Physiological Assessment of Rod and Cone Inputs to the Magnocellular Pathway in the Mesopic Luminance Range

Dingcai Cao 1, Barry B. Lee 2 & Hao Sun 3

1 Section of Ophthalmology & Visual Science, Department of Surgery, The University of Chicago
2 College of Optometry, State University of New York
3 Department of Optometry and Visual Sciences, Buskerud University College, Kongsberg, Norway

Mesopic Vision

Rods (>100 million): very sensitive to light
Cones (4-8 million): less sensitive to light

Scotopic Mesopic Photopic
Rods Rods and Cones Cones

Circuitry of Primate Retina

How rod and cone signals are combined in the MC pathway?

Purposes

• To assess rod and cone inputs with various temporal frequencies and retinal illuminance levels at mesopic range.
• To determine how rod and cone inputs are combined in the MC pathway at mesopic range.
• To compare primate physiological data with human psychophysical data.

Design Rationale

Isolated Rod Stimuli
Isolated Cone Stimuli
Combined Rod and Cone Stimuli

Methods

• Subjects: paralyzed, anesthetized macaque monkeys
• Technique: in vivo single unit recording in MC ganglion cells
• Full field Sinusoidal Stimuli:
  • Isolated rod stimuli
  • Isolated cone stimuli
  • Combined rod and cone stimuli
• Frequency Response Measurement: 0.62-20 Hz at 55%
• Contrast Response Measurement: 5-55% at 4.88 Hz
• Luminance: 0.2 - 200 Td
• MC Cells:
  • 20 MC cells (10 on-center and 10 off-center)
Cell Response Example: U3 (M-Off)

Linear Vector Sum Model

Response to Isolated Rod Stimuli

Response to Isolated Cone Stimuli

\[ \text{Response to Combined Stimuli} = A_{\text{rod}} \sin(2\pi ft + \#_{\text{rod}}) + A_{\text{cone}} \sin(2\pi ft + \#_{\text{cone}}) \]

Cell response to the combined stimuli can be predicted as a linear summation of responses to the isolated rod and cone stimuli.
The strength of rod input relative to cone input at each light level estimated from MC-cell recordings is comparable to that estimated from the psychophysical experiment using comparable stimuli.

The strength of rod input relative to cone input to the MC pathways weakens with increase in retinal illuminance level.

Rod and cone inputs are combined linearly in the MC pathways.

The rod input relative to cone input estimated from MC cell recording is comparable with that estimated from human psychophysics.