Physiological Mechanisms of the Effects of Yellow Lenses

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Observations of Yellow Lenses

- Subjective Attributes
  - Increased brightness perception
  - Increased ability to see objects against background
  - Increased overall clarity of vision
  - Increased patient comfort during eye exam
  - Decreased glare
Who uses yellow lenses?

- Marksmen
- Bikers
- Skiiers/snowboarders
- Pilots
- Hunters
- Drivers
- AMD sufferers
- Post-surgical cataract patients
- Optometrists/ophthalmologists
- Northwesterners (think overcast skies)
- Computer users (ex. Gunnar Optiks)
What does the literature say?

- Visual acuity and AC/A - no significant effect (Wolffsohn et al. 2000)
- Contrast sensitivity – ??
- Chromatic aberration – decreases by more than 1/3 ... in fish (Sivak et al. 1978)
- Selectively decreases blue-light damage to RPE cells (Tanito et al. 2006)
- Brightness – up to 40% increase (Kelly 1990)
- Discomfort glare – significant decrease (UMTRI)
- Subjective preference in glare conditions – Yes! (Wolffsohn et al. 2000)
But, how?

- **Multiple theories, no consensus**
  - Glare reduction
    - Possible rod involvement (Vos 2003)
    - S-cone inhibition
    - Pupillary response (Chung and Pease 1993)
    - Circadian receptor response (Kooi and Alferdink 2004)
  - Brightness perception
    - May be rod-mediated (Kelly 1990)
    - Psychological association with sun (Wright 1949)
    - Pupillary diameter (Chung and Pease 1993)
    - Opponent pathways, chromatic channels (Luque et al. 2006)
An intriguing study...

- Kooi and Alferdinck, TNO Human Factors 2004
  - Attempt to resolve confusion on mechanism behind discomfort glare reduction observed with yellow lenses
  - Rods
  - S-cones
  - Melanopsin
  - Pupil
Kooi and Alferdinck, 2004

- Method of adjustment procedure – match the brightness level

Subject viewing the stimulus pair

Rear view showing the optics and filters
Kooi and Alferdinck, 2004

Effect of the rods on discomfort

Effect of the S-cones on discomfort
S-cone spectral sensitivity

Cone Fundamentals
Stockman & Sharpe 2000 10-deg

S-cone
M-cone
L-cone

Relative Sensitivity

Wavelength (nm)

Wavelength

440
495
550
605
660
715
Sivak et al, 2005

- Measurement of discomfort glare from various types of headlamps
  - Blue-cone weighted power highly correlated with discomfort glare

![Graph showing the relationship between radiant power weighted by the blue-cone sensitivity function and de Boer rating.](image)

*Figure 6. Relationship of the blue-cone-weighted power to de Boer ratings of discomfort glare. (Lower de Boer units indicate more discomfort.)*
S-cones and brightness

- S-cones may play a key role in brightness-enhancing effects of yellow lenses as well.
- Experimental design in process to test this hypothesis.
Where the rubber meets the road

- Is it possible to design an “ideal” yellow ophthalmic lens?
- Can an algorithm be created to predict effects on brightness and discomfort glare?
- Potential utility in many fields – vision ergonomics, aviation, athletics, medicine, driving
References

Thank you!
Rods and cones

- 120 million rods
- 6-7 million cones
  - "red" cones (64%),
  - "green" cones (32%),
  - "blue" cones (2%)
- green and red cones are concentrated in the fovea centralis
- blue cones have the highest sensitivity and are mostly found outside the fovea
Triplicity of Vision

- Rod system
- S cone system
  - Earliest cone system
- R/G cone system
  - Newest cone system
Young-Helmholtz color theory

- **Trichromatic vision**

![Color Wheel Diagram](http://images.google.com/imgres?imgurl=http://www.diycalculator.com/imgs/cvision-how-works-01.jpg&imgrefurl=http://www.diycalculator.com/spcvision.shtml&usg=__bcKsdqqMJq21AcPwXRe14cOmeE4=&h=356&w=505&sz=44&hl=en&start=16&sig2=G-xnigItpoeGkLmeS3uBQ&um=1&tbnid=ofx71CnhO3LJumM:&tbnh=92&tbnw=130&prev=/images%3Fq%3Dcolor%2Bvision%26hl%3Den%26sa%3BN%26um%3D1&ei=bCzVShD9J5iQswP3pIGgCg)

Additive and subtractive color combinations

Primary, Secondary, and Tertiary colors based on Red, Yellow, and Blue (RYB) as the Primary Triad on a standard “Color Wheel”
Hering Color Theory

- color opponency
They are both right

- The difference?
  - Y-H moves from physical stimulus to perception
  - Hering looks at color from the perceptual side
Putting the 2 together

- It’s blue vs. red/green