity is defined as “1/a where a is the response in arc-minutes”.
- This acuity is usually measured by a grating test pattern and thus is defined using a line pair.
- It takes two pixels to generate a line pair (black and white).
- Based on a large number of tests, the resolution of the human eye is approximately 0.3 arc minutes.

Measures of Acuity

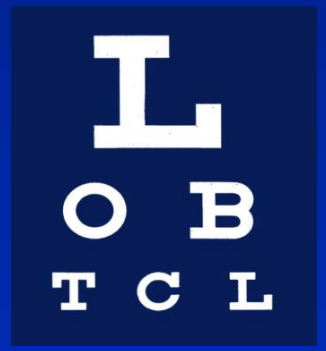


detection

min. detectable
0.5”

resolution

min. resolvable
30”



Snellen letters
30”

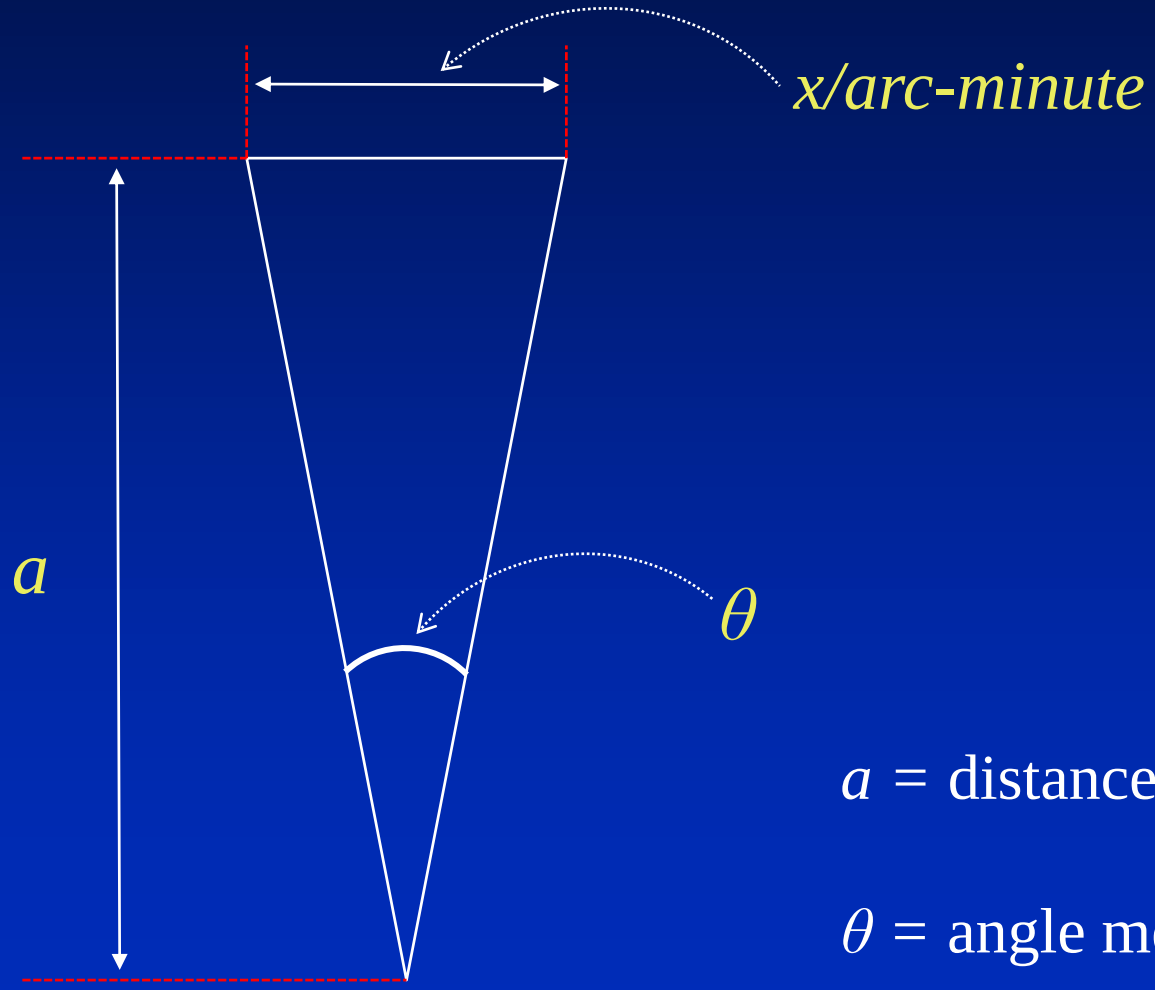
localization

vernier
5-7”

Resolution Limits

- **resolution is a function of contrast sensitivity**

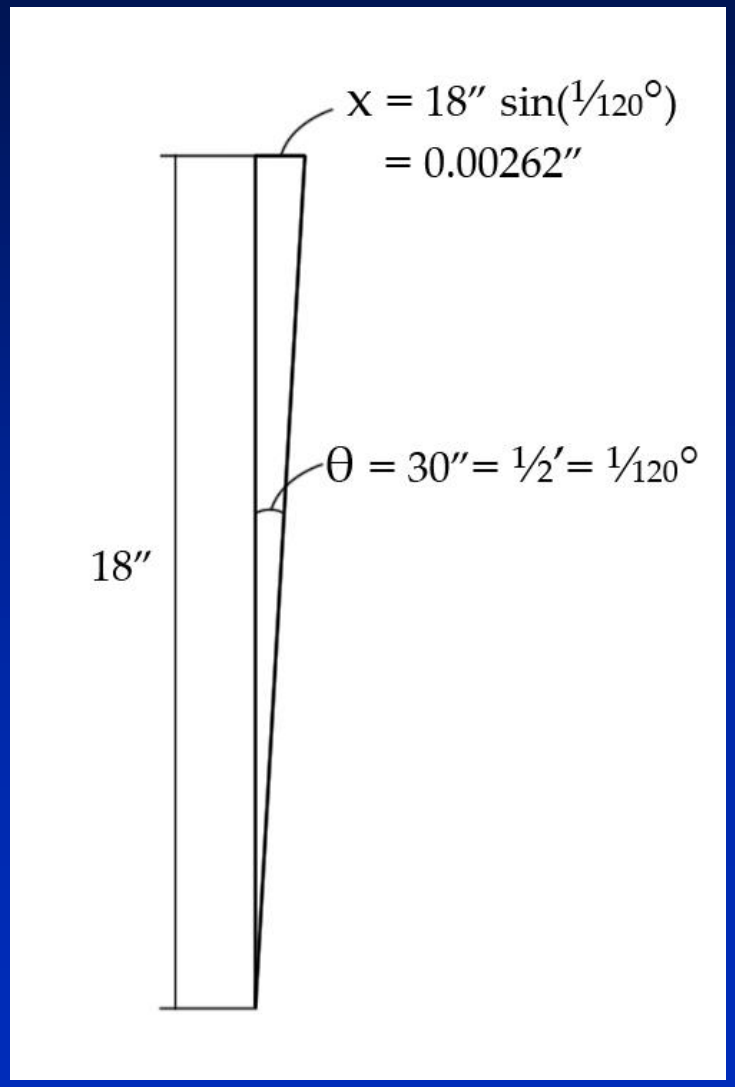
Resolution Limits



a = distance from the screen

θ = angle measured in arc-minutes

Resolution Limit for Reading at 18"



The triangle subtended by a 30 second angle

Sine of 30 sec = sine of 1/120 deg

= sin (0.0083333333)

= 0.000145444

Thus 18"sin(30 sec)

= 0.002617994"

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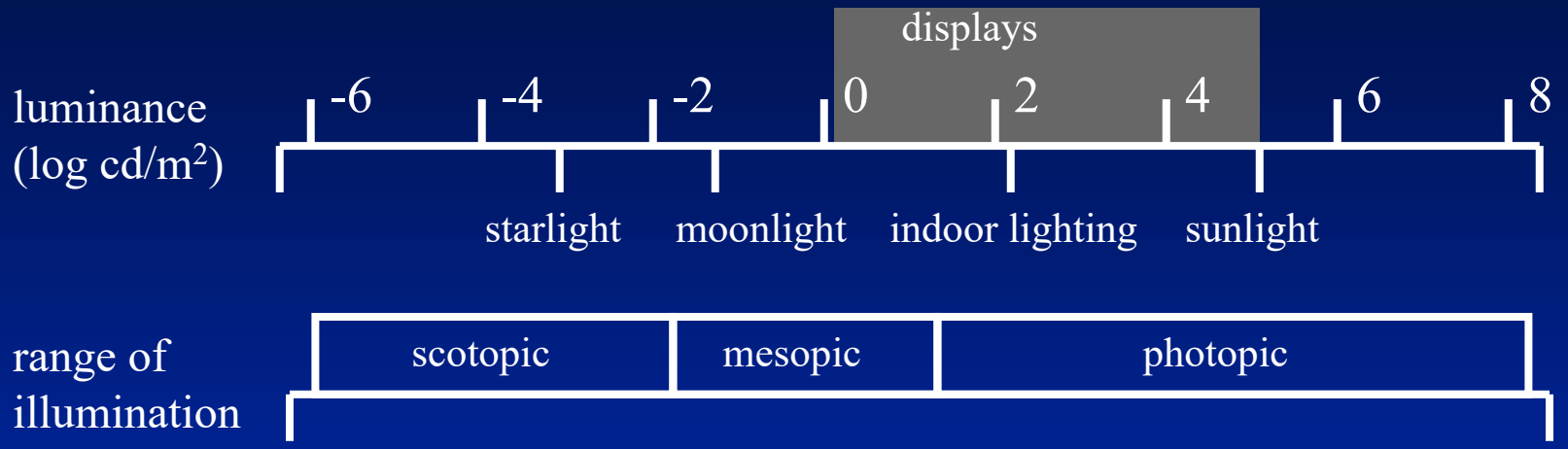
Dynamic Range



- poor contrast
- no color
- low acuity

- good contrast
- good color
- high acuity

- Resolution
- Dynamic range
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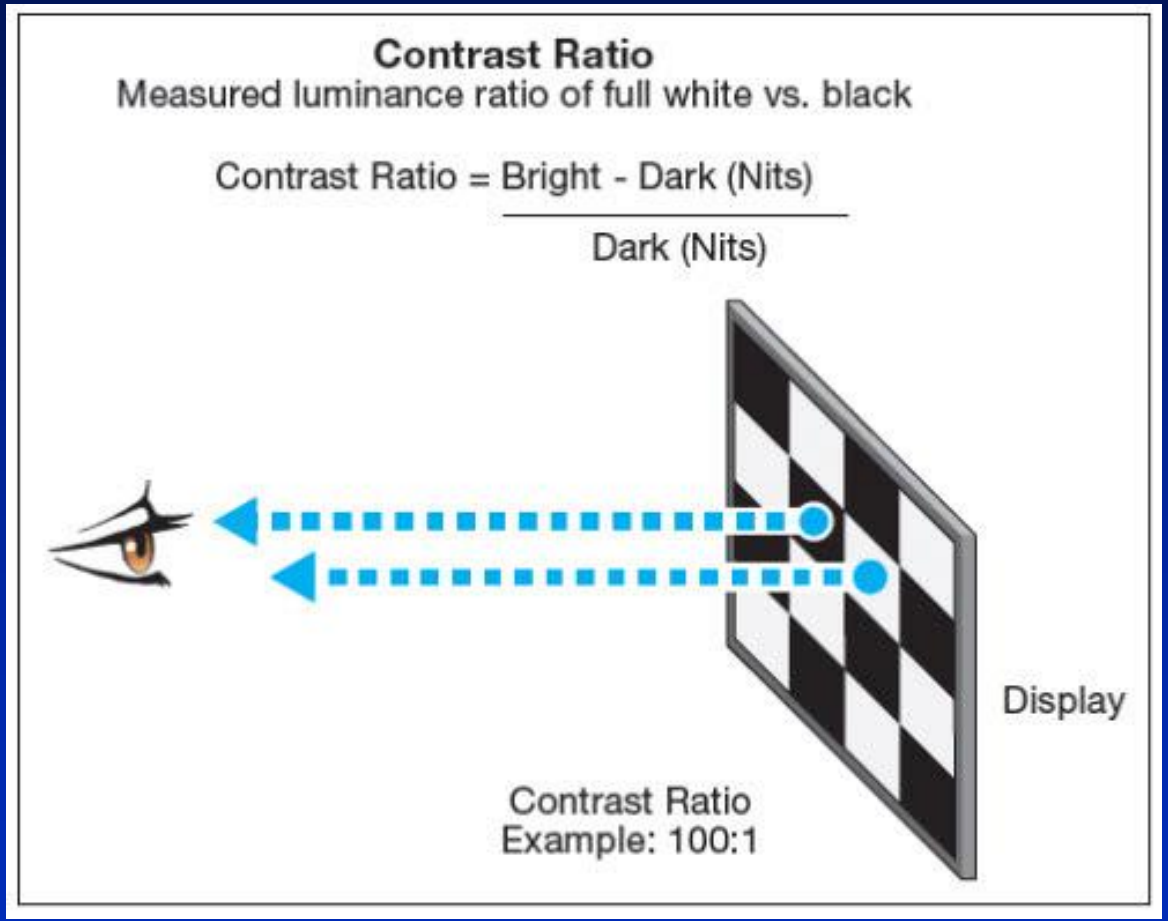
Contrast Ratio

- Contrast Ratio = $\frac{I_{max} - I_{min}}{I_{max} + I_{min}}$,

Contrast measurements in a real room



Contrast measurements in a real room

Contrast measurements in a real room

Three Identical Disks

- Alan Gilchrist. “Seeing in Black & White” Scientific American vol. 18, no. 2, 2008.

Mach Banding

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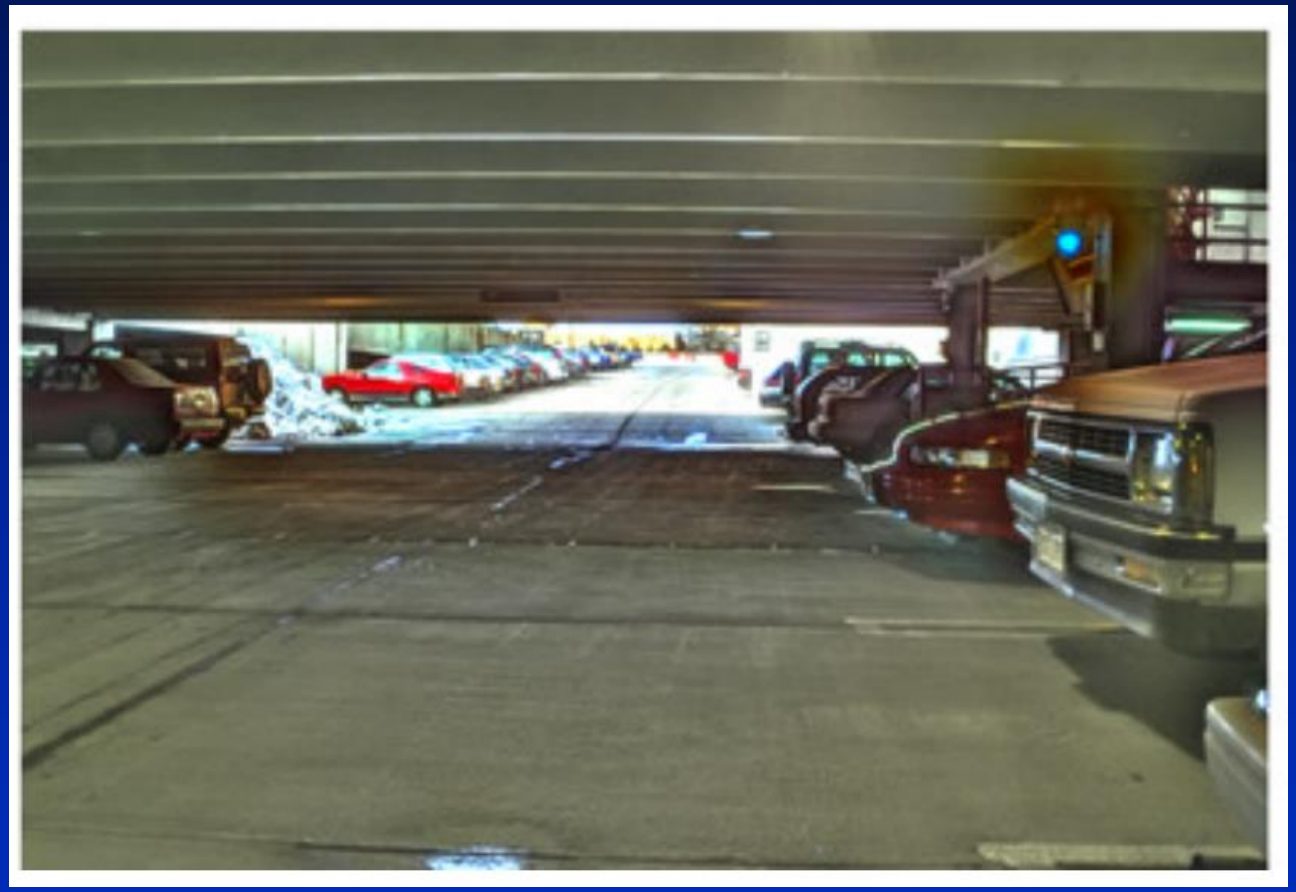
Contrast Sensitivity Function

Tone Mapping

Tone Mapping



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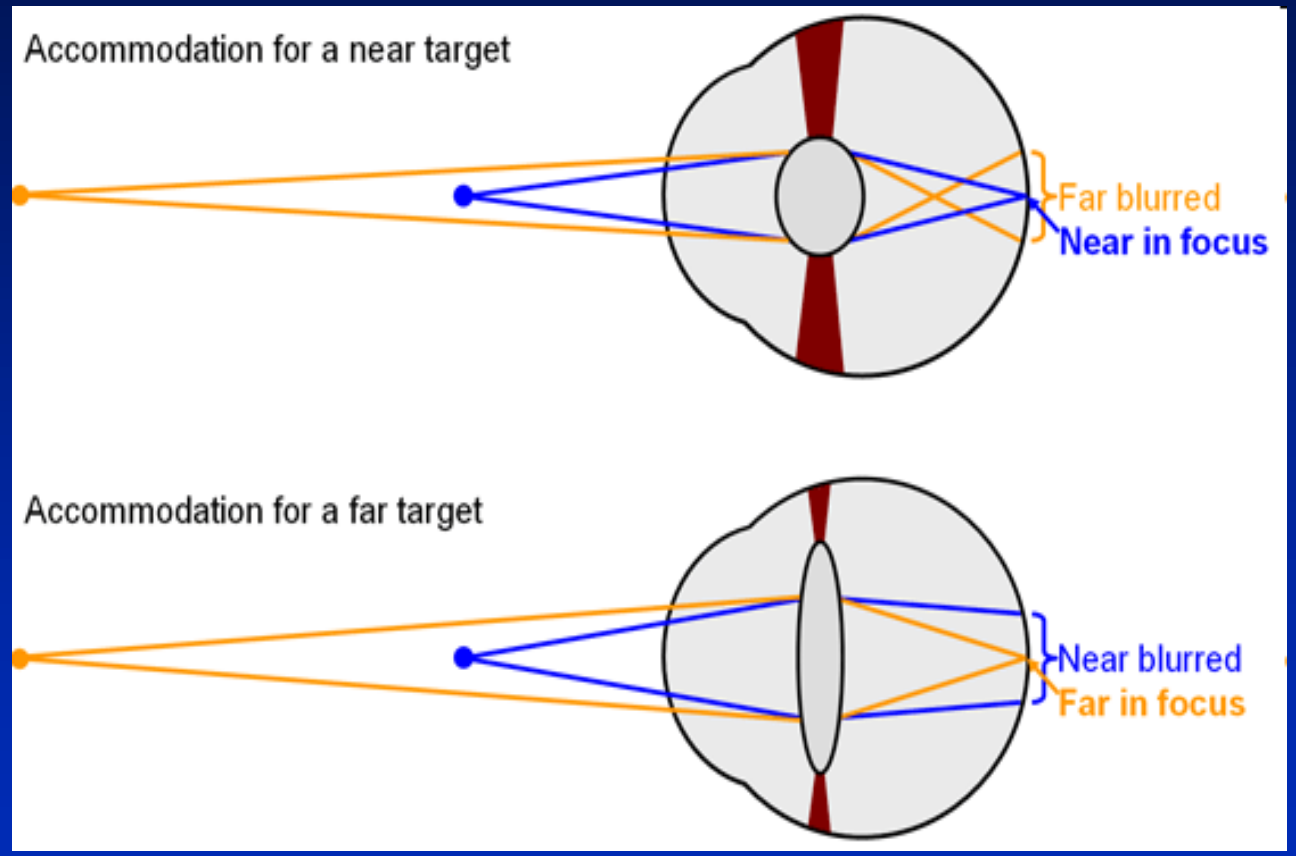


Note change in lens shape

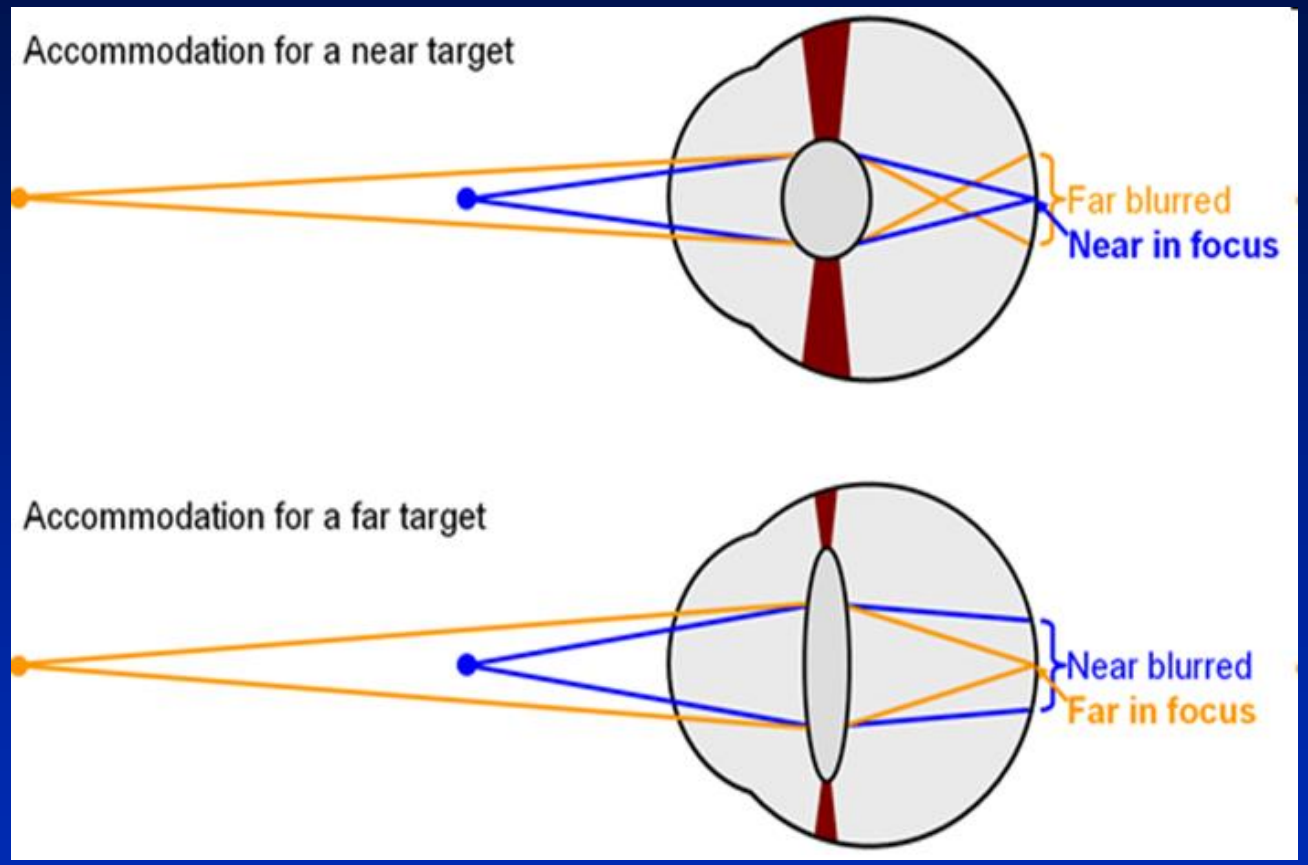

c
b
a

Vergence

- The simultaneous movement of the pupils of the eyes toward or away from one another during focusing.

- This measure of the convergence or divergence of a pair of light rays is defined as vergence.

Accommodation



The reflex can be controlled but cannot be ‘felt’

Accommodation amplitude declines with age

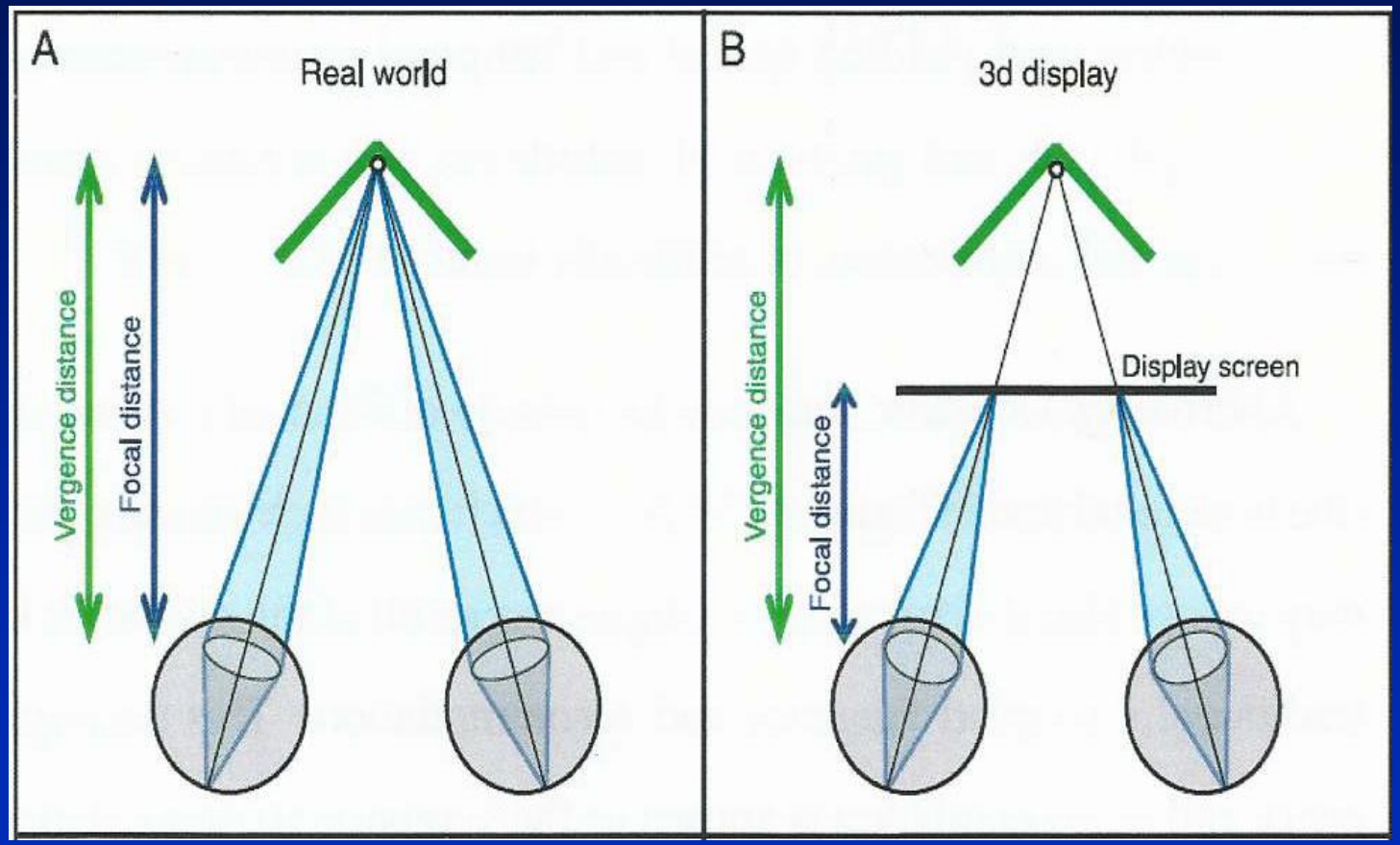
“Vision and Visual Disabilities – An Introduction,” by Gerd Waloszek, SAP User Experience

Vergence Accommodation Conflict

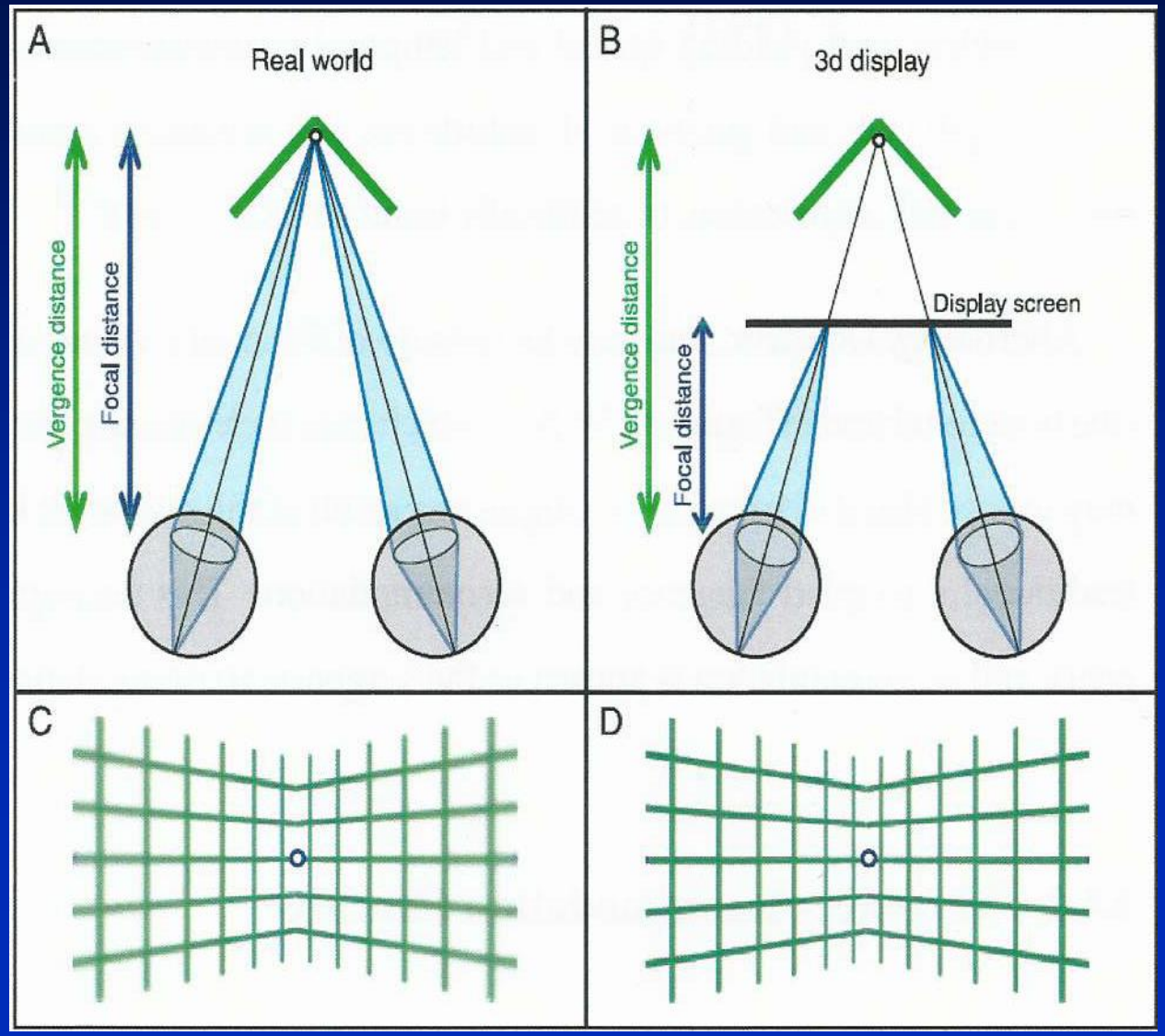
- Computer and projection displays present images on a single surface but have a focal distance (blur on the retina) which may be in front of or behind the screen
- The inability to fuse the binocular stimuli causes discomfort and fatigue to the viewer

David M. Hoffman, Ahna R. Girschick, Kurt Akeley, Martin S. Banks. “Vergence-accommodation conflicts hinder visual performance and cause visual fatigue, Journal of Vision, vol. 8, no. 3, article 33, March 28, 2008.

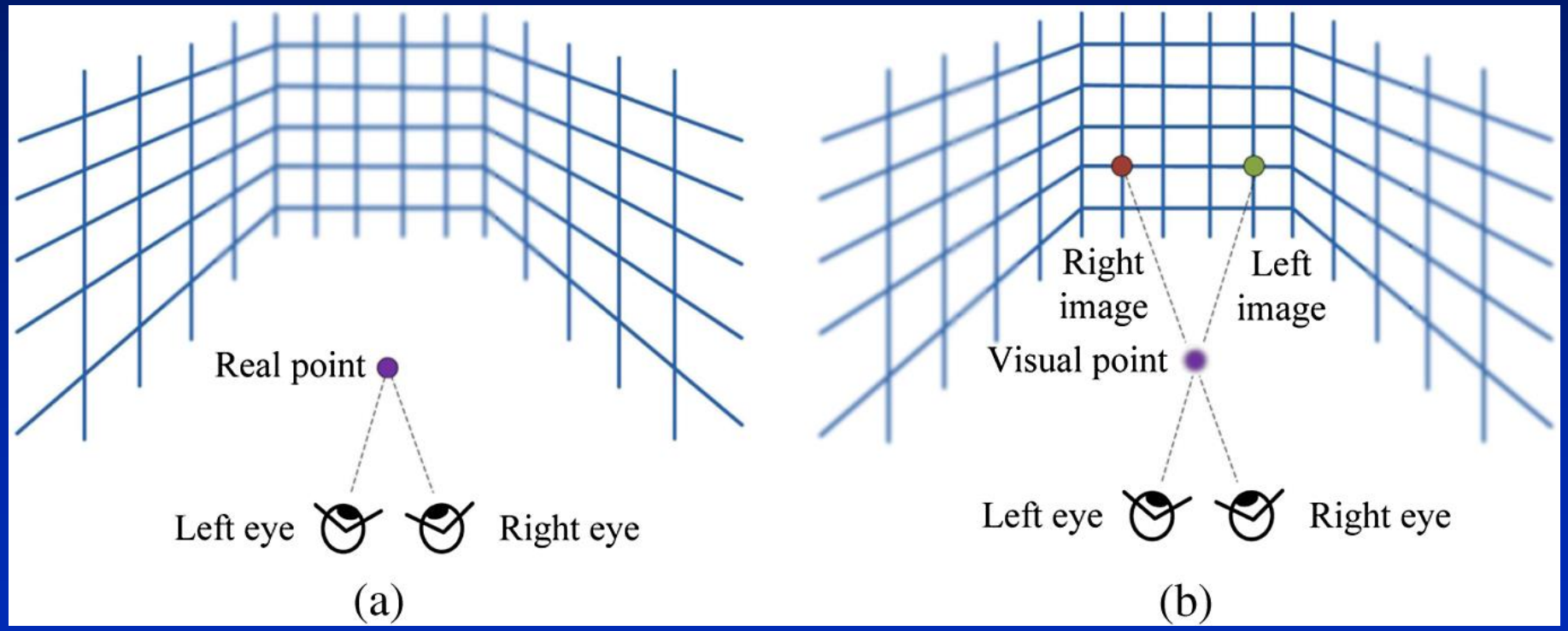
Vergence-Accommodation Conflict



Vergence – Accommodation Conflict



Vergence – Accommodation Conflict



End