

## OPTIMIZING VISUAL PERFORMANCE FOR SPORTS



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## Options to Enhance Visual Performance

- Refractive compensation for refractive errors
  - Methods for Refractive Compensation
  - Sports Protective Eyewear
- Filters to enhance visibility of important features
- Visual Performance Training
- Nutrient intake of carotenoids that enhance visual performance (e.g., Zeaxanthin, Lutein, Omega-3's)

## Refractive Compensation

- Optimize Visual Acuity and Contrast Sensitivity through a careful balanced refraction
  - Consider the visual demands of the sport
- Determine the optimal method to deliver the Rx



## Refractive Prescribing for Athletes

Prescribing Guidelines: "Raising the Bar"

Refractive Status	Consider Prescribing at:
Myopia	-0.25 or more
Hyperopia	+1.00 or more
Astigmatism	-0.50 or more (WTR vs. ATR vs. Oblique)
Anisometropia	0.50 or more (consider meridians)

- **Bottom Line:** Maximize VA & Balance

## Refractive Prescribing for Athletes

Other considerations for the Rx

- Timing of first prescription
- Value of over-minusing (CSF, Twilight)
- Re-evaluate visual performance with new Rx

## CONTACT LENS DESIGN FACTORS

- Selection of Material & Modality
  - Single use lenses vs "daily" vs extended wear vs RGP (or hybrid)
- Nuances of fitting athletes
- Adjustments for environment
  - Lenses for low humidity &/or low oxygen environments
- Performance enhancement tints
- Orthokeratology (CRT)
  - Higher order aberrations & decay of VA & Contrast sensitivity

### Laser Refractive Surgery

- Criteria: Who is a candidate
- Visual Effects
  - SVA post-surgery = SVA pre-surgery with Rx?
  - What is acceptable outcome for VA & Aniso?
  - Dry Eye symptoms? Glare & Halo?
- Physical Effects: surgical options
  - Surface procedures vs LASIK
- Clinicolegal Issues & Sports Eye Protection

### LENS DESIGN FACTORS

- Dress eyewear should never be used during contact sport activities
  - ANSI standards do not apply to sport
- Sports goggles & frames should meet ASTM safety standards
  - Traditional lens designs vs Wrap-around style
  - Protective eyewear
- Prescribe protection for athletes following eye trauma or ocular surgeries when the ocular tissues have been weakened
  - eg, keratoplasty, retinal detachments

### Functionally Monocular Athletes

- Criteria: <20/40 (6/12) best corrected
- Risk of blindness increased by >15x
- Risk is averted with protective eyewear use
- Discourage participation in sports with a risk for serious eye injury in which an effective method of eye protection does not exist
  - Examples: boxing, wrestling, martial arts

### American Society for Testing and Materials

- ASTM has established standards for sports where traditional eyewear designs are inadequate:
- F803 basketball, baseball fielders, racquet sports, field hockey and women's lacrosse
- F910 helmet shield, youth baseball batters/runners
- F513 shields for ice hockey
- F1776 protection for paintball
- F659 skiing goggles/shields

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### Filter Summary

- Athletes perform visual tasks that are driven by selected visual input
- Light filters have different activity applications depending on need
  - Task analysis: What should be enhanced?
- There remains an aspect of filter preference that is subjective in nature – the athlete must engage in trials to determine the best filters for his/her needs

### Performance Sun Eyewear

- Optical performance, especially in periphery
  - Laser headform testing
- Subjective “Drop” Testing

### Filters and Contact Lenses

- Amber & Gray-Green tints (in CLs) have been shown to improve contrast sensitivity function and photostress recovery in natural sunlight
- Filters modify luminance contrast between the target and background to enhance visibility
- The improvements with filters can be limited in poor lighting

### Filters and Contact Lenses

- Acuvue Oasys Transitions
  - Photochromic CLs (grey-ish tint)
  - 2-week lens
  - ~3x the cost of Acuvue Oasys

### Options to Enhance Visual Performance

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  - Methods for Refractive Compensation
  - Sports Protective & Sun Eyewear
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### PERCEPTUAL MECHANISM

- Visual Acuity
- Contrast Sensitivity
- Dynamic Visual Acuity
- Ocular Alignment
- Stereopsis
- Accommodative Function
- Vergence Function
- Oculomotor Function
- Peripheral Vision

### DECISION MECHANISM

- Speed of Recognition
- Visual Attention: Multiple Object Tracking
- Visualization/Imagery

### EFFECTOR MECHANISM

- Visual Motor Reaction/Response
- Vision & Balance
- Peripheral Responsiveness
- Coincidence-Anticipation

### Developing Sport-Specific Evaluations

- The test battery needs to assess the perceptual mechanism elements that cut across most sports
  - Visual Acuity (including Dynamic VA)
  - Contrast sensitivity
  - Refraction
  - Ocular alignment
  - Depth Perception (Stereopsis)

### Developing Sport-Specific Evaluations

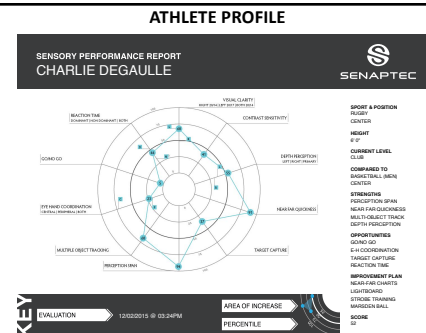
- The remainder of the test battery will be determined by the demands of the sport
  - Accommodation and Vergence function
  - Oculomotor function
  - Reaction time related issues (*Central vision*)
  - Peripheral Reaction/Response
  - Coincidence-Anticipation
  - Other areas specific to sport demands

### Developing Sport-Specific Evaluations

- Challenge for the Eye Care Professional:
  - Determine which visual factors are important for performance of sport task(s)
  - Determine which assessment methods and instrumentation provide comparable demand(s) to those needed for sport
    - Ecologically similar visual demands

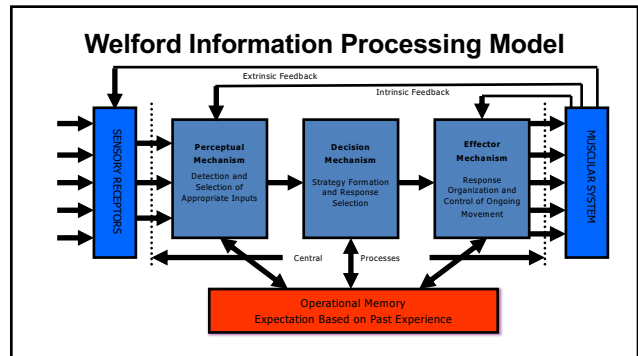
### Computer-based Visual Performance Systems

- Shift from Analog to Digital
- Standardized protocols for assessment
- Athlete databases for patient comparison
  - Senaptec Sensory Station
  - M&S Sports Vision Performance
  - Vizual Edge Performance Trainer
  - RightEye Sports Vision EyeQ
  - Centro de Optometria Internacional



### Visual Performance Training Overview

- Welford Model of Information Processing for Skilled Motor Performance
- Taxonomy Update:
  - Component Skill Training
  - Naturalistic Training



### AREAS OF SPORTS VT

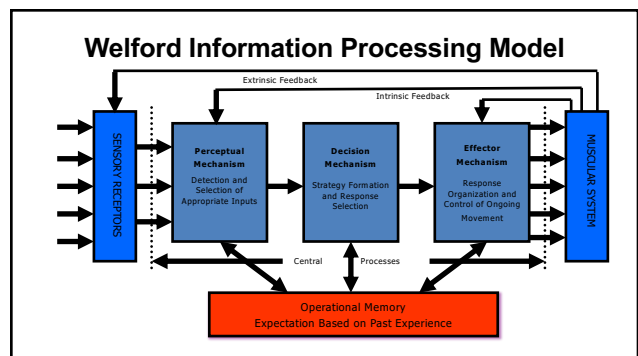
- Remediation of vision inefficiencies that may negatively impact performance consistency
  - Attentional load theories
- Enhancement of visually-dependent motor skills
- Enhancement of cognitive functions
  - Visual decision making
  - Modulation of attention

### VT Procedures Related to Sports Performance

- Relate procedure to sport tasks
- Emphasize **awareness** of response & strategy
- Achieve quality of response initially
- Push speed of response when ready
- Build automaticity of response
- Discuss strategies to assist transfer of skills to the playing field
  - Integrate vision training with sport training (Naturalistic)

### COMPONENT SKILL TRAINING

- The field of perceptual learning has demonstrated many examples of dramatic improvements in visual abilities from appropriately structured tasks
- Practice leads to substantial gains in sensitivity that can last for months or years (Crist, Li, & Gilbert, 2001)
- Benefits can transfer to new, untrained contexts (Bavelier, Green, Pouget, & Schrater, 2012; Deveau, Jaeggi, Zordan, Phung, & Seitz, 2014)



### Static & Dynamic Visual Acuity

- Blur interpretation activities

### Bangerter Foil Training Steps

- Step 1: Practice the activity without the foil goggles for a short period of time (e.g., 2-5 minutes).
- Step 2: Repeat the activity with the foil goggles for 5-10 minutes; work to increasing foil density
  - Change after 3-5 successes at a level
- Step 3: Remove the foil goggles and repeat activity for at least 5 minutes to maximize retention of improved performance.

### Static & Dynamic Visual Acuity

- Pitchback/ball machine with letters, numbers, colors, etc.

### ULTIMEYES



- ULTIMEYES interactive computer app uses an algorithm to provide customized vision training to “improve visual acuity, contrast sensitivity and attention”
- Neuroplasticity technology synchronizes task reinforcement with the appropriate stimuli to improve brain plasticity and vision by:
  - alerting and orienting cues (sounds spatially located with visual targets)
  - training of executive attention (distractors progressively become more similar to tasks targets)
  - tasks designed to help with sustained attention (exercises become progressively longer with time)

### ULTIMEYES

- UC Riverside baseball (19 position vs 18 pitchers)
  - 24 30-minute training sessions
- Results demonstrated improvements in both visual acuity (7 improved to 20/7.5) and contrast sensitivity
- Analysis of batting performance before and after the training program demonstrated a significant reduction in strikeouts (4.4% improvement) and a combined increase of 41.2 runs created
- When calculated in relation to the prevailing conference statistics using Bill James’ Pythagorean Theorem of Baseball, this led to an estimated 4 – 5 extra games won over the 54-game season

Devenu, Lovick, Seitz. “Broad-based visual benefits from training with an integrated perceptual-learning video game”, Vision Research, doi: 10.1016/j.visres.2013.12.015



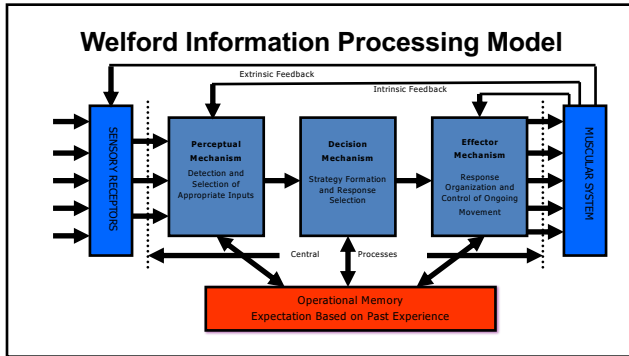
### RevitalVision™



- Revital Vision™ benefits advertised:
  - [Ability to see better](#) - in low light conditions
  - [Enhanced vision](#) - while driving and reading
  - Increase [contrast sensitivity](#) - 100% Increase in Contrast Sensitivity
  - Increase [visual acuity](#) - Improve vision two lines on an Eye Chart on average
- Research support for improvements in VA & CS
  - No control/placebo comparison; effect retained after 12 mo



J Cataract Refract Surg 2008; 34:570-577



### Speed of Recognition

- Tachistoscope activities
- Computer activities
- GOALS: targets

### NATURALISTIC APPROACHES

- Learning literature proposes that transfer of skill training occurs best if the training and transfer tasks engage highly overlapping cognitive processes (Dahlin, Neely, Larsson, Backman, & Nyberg, 2008)
- Naturalistic training situations that most closely resemble game situations might have the highest values in training practical athletic skills
- Technology innovations allow participants to practice actual or simulated sporting activities with altered or augmented visual information

### Game Vision™

- Formerly CP3 via GlassesOff app
  - “designed to challenge the brain’s image processing speed in order to achieve sharper vision focus faster”
  - Players identify flashing, near-threshold targets that vary in speed, size and contrast to progress through levels
    - Collinear facilitation
  - Prototype showed improvements in a wide range of visual tasks and overall enhancement in visual processing speeds (Lev & Polat, Federation of European Neuroscience Societies, 2015)
  - “Launched” in 2016, but no longer available

### Stroboscopic Training

- Strobeflights/Strobe eyewear
  - Develops speed of visual processing
  - Slower flash rates require faster processing
  - Use w/pitchback, ball catching, practice drills, etc
  - Strobe eyewear can be worn during sport performance to train sport-specific visual processing speed

### Strobe Training Steps

- Step 1: Practice the activity without the strobe for a short period of time (e.g., 2-5 minutes).
- Step 2: Repeat the activity with the Strobe for 5-10 minutes; work to decrease flash rate
  - Change after 3-5 successes at a level
- Step 3: Remove the strobe and repeat activity for at least 5 minutes to maximize retention of improved performance.

### Senaptec Strobe (formerly Nike)

- Integration training applications for various sports
  - Baseball/Softball, Football, Soccer, Basketball, Volleyball, Skiing/Surfing, Golf, etc.
- Duke University vision cognition research (N=504)
 

“Those who trained with the Nike Strobes showed greater improvements than those in the control group, revealing training benefits due to the stroboscopic experiences.” VSS ‘11  
<http://today.duke.edu/2011/05/nikestrobe>



### Stroboscopic Training

- Stroboscopic training increased dynamic visual acuity (after one training session) and ball catching performance (over the course of the training) compared to training without a stroboscopic effect
  - Holliday, Joshua, "Effect of Stroboscopic Vision Training on Dynamic Visual Acuity Scores: Nike Vapor Strobe® Eyewear" (2013). <http://today.duke.edu/2011/05/nikestrobe>
- The strobe group averaged an 18% improvement in on-ice skill performance from pretraining to posttraining, whereas the control group's performance did not improve
  - Enhancing Ice Hockey Skills Through Stroboscopic Visual Training. Mitroff et al., Athletic Training & Sports Health Care 2013, 5.
- Stroboscopic illumination reduced the severity of motion sickness symptoms, and shutter glasses with a flash frequency of 4 Hz are as effective as a strobe light
  - Reschke et al. Stroboscopic Vision as a Treatment for Motion Sickness: Strobe Lighting vs. Shutter Glasses. Aviat Space Environ Med 2006; 77:2-7.

### Other Occlusion Products



swavelvision.com

Hit and Field  
Specs Baseball  
and Softball  
Head Down  
Training Aid

### Brain Training Games

- HeadTrainer app targets five areas of mental function specifically tailored to athletes ([www.headtrainer.com](http://www.headtrainer.com))
- BrainHQ partnered with TB12 to promote a sports-specific cognitive training module ([www.brainhq.com](http://www.brainhq.com))
- Lucid app targets visualization and mindfulness attributes for athletes ([www.getlucid.com](http://www.getlucid.com))
- Promising platforms, but no research at this time ...

### NeuroTracker

- Immersive three-dimensional **Multiple Object Tracking** intervention with added dual-task functions to increase cognitive load
- Tracking objects (balls) as they move through space – targets and non-targets
  - Analogous to tracking teammates & opponents
- Speed and object number are adjusted in a staircase procedure, with other tasks added
- “Customize” and “Pro” versions  
 (Note: This is not NeuroTrainer)

### NeuroTracker

- Research shows it can discriminate high-level from lower-level athletes, and that a brief training regimen with the program can produce improvements in sports-related ability  
 (Faubert, Scientific Reports 2013)
- Performance has been correlated with actual game performance in professional basketball players (assists, steals & assist-to-turnover ratio), and that training with this program can selectively transfer to improved small-sided game passing performance in university-level soccer players  
 (Mangine et al., 2014; Romeas, Guldner, & Faubert, 2016)

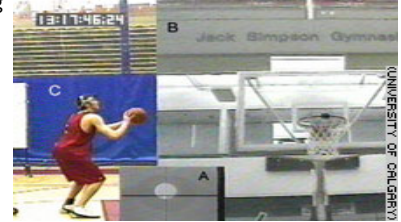


### NeuroTrainer

- Virtual reality simulations that “integrate components across the perception-cognition-action continuum”
- Series of dual tasks that simultaneously challenge attention and peripheral vision, and purports to train eye-hand coordination, dynamic visual acuity, tracking, and visual reaction time
- Battery includes a number of visual tasks such as MOT, visual discrimination, visual search, visual crowding and go/no-go

### The Quiet Eye™

- Mobile Eye Tracking

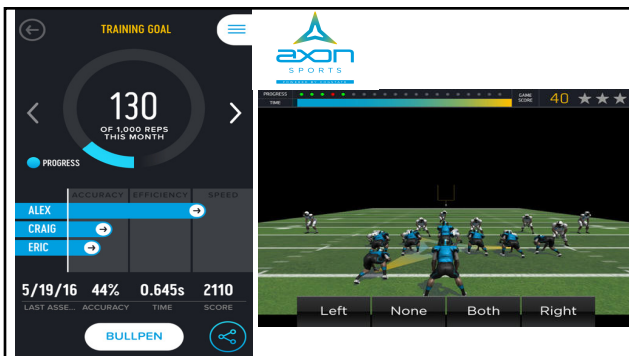


### SPORT SIMULATION APPROACHES

- Computerized simulations and virtual reality (VR) platforms have gained substantial use as alternate means by which to simulate game action, allowing athletes to gain ‘mental repetitions’ that mimic actual plays being run in the first-person with little-to-no risk of injury

### SPORT SIMULATION APPROACHES

- Research with customized applications have evaluated the capacity to implement realistic sports-specific simulations of:
  - Baseball (Fink et al, 2009; Gray 2002; Zaal & RJ, 2011)
  - Tennis (Xu et al., 2009)
  - Ping pong (Knorlein et al, 2007)
  - Billiards (Gourishankar et al, 2007)
  - Archery (Gobel et al, 2010)
  - Handball (Bolte et al, 2010)
  - Rugby (Miles et al 2012)



### Virtual reality applications





### Virtual reality applications

- Steps 1 & 2: Compete & Assessment
  - Strike Recognition will measure your Reaction Time with millisecond precision on every pitch you call a strike.
  - Pitch Recognition will do the same for pitches you sit on.
  - Both games will tell you how fast you are chasing pitches or how slow you are when you're late. Your Accuracy will measure how good your recognition is.
  - Ranks the athlete against the competition.



### Virtual reality applications

- Step 3: Training
    - Reaction Time Enhancement will use occlusion to train faster decisions.
    - Hitter's Eye Zone Enhancement allows targeting of those parts of the strike zone most problematic.
  - Available in VR & Mobile platforms
- <https://decervo.com/index.html>

### A.M.P. system

- VR system designed to evaluate and train:
  - Eye-Hand, Eye-Foot & Eye-Body Coordination & Quickness
  - Eye Tracking
  - Depth Awareness
  - Dynamic Acuity
  - Attention Span
  - Balance
  - Contrast Sensitivity
  - Visual Memory
  - Decision Making Tasks
  - Realistic Immersed On-Field (including weather & lighting condition controls)

[www.ampsystem.net](http://www.ampsystem.net)

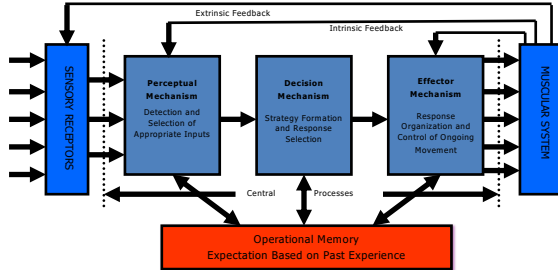


### Beyond Sports

- Artificial intelligence visualization company using VR
- Designed to enhance “players spatial awareness and take faster decisions in future matches”

[www.beyondsports.nl](http://www.beyondsports.nl)

### Welford Information Processing Model




### Visual-Motor Reaction/Response Time & Accuracy (Eye-Hand, Body, Foot Coordination)

- Wayne Saccadic Fixator or Equivalent
- Pitchback/Table Tennis with strobe
- Juggling
- Split Attention
- Strobe training

### Central Eye-Hand Reaction Time

- Vision Rings
- HECOSstix
- HawkEye Coordinator Stick
- Vector Ball



<https://frozen-ropes.myshopify.com/products/vision-rings-and-rods>

<https://eyeonballinc.com/>

<https://hecostix.com/>

<http://www.hawkeyesportsvision.com/>

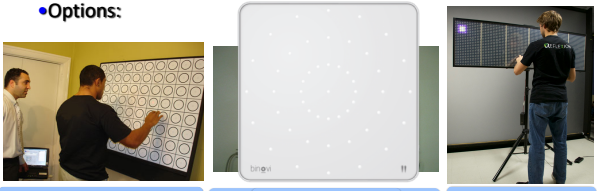
### Lightboard-type Technologies

Most provide a platform of:

- Interactive computer-based programs
- Large touchboard or touchscreen monitor
- Training algorithms for peripheral eye-hand response speed
- Training algorithms for decision-based peripheral eye-hand response speed
- Training algorithm for split attention

### Lightboard-type Technologies


•Options:



**SVT (Australia)**      **Binovi Touch**      **Reflexion Edge**

### Lightboard-type Technologies

•Options:



**Vision Coach**      **BATAK Pro**      **Dynavision**

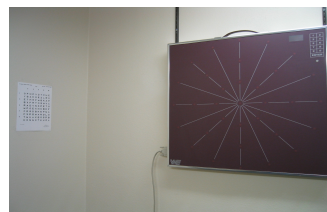
### Lightboard-type Technologies



**Senaptec Sensory Station**      **FitLight**      **SIBOASI Reaction Lights**

### Visual Attention, Awareness & Responsiveness

- Metronome activities
- Yoked Prism Glasses
- Stress overloading activities
- Split Attention activities



### Lightboard-type Technologies

- Good test-retest reliability for evaluation
- Dynavision with other SVT on collegiate baseball players found that batting averages, slugging percentage, and on-base percentage were all improved as compared to the previous season when no vision training was performed (Clark et al., 2012)
  - 6 weeks of preseason training with 3x/week during the season
- With collegiate football, concussion incidences during the four years studied were reduced relative to the four years prior to the implementation of the training programs (Clark, Graman, et al., 2015)

### Lightboard-type Technologies

- A 6-week training study used Dynavision with youth field hockey players
- Dynavision was used both as an assessment tool and as one of five training stations
  - along with Eyeport®, Hart charts, P-Rotator, and the Vision Performance Enhancement Program
- Performance on the Dynavision assessment task and a functional field of view assessment task both improved compared to a control group, but there was no difference in the MOT assessment (a transfer task)

*Schwab & Memmert, Journal of Sports Science and Medicine, 11(4), 624–631.*

### The Quick Board



### The Quick Board

- The Quick Board consists of a rubber mat positioned on the ground with sensor pads in five locations
- The mat is connected to a control device that provides visual stimulus and feedback information about the movement responses
- Four weeks of training with the Quick Board has been shown to produce significant improvements in foot speed, choice reaction and change-of-direction in moderately active adults

(Galpin, Li, Lohnes, and Schilling 2008)

### Vision & Balance

- Wayne Saccadic Fixator with Balance Board
- Balance Board Activities with reaction time
- Balance activities with other VT activities



### Coincidence-Anticipation Timing

- Senaptec Synchrony
- Bassin Anticipation Timer
- Stroboscopic activities



<https://www.senaptec.com/product/synchrony-pro>

### Integrated Sensorimotor Batteries

- Senaptec Sensory Station
- Vizual Edge Performance Trainer®
- Most of the research has correlated performance on specific measures of vision with sports performance metrics
- Training studies with these instruments demonstrate improvements in visual performance measures, but there are only preliminary studies designed to determine effects on sports performance

### Senaptec Sensory Station: Training Programs

- Eye-Hand Coordination
- Go/No Go
- Depth Perception
- Near-Far Quickness
- Multiple Object Tracking.
- Dynamic Perception
- Post-TBI recovery



### Senaptec Sensory Station

- The Sensory Station was used as both a training tool and an evaluation benchmark in an applied program conducted by the University of Texas varsity softball
- This intervention involved multiple weeks of SVT drills including practice with:
  - Strobe Eyewear, Marsden Balls, Brock Strings, and Near Far Charts, as well as the Depth Perception, Eye-Hand Coordination, and Go/No-Go tasks on the Sensory Station
- Results from 15 athletes who underwent SVT and 10 teammates who did not indicate significant relative improvements for the SVT group in three Sensory Station tasks (Near-Far Quickness, Target Capture & Go/No-Go)

*Appelbaum et al., 2016; Athletic Training & Sports Health Care.  
doi:10.3928/19425864-20160314-01*

### Integrated Training Programs

#### Vizual Edge Performance Trainer®

- Training Paradigms
  - Vizual Flexibility®
  - Vizual Recognition®
  - Vizual Tracking®

#### RightEye

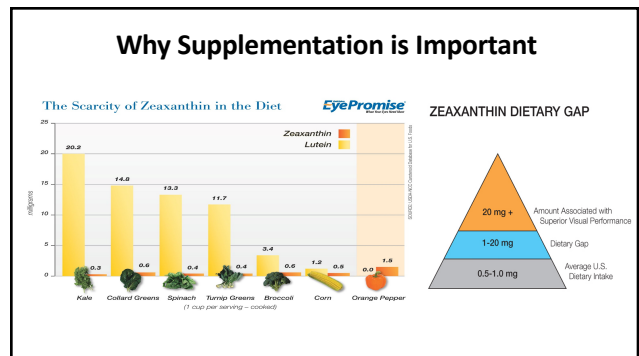
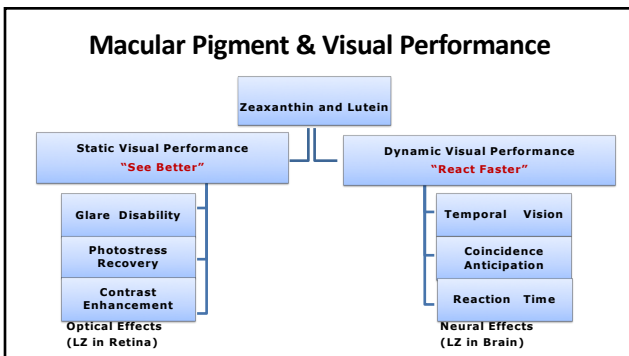
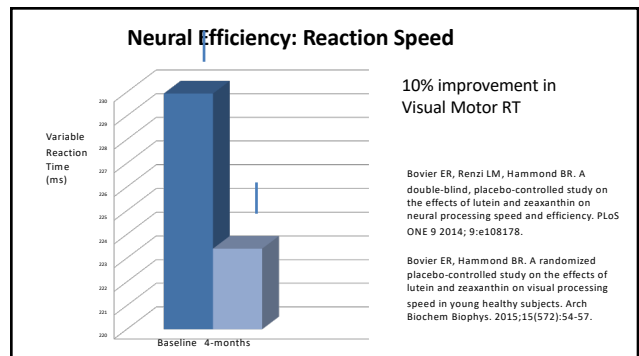
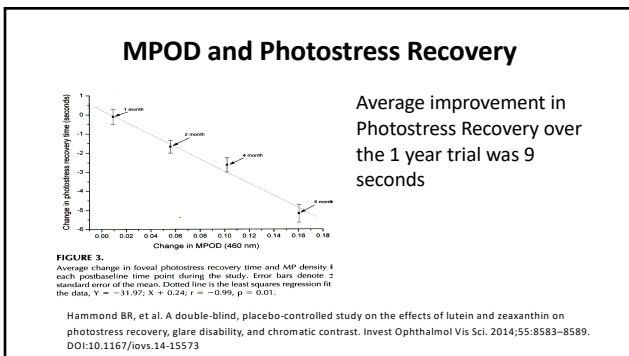
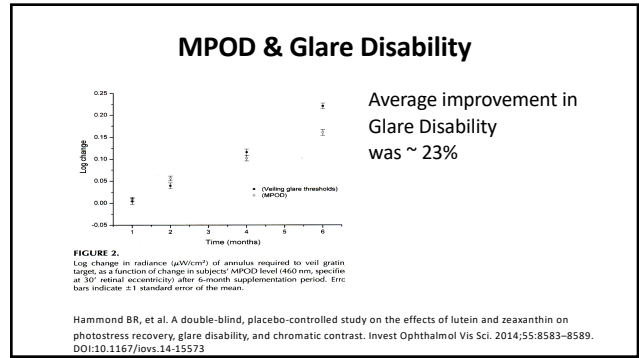
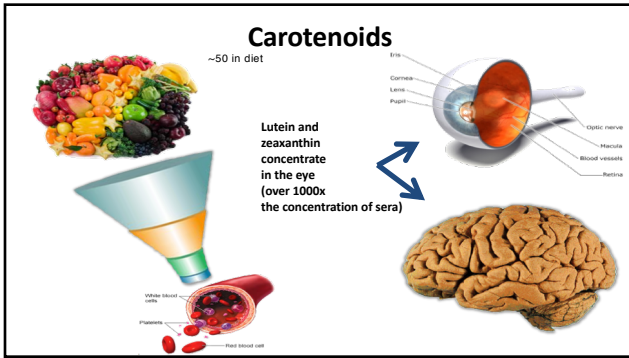
- Training Paradigms
  - RightEye Cosmos Combat™
  - Space Storm™

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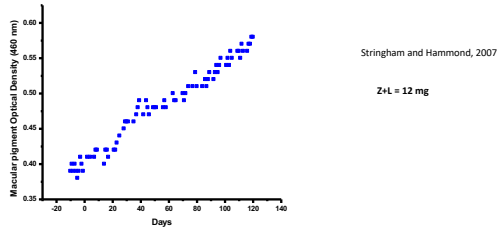
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### Nutrition for Better Performance: ZEAXANTHIN

- 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



### MPOD Increases Due to Supplementation



### 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®*

### QUESTIONS?



#### References

- Erickson GB. Sports Vision: Vision Care for the Enhancement of Sports Performance 2<sup>nd</sup> Ed. Butterworth (Elsevier) 2022. ISBN 9780323755436
- Appelbaum LG, Erickson G. Sports vision training: A review of the state-of-the-art in digital training techniques. Int Rev Sport & Exercise Psychology 2016; DOI: 10.1080/1750984X.2016.1266376