

Concussion-Related Vision Problems: Vision Rehabilitation

Mitchell Scheiman, OD, PhD



Mary Switzer Lecture



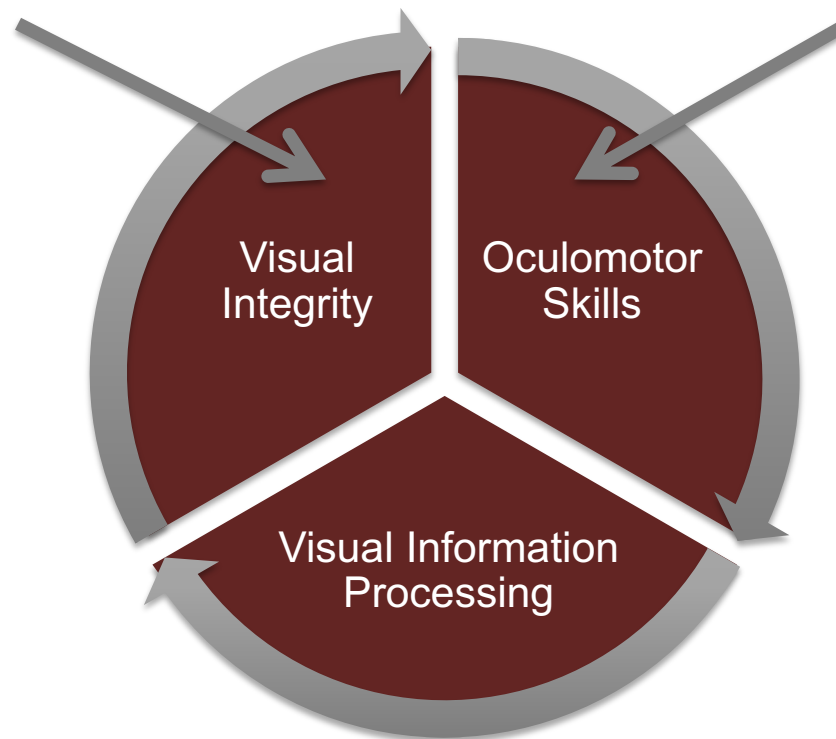
Financial Disclosures

■ None

Presentation Overview

- Definitions
- Prevalence of vision problems after mTBI/concussion
- Vision Rehabilitation
- Underlying mechanisms for improved function

Three Component Model of Vision



Visual Integrity

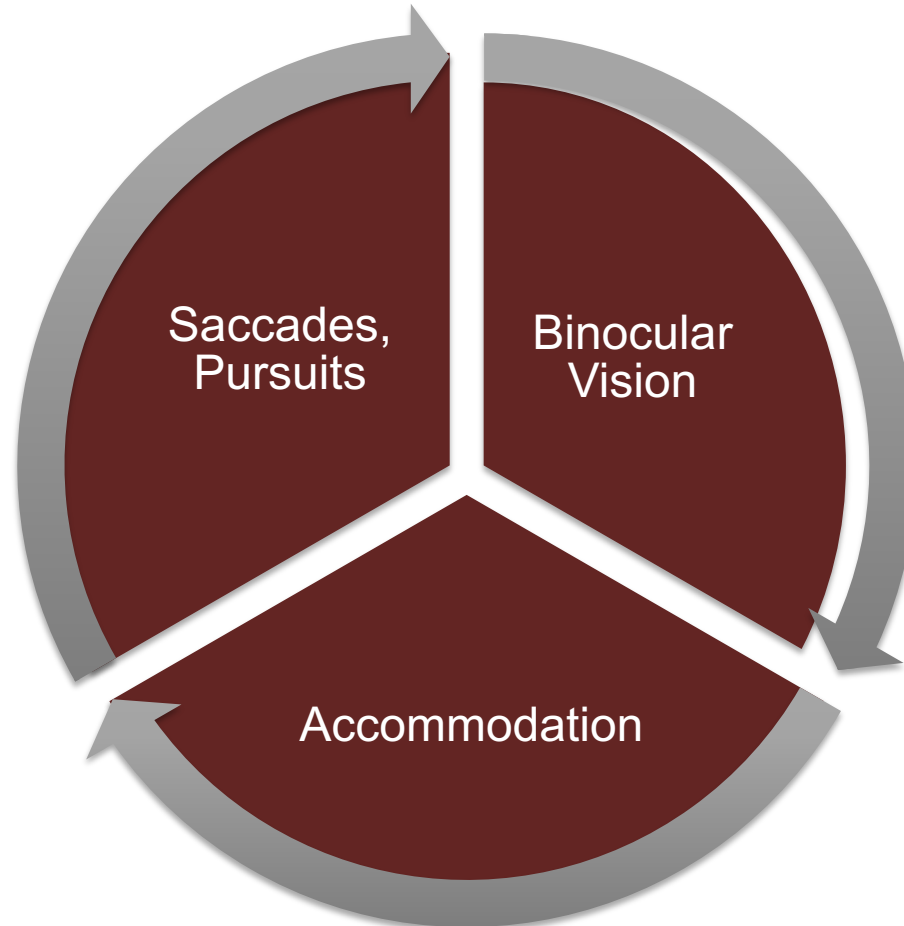
Visual Acuity

Optics

Eye Health



Oculomotor Skills



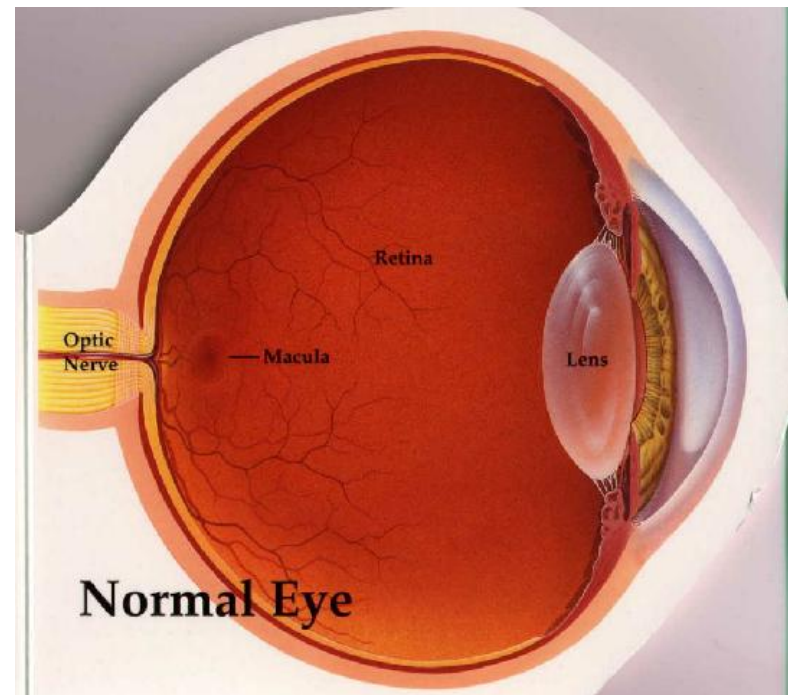
Accommodation Disorders

■ Definition

- Age-related loss of accommodation
 - ◆ Structural
- Concussion-related loss of accommodation
 - ◆ Visual Pathway

■ Most common accommodative problem

- Accommodative Insufficiency



Binocular Vision Disorders

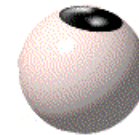
■ Convergence Insufficiency

- Condition in which eyes struggle to maintain convergence at near

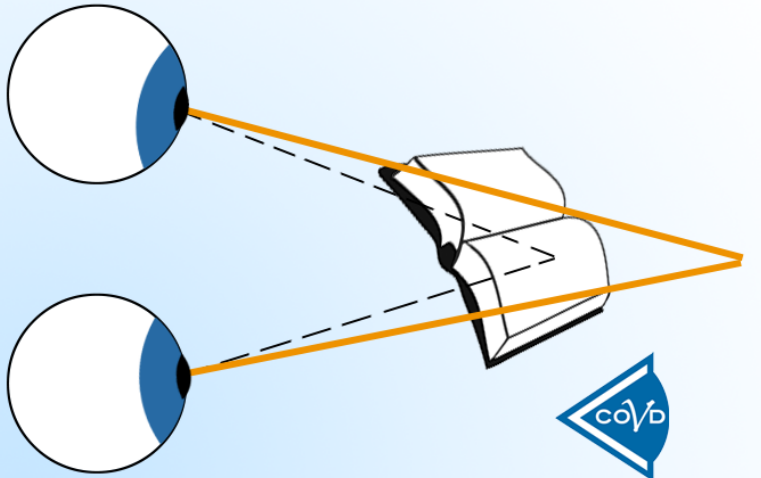
■ Symptoms

- Eyestrain
- Blurred vision
- Double vision
- Inability to sustain attention on task
- Reduced comprehension

Convergence



Convergence Insufficiency



College of Optometrists
in Vision Development

Convergence Insufficiency
can make text look double
when trying to read

Some people with
Convergence Insufficiency
experience a 'halo effect'
instead of double vision



Eye Movement Disorders

- Eye movement problems
 - Saccades
 - Pursuits



Symptoms of Oculomotor Disorders

- Eyestrain
- Blurred vision
- Double vision
- Words moving on page
- Inability to sustain attention on task
- Reduced comprehension
- Loss of place
- Dizziness/nausea

Prevalence of Vision Deficits - Overview

Normal Population

- Binocular vision – 10%
- Accommodation – 3%
- Eye Movements – 2%

After Concussion/mTBI

- Binocular vision – 30%-45%
- Accommodation – 10%-50%
- Eye Movements – 20%-40%

Prevalence Studies - Summary

Problem	Goodrich N=46 Mean age=28	Brahm N=192 Mean age=28	Stelmack N=192 Mean age=31	Cuiffreda N=160 Mean age=42	Suchoff N= 62 Mean age=49	Master/Schei man N= 100 Mean age=14
Convergence Insufficiency (10%)	30%	42%	28%	36%	42%	49%
Accommodative Dysfunction (3%)	22%	42%	47%	41%	10%	50%
Saccadic Dysfunction (2%)	20%	33%	9%	57%	40%	29%

Concussion-Related Vision Problems in Adolescents

- Salus University/Children's Hospital of Philadelphia (CHOP)
 - Objective: Determine prevalence of vision problems in children 11-17 years old with a medical diagnosis of concussion
 - Method: Performed vision exam on 100 consecutive adolescents with diagnosis of concussion

Results

- N = 100
- Mean age = 14.3 years
- 69% had at least 1 vision problem
 - Accommodative problems: 50%
 - Convergence insufficiency: 49%
 - Saccadic dysfunction: 29%

Impact on Recovery

- Retrospective cohort of 432 pediatric patients with concussion
- The main outcome of interest was time to clinical recovery
- Results: 378 of 432 subjects (88%) presented with vision or vestibular problems
- Conclusions: Vision and vestibular problems predict prolonged concussion recovery in children
- Vision assessments in concussion must include smooth pursuits, saccades, near point of convergence, and accommodative amplitude

Treatment Options

- Lenses
- Prism
- Vision therapy/vision rehabilitation

Vision Therapy/Vision Rehabilitation

- Rehabilitation of ocular motor and other visual deficits using lenses, prisms, instrumentation, software
- Very basic techniques are sometimes integrated into physical therapy/vestibular Therapy
- Typically done by specialty trained optometrists
- In-office and home therapy components

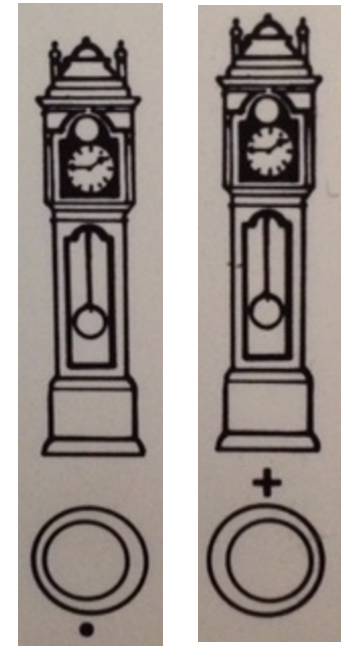
Oculomotor Rehabilitation

VIDEO EXAMPLE



SALUS
UNIVERSITY

Example of VT: Aperture Rule





Is Oculomotor Rehabilitation Effective?

Vision Rehabilitation: Effectiveness

- More research in non-traumatic brain injury (TBI) patients
- Expanding research in TBI/concussion

A Randomized Clinical Trial of Treatments for Convergence Insufficiency in Children

Mitchell Scheiman, OD; G. Lynn Mitchell, MAS; Susan Cotter, OD; Jeffrey Cooper, OD, MS; Marjean Kulp, OD, MS; Michael Rouse, OD, MS; Eric Borsting, OD, MS; Richard London, MS, OD; Janice Wensveen, OD, PhD; for the Convergence Insufficiency Treatment Trial (CITT) Study Group

Objective: To compare vision therapy/orthoptics, pencil push-ups, and placebo vision therapy/orthoptics as treatments for symptomatic convergence insufficiency in children 9 to 18 years of age.

Methods: In a randomized, multicenter clinical trial, 47 children 9 to 18 years of age with symptomatic convergence insufficiency were randomly assigned to receive 12 weeks of office-based vision therapy/orthoptics, office-based placebo vision therapy/orthoptics, or home-based pencil push-ups therapy.

Main Outcome Measures: The primary outcome measure was the symptom score on the Convergence Insufficiency Symptom Survey. Secondary outcome measures were the near point of convergence and positive fusional vergence at near.

Results: Symptoms, which were similar in all groups at baseline, were significantly reduced in the vision therapy/orthoptics group (mean symptom score decreased from

32.1 to 9.5) but not in the pencil push-ups (mean symptom score decreased from 29.3 to 25.9) or placebo vision therapy/orthoptics groups (mean symptom score decreased from 30.7 to 24.2). Only patients in the vision therapy/orthoptics group demonstrated both statistically and clinically significant changes in the clinical measures of near point of convergence (from 13.7 cm to 4.5 cm; $P < .001$) and positive fusional vergence at near (from 12.5 prism diopters to 31.8 prism diopters; $P < .001$).

Conclusions: In this pilot study, vision therapy/orthoptics was more effective than pencil push-ups or placebo vision therapy/orthoptics in reducing symptoms and improving signs of convergence insufficiency in children 9 to 18 years of age. Neither pencil push-ups nor placebo vision therapy/orthoptics was effective in improving either symptoms or signs associated with convergence insufficiency.

Arch Ophthalmol. 2005;123:14-24

Randomized Clinical Trial of Treatments for Symptomatic Convergence Insufficiency in Children

*Convergence Insufficiency Treatment Trial Study Group**

Mitchell Scheiman, OD; Susan Cotter, OD, MS; G. Lynn Mitchell, MAS; Marjean Kulp, OD, MS; Michael Rouse, OD, MEd; Richard Hertle, MD; Maryann Redford, DDS, MPH. Jeffrey Cooper, MS, OD; Rachel Coulter, OD; Michael Gallaway, OD; David Granet, MD; Kristine Hopkins, OD, MSPH; Brian G. Mohny, MD; and Susanna Tamkins, OD.

Objective: To compare home-based pencil push-ups (HBPP), home-based computer vergence/accommodative therapy and pencil push-ups (HBCVAT+), office-based vergence/accommodative therapy with home reinforcement (OBVAT), and office-based placebo therapy with home reinforcement (OBPT) as treatments for symptomatic convergence insufficiency.

Methods: In a randomized clinical trial, 221 children aged 9 to 17 years with symptomatic convergence insufficiency were assigned to 1 of 4 treatments.

Main Outcome Measures: Convergence Insufficiency Symptom Survey score after 12 weeks of treatment. Secondary outcomes were near point of convergence and positive fusional vergence at near.

Results: After 12 weeks of treatment, the OBVAT group's mean Convergence Insufficiency Symptom Survey score (15.1) was statistically significantly lower than those of 21.3, 24.7, and 21.9 in the HBCVAT+, HBPP, and OBPT groups, respectively ($P < .001$). The OBVAT group also

demonstrated a significantly improved near point of convergence and positive fusional vergence at near compared with the other groups ($P \leq .005$ for all comparisons). A successful or improved outcome was found in 73%, 43%, 33%, and 35% of patients in the OBVAT, HBPP, HBCVAT+, and OBPT groups, respectively.

Conclusions: Twelve weeks of OBVAT results in a significantly greater improvement in symptoms and clinical measures of near point of convergence and positive fusional vergence and a greater percentage of patients reaching the predetermined criteria of success compared with HBPP, HBCVAT+, and OBPT.

Application to Clinical Practice: Office-based vergence accommodative therapy is an effective treatment for children with symptomatic convergence insufficiency.

Trial Registration: clinicaltrials.gov Identifier: NCT00338611

Arch Ophthalmol. 2008;126(10):1336-1349

ORIGINAL ARTICLE

Treatment of Accommodative Dysfunction in Children: Results from a Randomized Clinical Trial

Mitchell Scheiman^{*}, Susan Cotter[†], Marjean Taylor Kulp[†], G. Lynn Mitchell[‡], Jeffrey Cooper[§],
Michael Gallaway^{||}, Kristine B. Hopkins[¶], Mary Bartuccio^{**}, Ida Chung^{||},
and the Convergence Insufficiency Treatment Trial Study Group

ABSTRACT

Purpose. To report the effectiveness of various forms of vision therapy/orthoptics in improving accommodative amplitude and facility in children with symptomatic convergence insufficiency (CI) and co-existing accommodative dysfunction.

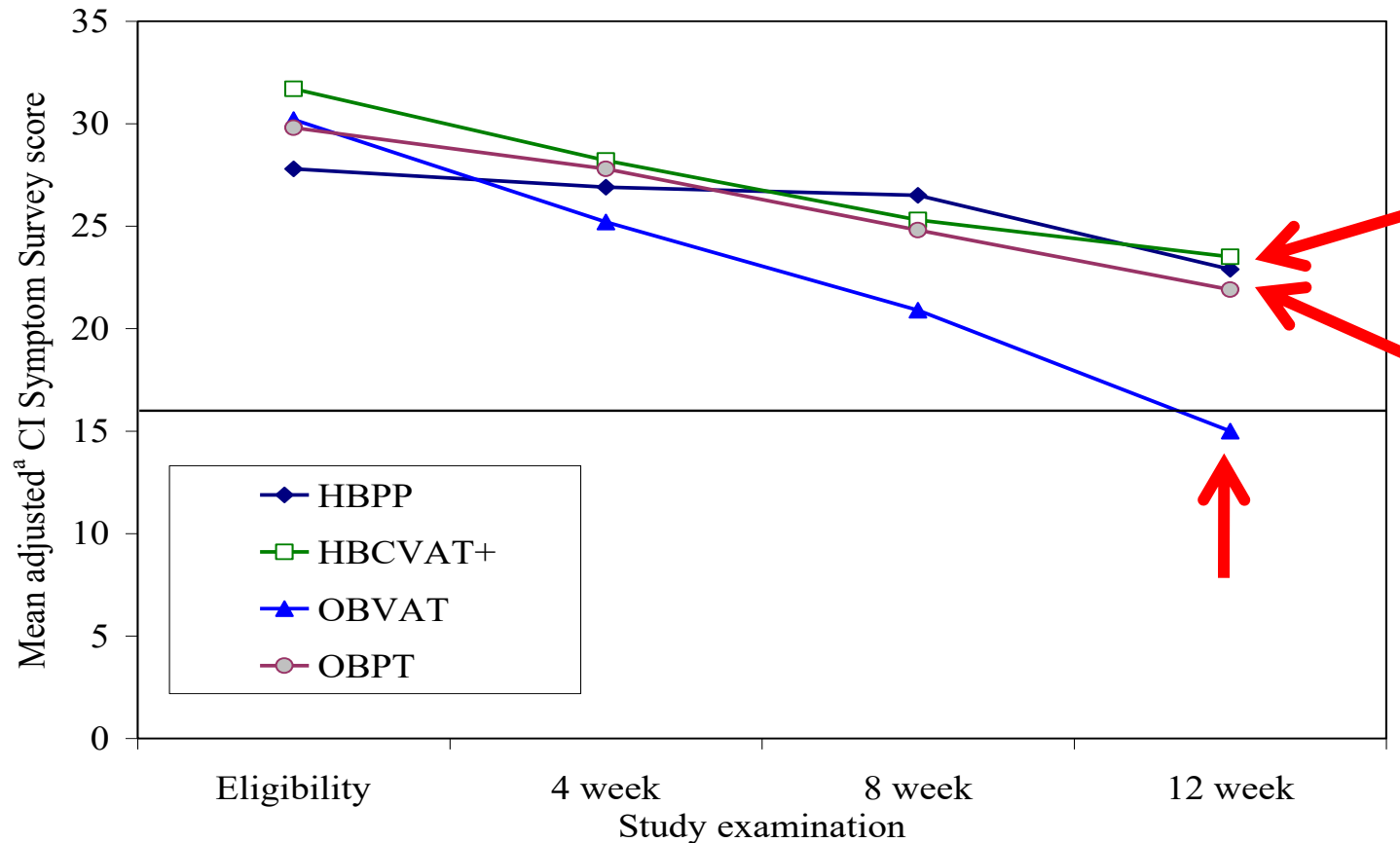
Methods. In a randomized clinical trial, 221 children aged 9 to 17 years with symptomatic CI were assigned to one of four treatments. Of the enrolled children, 164 (74%) had accommodative dysfunction; 63 (29%) had a decreased amplitude of accommodation with respect to age, 43 (19%) had decreased accommodative facility, and 58 (26%) had both. Analysis of variance models were used to compare mean accommodative amplitude and accommodative facility for each treatment group after 4, 8, and 12 weeks of treatment.

Results. After 12 weeks of treatment, the increases in amplitude of accommodation [office-based vergence/accommodative therapy with home reinforcement group (OBVAT) 9.9 D, home-based computer vergence/accommodative therapy group (HBCVAT+) 6.7 D, and home-based pencil push-up therapy group (HBPP) 5.8 D] were significantly greater than in the office-based placebo therapy (OBPT) group (2.2 D) (p -values ≤ 0.010). Significant increases in accommodative facility were found in all groups (OBVAT: 9 cpm, HBCVAT+: 7 cpm, HBPP: 5 cpm, OBPT: 5.5 cpm); only the improvement in the OBVAT group was significantly greater than that found in the OBPT group ($p = 0.016$). One year after completion of therapy, reoccurrence of decreased accommodative amplitude was present in only 12.5% and accommodative facility in only 11%.

Conclusions. Vision therapy/orthoptics is effective in improving accommodative amplitude and accommodative facility in school-aged children with symptomatic CI and accommodative dysfunction.

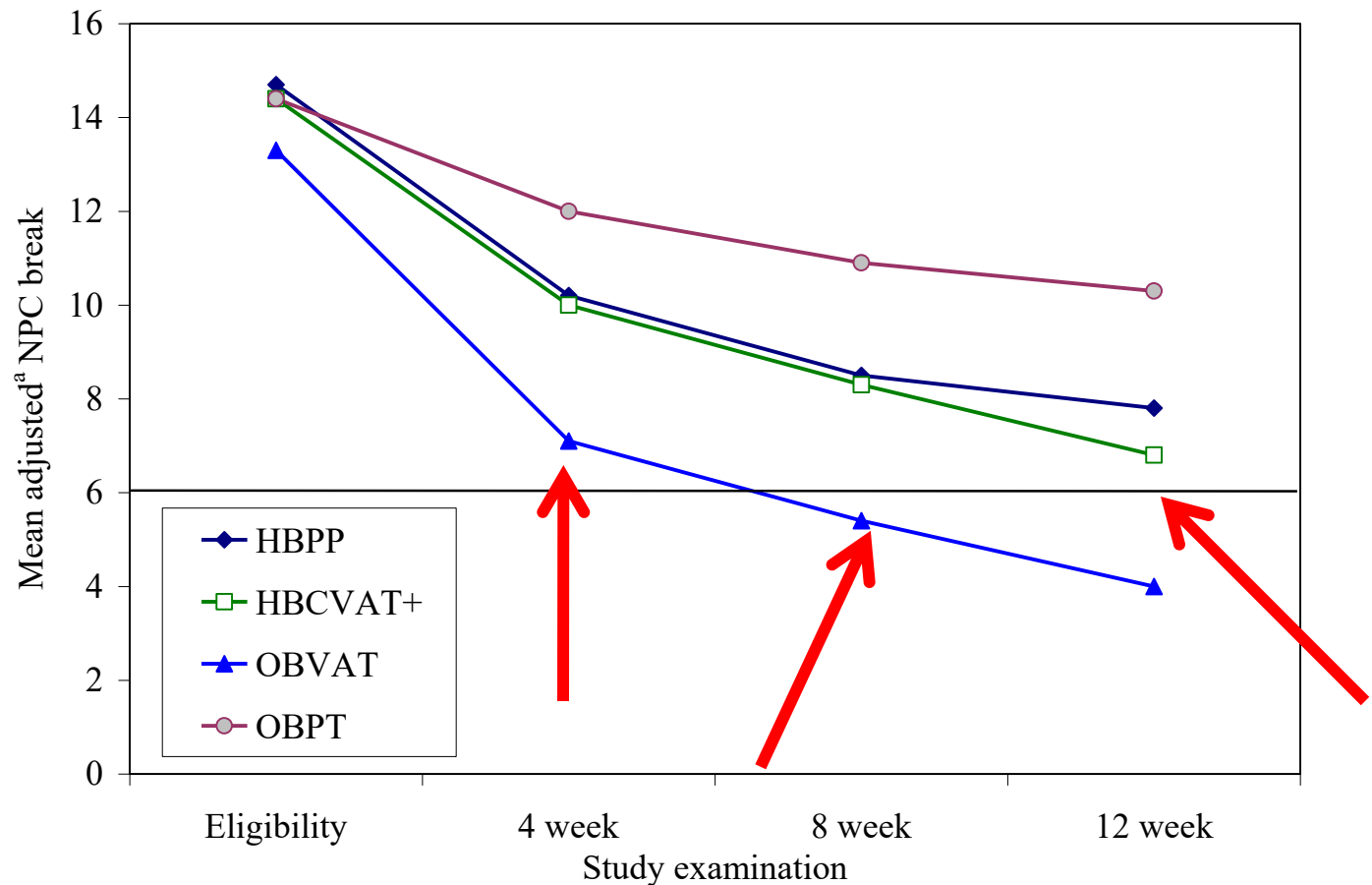
(Optom Vis Sci 2011;88:1-●●●)

Mean CISS Scores by Group



No significant differences were observed between the HBPP, HBCVAT+, and OBPT groups (pair-wise p-values all ≥ 0.38).

Mean NPC break by Group



Non-surgical interventions for convergence insufficiency (Review)

Scheiman M, Gwiazda J, Li T



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This is a reprint of a Cochrane review, prepared and maintained by The Cochrane Collaboration and published in *The Cochrane Library* 2011, Issue 3

<http://www.thecochranelibrary.com>

Recent Treatment Studies

Vision Rehab after mTBI

- Thiagarajan P, Ciuffreda KJ. Effect of oculomotor rehabilitation on vergence responsivity. *J Rehabil Res Dev* 2013;50:1223-40
- Thiagarajan P, Ciuffreda KJ. Effect of oculomotor rehabilitation on accommodative responsivity. *J Rehabil Res Dev* 2014;51:175-91

Research - Adults after mTBI

- Funded by Department of Defense
 - Compared office-based VT to placebo VT in adult patients with mTBI
 - Not only used placebo control, but first study to use objective measures of vergence
 - ◆ Not susceptible to bias

Results

- Objectives measures of vergence improved markedly
- Near-vision symptoms reduced along with improved visual attention
- None of the measures were found to change significantly following the placebo training
- Demonstrates brain visual system plasticity after mTBI in adult subjects

Potential Underlying Mechanisms

Neural Synchronization

Out of sync...Analogous to a conductor in an orchestra who facilitates the synchronization of the musicians

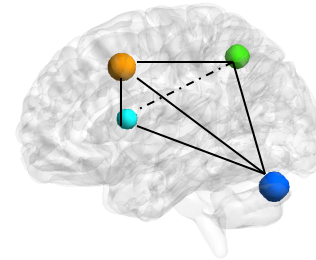
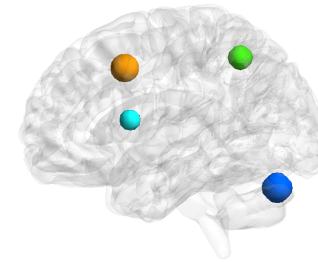
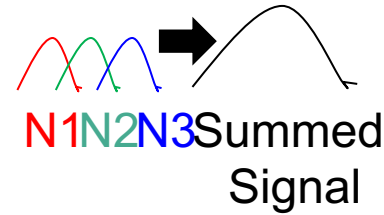
Neural Recruitment

Fewer neurons participating in the task

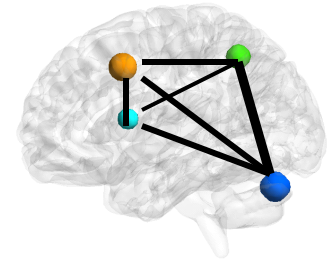
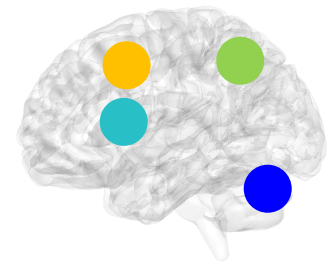
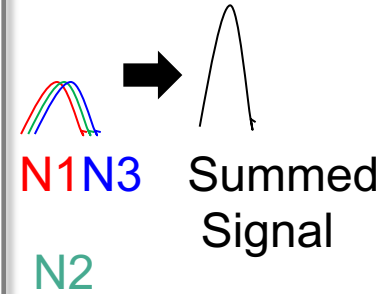
Functional Connectivity

Poorer connectivity between neural sites involved in vergence or other visual functions

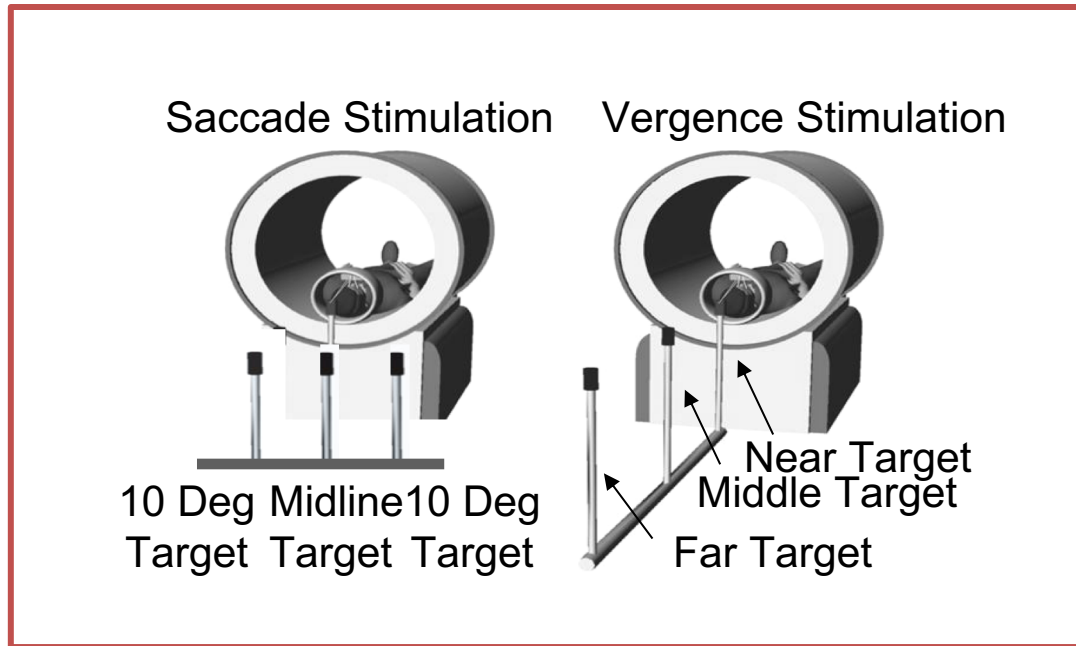
Concussion



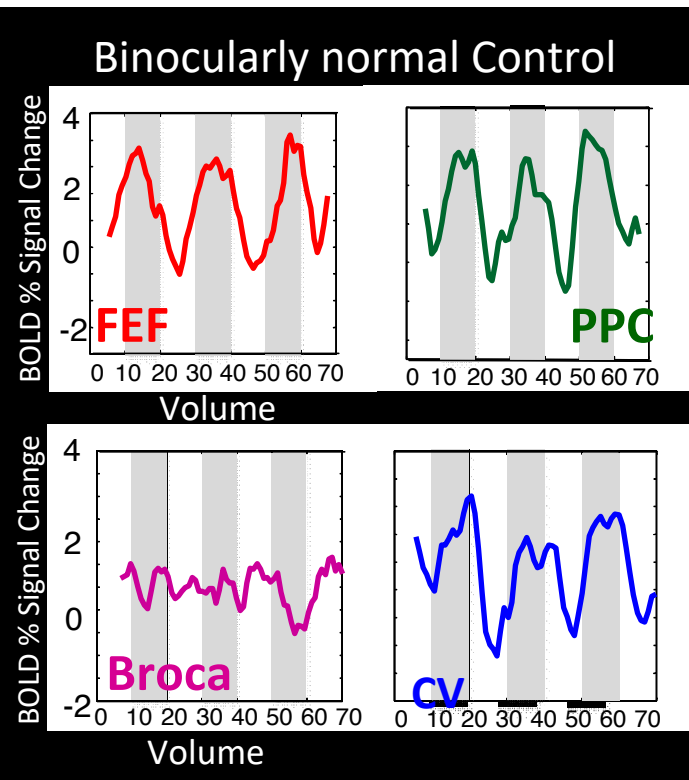
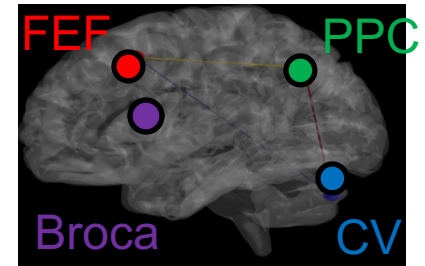
Normal



Experimental Set-Up for fMRI Eye Movement Experiments



Vergence Therapy Improves Synchronization



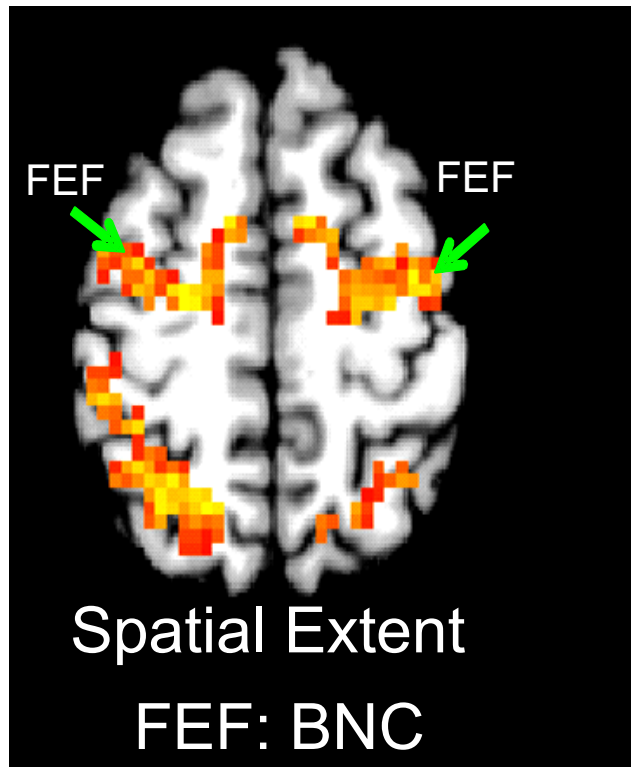
Interpretation: Vision Therapy stimulates improved neuronal synchronization

Vergence Therapy Stimulates Neural Recruitment

Binocular Normal
Control (BNC)

CI Before
Therapy

CI After
Therapy



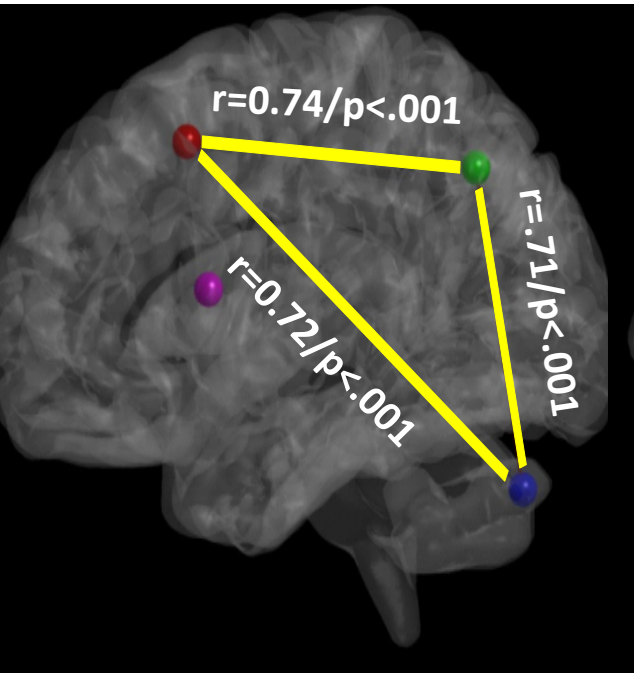
Frontal Eye Fields (FEF shows by green arrows) shows an increase in spatial extent
Interpretation: Vision Therapy stimulates increase in spatial extent

Vergence Therapy Improves Task Induced Functional Connectivity

Binocularly
Normal Control

CI Before
Vergence Therapy

CI After
Vergence Therapy



The correlation between the time series of FEF (red) PPC (green) and CV (blue) improves. Broca's region (purple) was not correlated to FEF, PPC or CV

Interpretation: Vision Therapy stimulates improved functional connectivity

Summary

- Underlying mechanism of for improvement after vision therapy:
 - Neural Synchronization
 - Neural Recruitment
 - Functional Connectivity

Conclusions

- Vision evaluation and rehabilitation should be part of the interprofessional care provided to patients after mTBI
- Non-eye care professionals should screen for oculomotor problems after concussion
 - Consider referrals for comprehensive oculomotor examination
 - Consider oculomotor rehabilitation
 - Randomized clinical trials required

Contact Information

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Thank You!