NUTRACEUTICALS FOR VISUAL (SPORTS) PERFORMANCE

COPE 69590-GOI

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Disclosures: [1]Eye Promise Scientific Advisory Board
[2] Eye Promise Research Grant Recipient

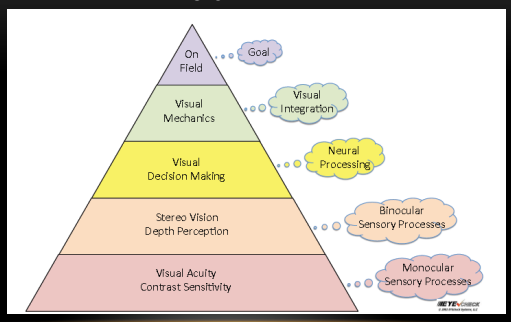
1

VISUAL PERFORMANCE ENHANCEMENT AND SPORTS

attribution www.nytimes.com

2

THE VISION PYRAMID



Courtesy of Drs. David Kirschen and Dan Laby

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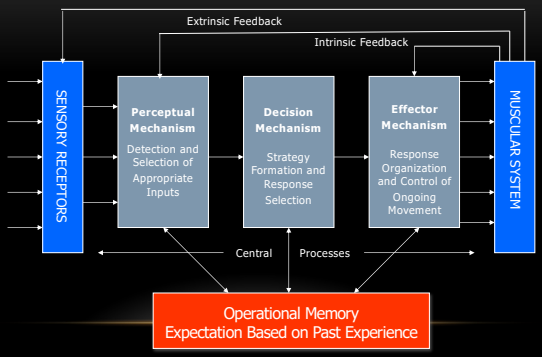
WELFORD INFORMATION PROCESSING MODEL



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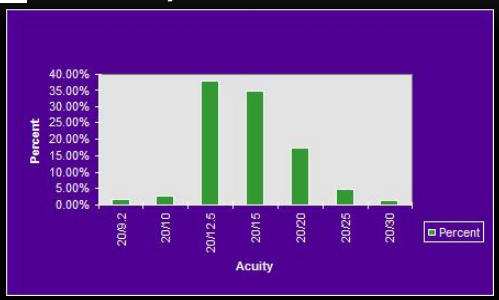
SELF SELECTION?

Hyper Visual Acuity of Professional Baseball Players



Laby, Kirschen, et al - Am J Ophthalmol 122(4):476-85, 1996

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VISIBILITY, CONTRAST SENSITIVITY & GLARE

(TYPICALLY NOT EVALUATED IN THE EYE EXAM)

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OPTIONS TO ENHANCE VISUAL ACUITY & CONTRAST SENSITIVITY

- Refractive compensation
  - Methods for refractive compensation
- Filters / tints to enhance visibility of important features
- Visual feedback training to enhance CS function
- Nutrient intake of carotenoids

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WHICH NUTRIENTS ARE BENEFICIAL FOR EYE HEALTH & FUNCTION?

- Endogenous – 60% of antioxidant capacity
- Exogenous Nutrients – 40% of antioxidant capacity of eye
  - Lutein & Zeaxanthin
  - Vitamin D3 (really a hormone)
  - Omega-3 fatty acids
  - Non-enzymatic antioxidants
    - Vitamins A, C, E, COQ10 and glutathione
  - Minerals
    - Magnesium, Zinc, Selenium
  - OTHER NEWCOMERS:
    - quercetin, resveratrol, pterostilbene, pycnogenol and astaxanthin

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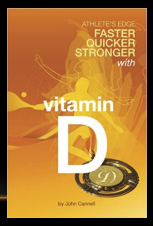
WHAT DO THESE NUTRIENTS DO?

- Protective effects for age-related changes to the crystalline lens & retina (eg, cataracts & AMD)
  - AREDS B carotene, C and E, Zinc, lutein & zeaxanthin
- Epigenetic modulators (longevity)
  - Omega-3's - dry eye / MGD / AMD
  - Vitamin C, D3 & magnesium- arcus, retina CVDz
  - Vitamin A & selenium, night vision, dry eye
- Protect both retina and brain
  - Lutein, Zeaxanthin, DHA



John Cannell, MD

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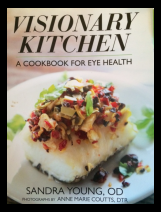
WHERE ARE THESE NUTRIENTS FOUND?

- Green, leafy vegetables such as spinach, kale, collards and orange peppers / paprika / goji berries
- Salmon, tuna, and other oily (cold-water) fish
- Eggs, nuts, beans, and other protein sources
- Oranges and other citrus fruits - C / bioflavanoids
- Colorful fruits and vegetables (bell peppers, berries)- polyphenols
- Whole grains such as quinoa, brown rice, whole oats
- Flaxseed oil (females), EPR, black currant seed oil



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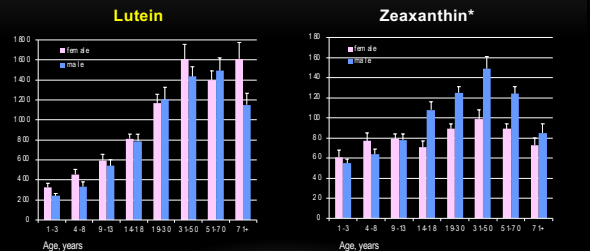
LUTEIN AND ZEAXANTHIN INTAKE (MCG/D) BY AGE

(NHANES 2003-2004 DATA)



*Note the 10-fold difference in the y-axis scale between lutein and zeaxanthin.

Johnson EJ, et al. *J Am Diet Assoc.* 2010;110:1357-1362.

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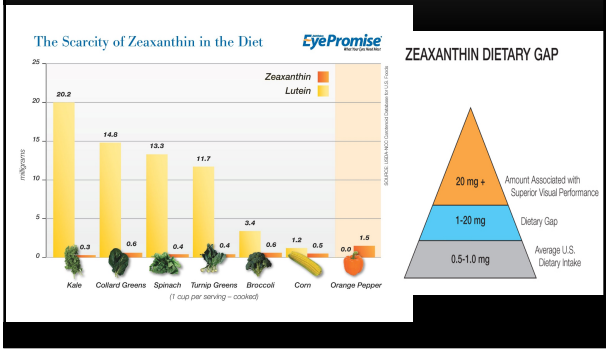
ZEAXANTHIN: WHY SUPPLEMENTATION IS IMPORTANT



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THINK - ZEAXANTHIN INTAKE

- Zeaxanthin and Lutein accumulate at a 2:1 ratio (Z to L) in the fovea
  - Zeaxanthin isomers (Z & M) are the foveal carotenoids
  - The fovea has 3x the metabolic activity of any other tissue
  - Potently increase foveal (1 degree) MPOD
  - Z publication data supports fewer anti-VEGF injections required
- AVG American diet consists of 5:1 ratio of L to Z and the avg American gets << 1 mg of Z per day
  - Why Supplementation is Important

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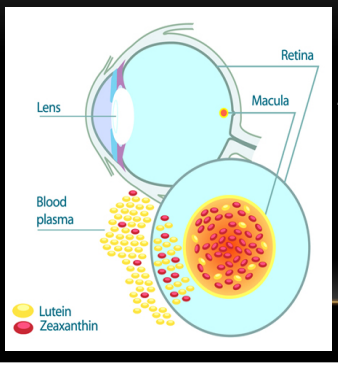
COMPOSITION OF MACULAR PIGMENT



Zeaxanthin and Lutein – 2:1 ratio in the macular pigment.

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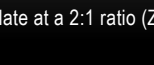
NUTRITION FOR BETTER PERFORMANCE: ZEAXANTHIN

- Nutrient found in bright colored fruits and vegetables
- 20+ years of research, 150+ published studies to support zeaxanthin's role in healthy vision
  - Masked, placebo-controlled studies
- Higher daily intake of zeaxanthin relates to improved vision, faster response time



Richer et al, The Zeaxanthin and Visual Function Study (ZVF), 2011, ClinicalTrials.gov Identifier: NCT00564902

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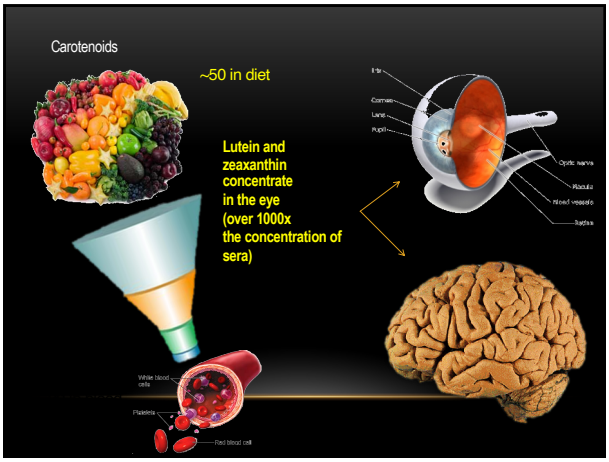

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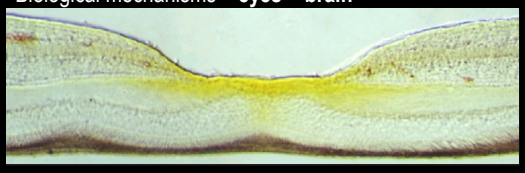
LUTEIN AND ZEAXANTHIN MISSING FROM THE DIET CAN INFLUENCE VISUAL FUNCTION THROUGH OPTICAL AS WELL AS BIOLOGICAL MECHANISMS

- **Optical mechanisms**
  - **GD, GR, CSF, CC, VISUAL RANGE**
- Biological mechanisms – **eyes + brain**



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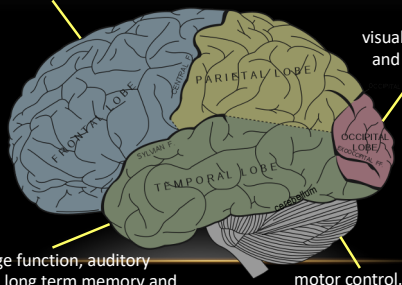
REGIONS OF THE BRAIN ANALYZED FOR CAROTENOIDS

(CRAFT ET AL., 2004; VISHWANATHAN ET AL., 2011, JOHNSON ET AL., 2012)

thinking, planning, central executive function, attention and motor execution



visual perception and processing

Language function, auditory perception, long term memory and emotion

motor control, language and attention

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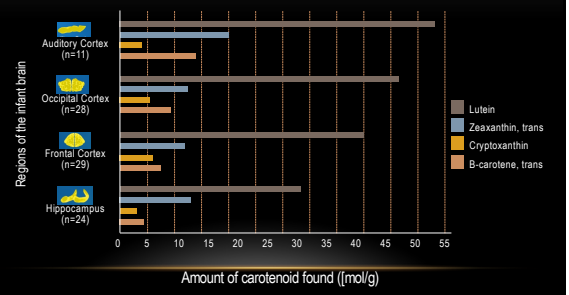
BRAIN CAROTENOIDS



Vishwanathan R, et al. Acta Biologica Cracoviensia. 2011; 53(suppl 1). Abstract 1.23

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VISUAL PERFORMANCE & MACULAR PIGMENT

- SPORTS
- MILITARY
- DRIVING

- CFF
- CSF
- DG
- Visual Adaptation
  - Cones
  - Rods
- UFOV
- Peripheral Motion Sensitivity

CNS Benefits
"MPOD & Steady State VEPs"
S Anna Ceravalo et al 2019
1) Better Visual Memory
2) Faster Visual Processing
3) Superior power of EEG activation
4) Better signal to noise ratio

fMRI *Lidbergh et al 2019*
** Neuroplasticity compensation in older adults*

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INDIVIDUAL DIFFERENCES IN VISUAL FUNCTION
HAMMOND & BUCH, EXP EYE RESEARCH 2020

- There are dramatic individual differences in visual function even in college students
  - Vernier acuity
  - Resolution Acuity
  - Lens density
  - Intra-ocular light scatter
  - MPOD by retinal eccentricity
  - Photoreceptor loss
- Performance declines before midlife aging and obvious disease, and may indicate poor aging and susceptibility to disease
- Concierge optometry ?

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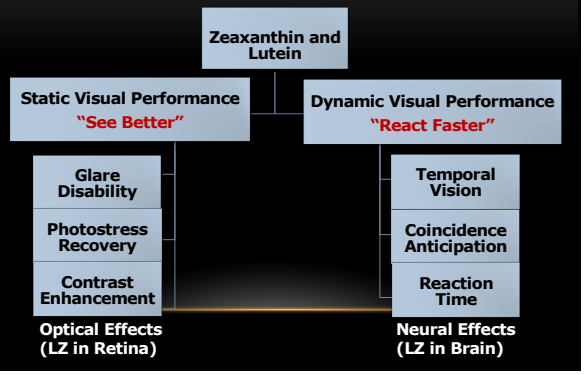
Macular Pigment & Visual Performance



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EFFECTS OF SUPPLEMENTATION

Table 3. Changes in Macular Pigment and Visual Function Compared to Placebo

Variable	Slope, Change per Day*	SE of Slope	*P* Value
MPOD 10′	0.00025	0.00006	<0.0001†
MPOD 30′	0.00025	0.00005	<0.0001†
MPOD 60′	0.00013	0.00005	0.006†
MPOD 105′	0.00016	0.00004	0.0004†
Photostress recovery	−0.019	0.008	0.013†
Glare disability	0.00018	0.00014	0.21
Chromatic contrast	0.00037	0.00017	0.030†

* Daily change in treatment group versus daily change in placebo group.
† $P < 0.05$.

Hammond BR, et al. A double-blind, placebo-controlled study on the effects of lutein and zeaxanthin on photostress recovery, glare disability, and chromatic contrast. Invest Ophthalmol Vis Sci. 2014;55:8583–8589. DOI:10.1167/iovs.14-15573

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Improved Contrast Sensitivity

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CONTRAST SENSITIVITY IN SPORT

- Judgment of subtle differences in contrast:
  - Between the "target" and its background
  - Rotation of the "target"
- ➢ Helps to better judge speed & trajectory
  - **Research: Athletes > Non-athletes**
- Reduced sensitivity may contribute to performance inconsistency due to variable lighting conditions, figure-ground characteristics

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YELLOW RANGE FILTERS

- Selectively filters shorter wavelength light
- Ocular media scatters short wavelength light more - improves contrast by eliminating some of this "internal glare"
- May enhance contrast differences (contours) by reducing chromatic aberration

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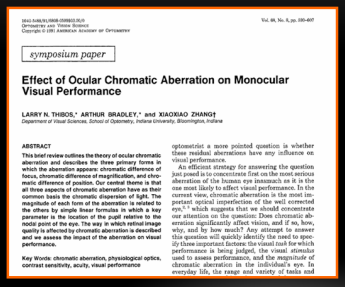
CHROMATIC ABERRATION



symposium paper

Effect of Ocular Chromatic Aberration on Monocular Visual Performance

LARRY N. THIBOS,* ARTHUR BRADLEY,* and XIAOXIAO ZHANG†

Department of Visual Sciences, School of Optometry, Indiana University, Bloomington, Indiana

ABSTRACT

This brief review outlines the theory of ocular chromatic aberration and describes the three primary forms in which the aberration appears: chromatic difference of focus, chromatic difference of magnification, and chromatic difference of position. Our central theme is that all three aspects of chromatic aberration have as their common basis the chromatic dispersion of light. The magnitude of each form of the aberration is related to the others by simple linear formulas in which a key parameter is the location of the pupil relative to the nodal point of the eye. The way in which retinal image quality is affected by chromatic aberration is described and we assess the impact of the aberration on visual performance.

Key Words: chromatic aberration, physiological optics, contrast sensitivity, acuity, visual performance

optometrist a more pointed question is whether these residual aberrations have any influence on visual performance.

An efficient strategy for answering the question just posed is to concentrate first on the most serious aberration of the human eye inasmuch as it is the one most likely to affect visual performance. In the current view, chromatic aberration is the most important optical imperfection of the well corrected eye,[1] which suggests that we should concentrate our attention on the question: Does chromatic aberration significantly affect vision, and if so, how, why, and by how much? Any attempt to answer this question will quickly identify the need to specify three important factors: the visual *task* for which performance is being judged, the visual *stimulus* used to assess performance, and the *magnitude* of chromatic aberration in the individual's eye. In everyday life, the range and variety of tasks and

- *"In the current view, chromatic aberration is the most important optical imperfection of the well corrected eye."*

Thibos, L., et.al., Optom. & Vis. Sc., 1991

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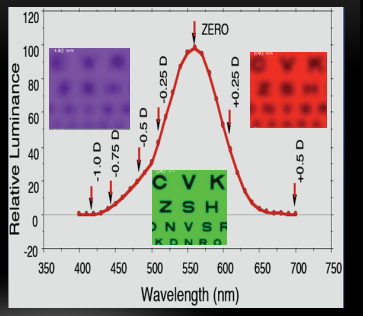
CHROMATIC ABERRATION

The inability of the ocular system to bring the various colors of light to focus at a single point.



Thibos, 5th Wavefront Congress, Feb 2004

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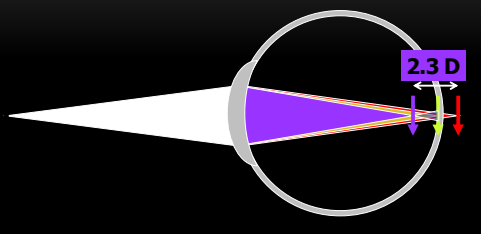
CHROMATIC ABERRATION



Chromatic Aberration of the Eye

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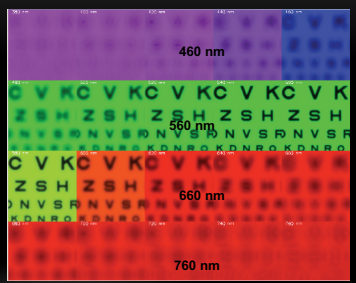
CHROMATIC ABERRATION

Decreases the visual system's potential speed of reaction to individual object's color, shape and speed differences across the range of wavelengths



Thibos, 5th Wavefront Congress, Feb 2004

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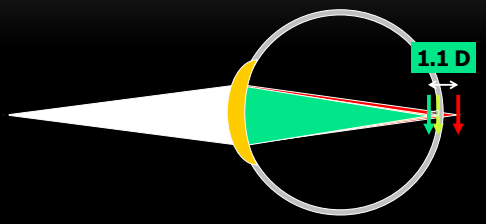
CHROMATIC ABERRATION REDUCTION



Reduced Chromatic Aberration of the Eye with Light Filtration

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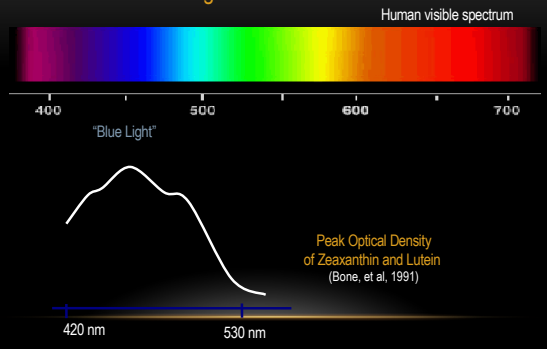
Zeaxanthin/lutein absorbs blue light which is a major factor in limiting our vision outdoors



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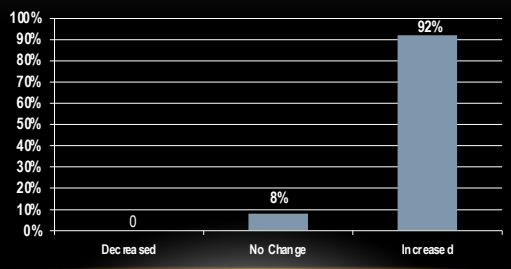
2012 MINOR LEAGUE BASEBALL SUPPLEMENTATION TRIAL

Contrast Acuity



N = 12 (45 did not participate)

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Glare Disability and Comfort

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GLARE EFFECTS IN SPORT

- Judgment of "target" speed and trajectory can be affected by
  - Sun angle and intensity
  - Stadium lighting
  - Color contrast between "target" and background
- Glare sensitivity and slow glare recovery may contribute to errors in certain game conditions

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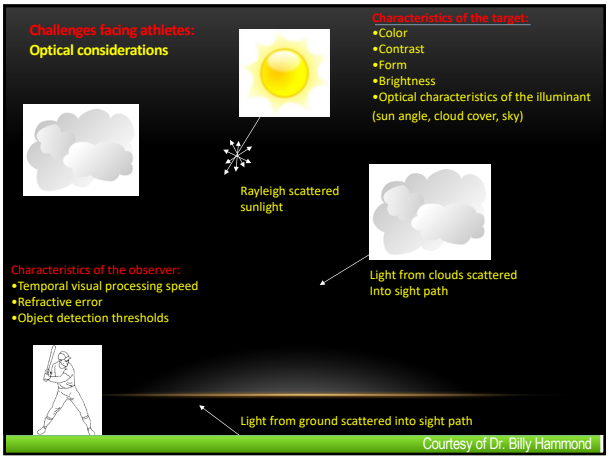
Challenges facing athletes: Optical considerations



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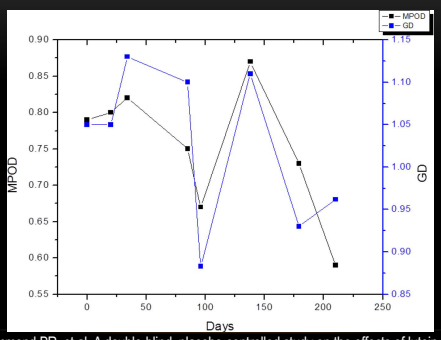
MACULAR PIGMENT & GLARE DISABILITY



Hammond BR, et al. A double-blind, placebo-controlled study on the effects of lutein and zeaxanthin on photostress recovery, glare disability, and chromatic contrast. Invest Ophthalmol Vis Sci. 2014;55:8583–8589. DOI:10.1167/iovs.14-15573

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MPOD & GLARE DISABILITY

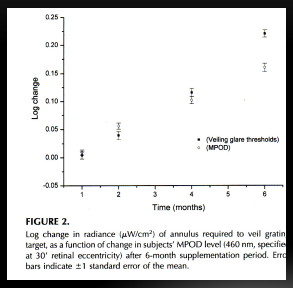

FIGURE 2.
Log change in radiance (μW/cm²) of annulus required to veil gratin target, as a function of change in subjects' MPOD level (460 nm, specifie at 30' retinal eccentricity) after 6-month supplementation period. Erro bars indicate ±1 standard error of the mean.

Average improvement in Glare Disability was ~ 23%

Hammond BR, et al. A double-blind, placebo-controlled study on the effects of lutein and zeaxanthin on photostress recovery, glare disability, and chromatic contrast. Invest Ophthalmol Vis Sci. 2014;55:8583–8589. DOI:10.1167/iovs.14-15573

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PHOTOSTRESS: VISUAL RECOVERY AFTER A BLINDING LIGHT EXPOSURE

- Improvement in photostress recovery has been found to be proportional to the level of macular pigment

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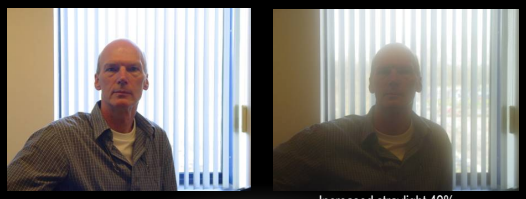
AVERAGE GLARE DISABILITY IMPROVEMENT FROM LOW TO HIGH MACULAR PIGMENT IS ABOUT 40% (AVERAGE IS ~23%)



Increased straylight 40%

Image: TJTP Van Den Berg

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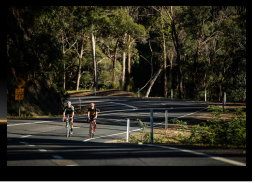
PHOTOSTRESS RECOVERY EFFECTS IN SPORT

- Some sport situations require the athlete to move quickly between areas of bright sunlight and shadow
- Slow visual recovery following photoreceptor supersaturation can lead to performance errors
  - These errors may put the athlete at risk for injury, such as in cycling sports or downhill skiing



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MPOD AND PHOTOSTRESS RECOVERY

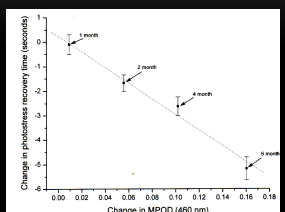

FIGURE 3.
Average change in foveal photostress recovery time and MP density f each postbaseline time point during the study. Error bars denote ± standard error of the mean. Dotted line is the least squares regression fit t the data, Y = −31.97; X + 0.24; r = −0.99, p = 0.01.

Average improvement in Photostress Recovery over the 1 year trial was 9 seconds

Hammond BR, et al. A double-blind, placebo-controlled study on the effects of lutein and zeaxanthin on photostress recovery, glare disability, and chromatic contrast. Invest Ophthalmol Vis Sci. 2014;55:8583–8589. DOI:10.1167/iovs.14-15573

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NUTRITION EFFECTS ON NEURAL PERFORMANCE

- MPOD is linked to L and Z levels in the brain
- Neuroimaging of brain structure in vivo confirms L&Z influences white matter integrity, particularly in regions vulnerable to age-related decline
- L and Z are incorporated in cell membranes and axonal projections, which serve to enhance inter-neuronal and neural-glial communication
- 66-76% of total carotenoid concentration in occipital cortex, but highly variable

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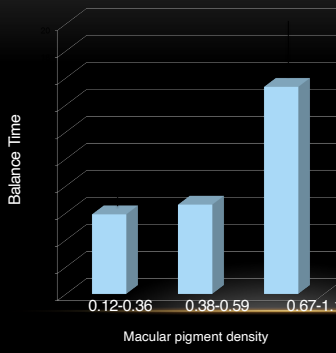
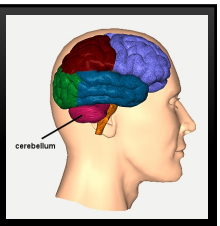
CNS EFFECTS OF L AND Z





Renzi, LM, Bovier ER, Hammond BR. A role for the macular carotenoids in visual motor response. Nutritional Neurosci 2013; 16:262-8.

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VISUAL MOTOR EFFECTS OF A CAROTENOID INTERVENTION (1 YEAR STUDY)

Study design: Randomized, double-blinded, placebo-controlled, intervention trial

Subjects: Healthy young healthy adults (18-32 yrs)
N = 92 in 1 year study 4 month data

3 Interventions:
1) Placebo (n=10)
2) Zeaxanthin, 20 mg/d (n=29)
3) Multi-condition, 26 mg Z, 8 mg L
1480 mg Omega-3 fatty acids (n =25)
(Eye Promise Vizual Edge Pro)

Bovier ER, Renzi LM, Hammond BR. A double-blind, placebo-controlled study on the effects of lutein and zeaxanthin on neural processing speed and efficiency. PLoS ONE 9 2014; 9:e108178.

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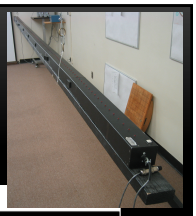
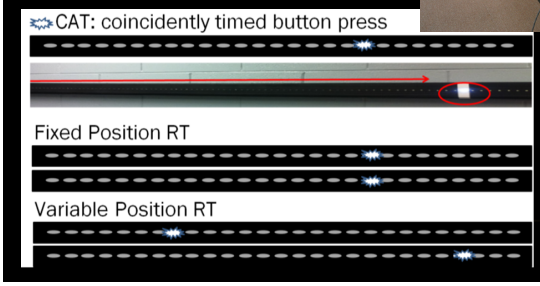
Cross-sectional arm (n = 92): LZ measured in the retina strongly related (p<0.01) to fixed and variable reaction time, temporal contrast sensitivity, Critical flicker fusion thresholds, Coincidence anticipation timing (15 mph).





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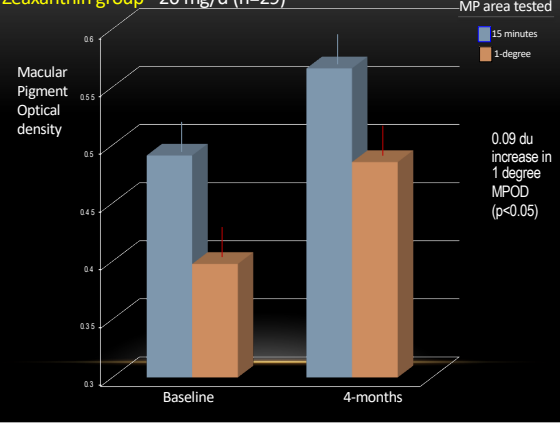
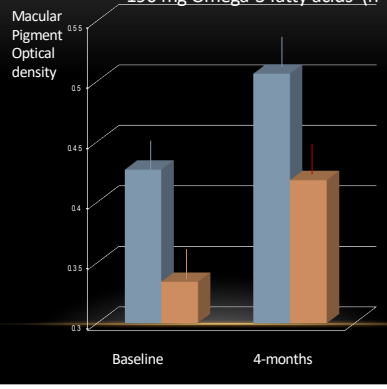
Zeaxanthin group - 20 mg/d (n=29)



0.09 du increase in 1 degree MPOD (p<0.05)

47

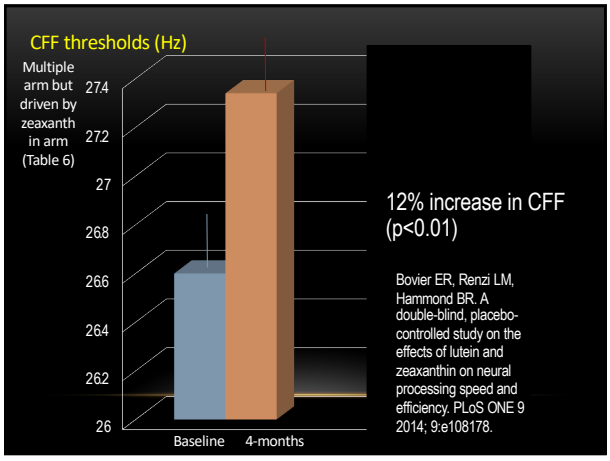
Multiple supplement group 26 mg Z, 8 mg L, 190 mg Omega-3 fatty acids (n=25)



0.075 increase in 15 of arc

(for 1 degree P < 0.055 based on 1 tailed T test)

48



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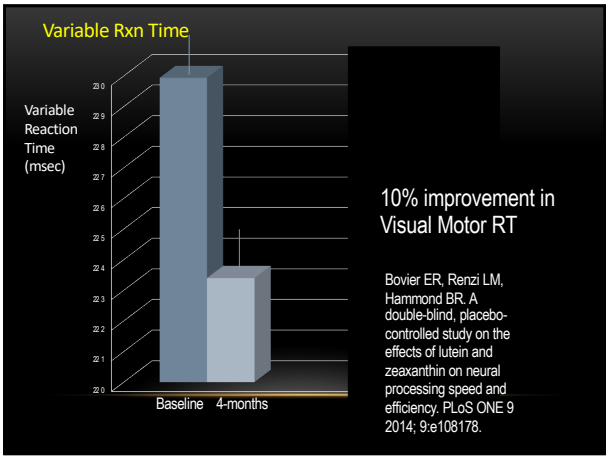

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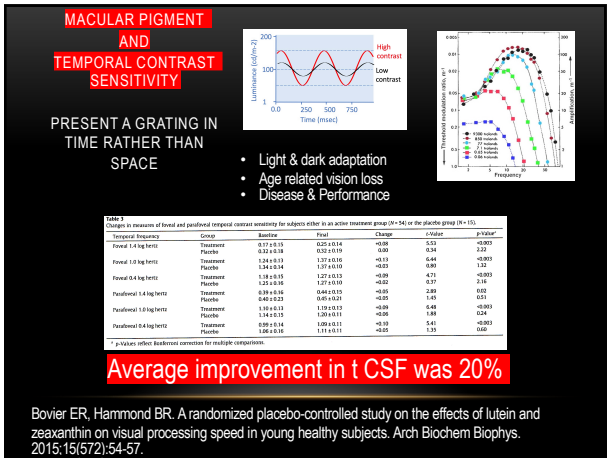

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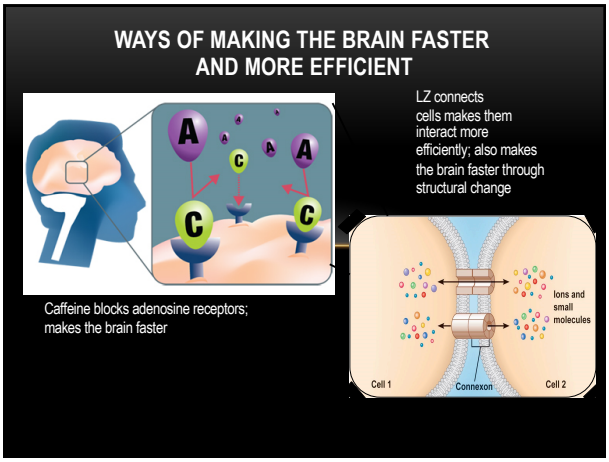

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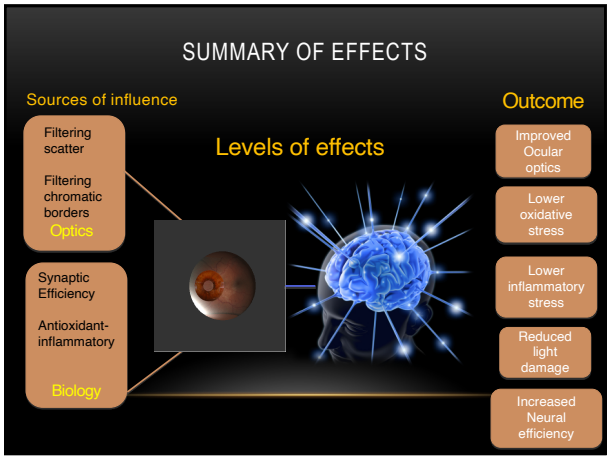

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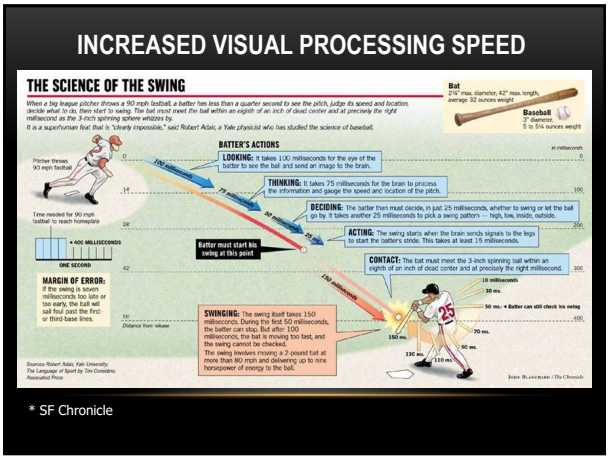

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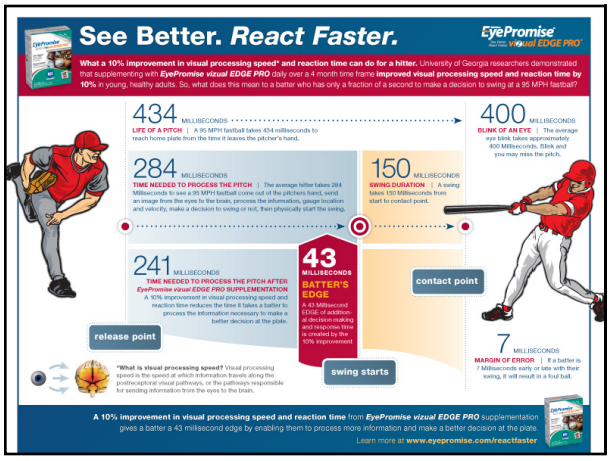

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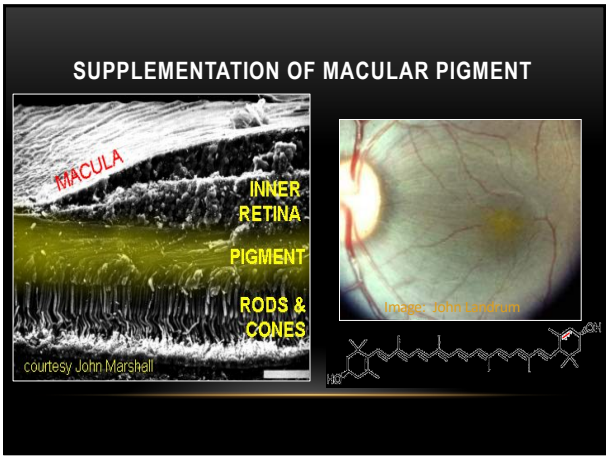

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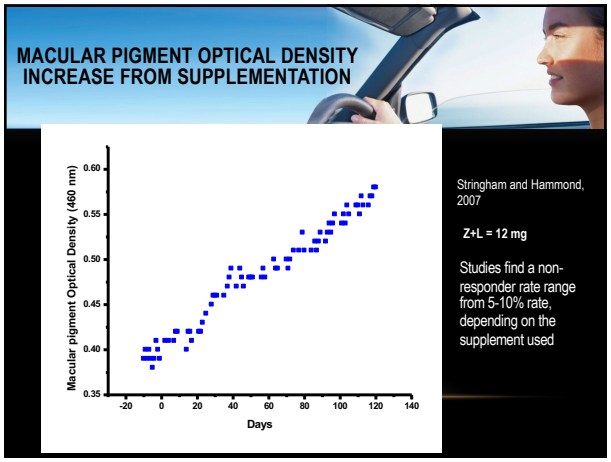

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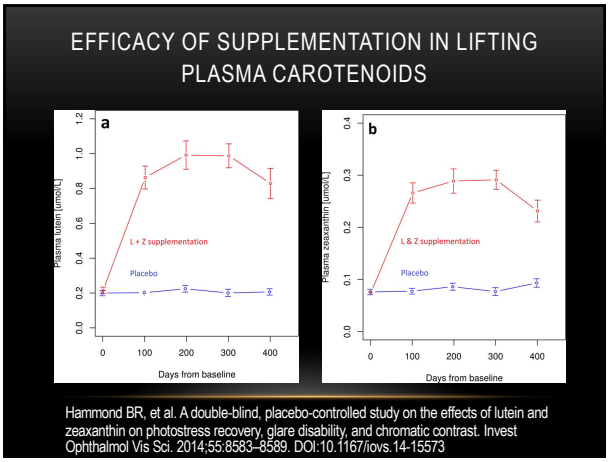

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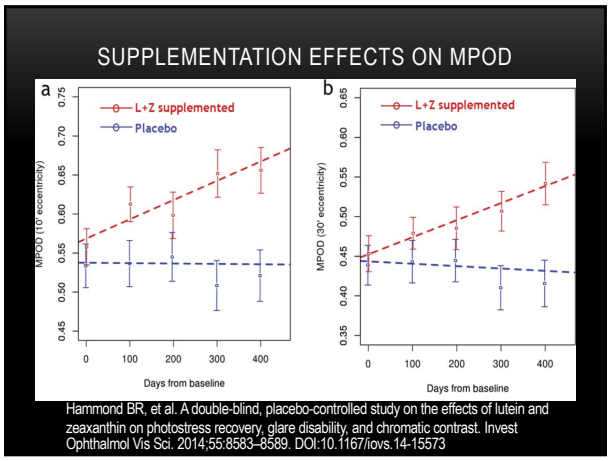

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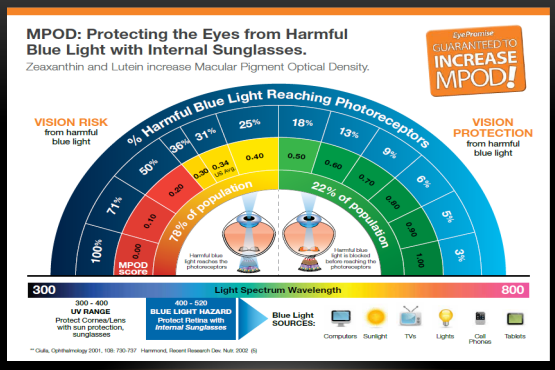

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2012 MLB Season Trial

- **100%** of the players did not need their sunglasses as often outside.
- **89%** of players were less sensitive to light.
- **63%** of players had less issue with losing the ball in the sky.
- **63%** of players were able to find the ball easier in the night sky and/or stadium lights.
- **71%** of players were able to pick up on the ball's rotation and/or see the threads on the ball better.

N = 43

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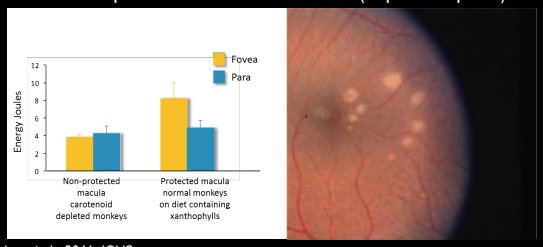
EXTRA PROTECTION BY INCREASED MP

- Reduced "blue-light" damage
- ↑ antioxidant and anti-inflammatory effects
- Possible protection from screen time (esp. in e-sports)



Barker et al., 2011, IOVS

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SUPPLEMENTS AND COMPETITIVE ATHLETES

- Advise athletes to verify any supplements to assure that the ingredients are certified as acceptable for sports competition regulations.
- I reference the NSF International website:
  - http://info.nsf.org/Certified/BannedSub/listings.asp
  - Products will say: *NSF Certified for Sport®*

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TIMING OF SUPPLEMENTATION BENEFITS

- **Protects Vision:** *Immediately*
- **Vision Quality Benefits:** *1-2 months*
- **Visual Processing Speed Benefits:** *3 -4 months*

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CHALLENGES OF NUTRIENT SUPPLEMENT STUDIES

- Nutrient trials are not pharmaceutical trials because all subjects have been exposed to the nutrients
  - No real "placebo" group since everyone ingests nutrients
    - A true RCT would require subjects that are nutritionally deficient
    - Cannot adequately control for daily nutrient intake
  - Nutrients are pan-systemic vs. system targeted
  - As a disease/condition prevention, the sample size to show effect would have to be extremely large

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THANK YOU

OCULAR WELLNESS & NUTRITION SOCIETY

A Society Focused on

Ocular Wellness & Nutrition Education

www.ocularnutritionsociety.org

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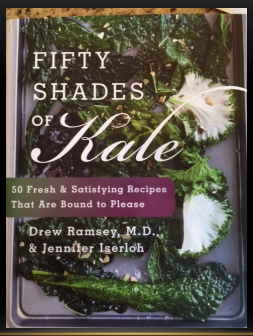
SUMMARY & QUESTIONS



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