# Vision therapy for mild traumatic brain injury: the concepts and the evidence

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"Kvalitet, faglighed og evidens i neurorehabiltering"

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**THE RATIONALE FOR 'VISION THERAPY' (EYE MOVEMENT EXERCISES) IN mTBI**

Why we do offer treatments for anything…in general?

- based on (good) evidence-based proof of efficacy
- If insufficient evidence, a physiologically plausible, logical rationale *("does it make sense?")*

**OUTLINE**

1.Are visual symptoms common after head trauma?

2.Are eye movements abnormal after head trauma?

3.Do eye movement problems cause visual symptoms?

4.Is there empiric evidence that eye movement exercises reduce visual symptoms from head trauma?

# 1. ARE VISUAL SYMPTOMS COMMON AFTER MILD HEAD TRAUMA?

- **retino-striate damage** is RARE with mild TBI - 6% 'field defects', 0% decreased acuity.

- many have **non-specific symptoms** (blur, diplopia, dizziness, light sensitivity, eye strain…)
  e.g. "difficulty reading" – lose place, have to re-read, can't remember what they read

- "**post-trauma vision syndrome**"

| ***Symptoms*** | ***Signs*** |
|---|---|
| diplopia | exotropia or exophoria |
| blurred vision | convergence insufficiency |
| avoidance of near tasks | |
| reading difficulties | ocular motor dysfunction |
| illusory motion of stationary objects | |
| sensitivity to visual motion | accommodative insufficiency |
| intolerance of complex environments | pseudo-myopia |
| asthenopia | |
| headaches | |
| photophobia | |
| short-term visual memory | |
| concentration/attention | |
| balance/posture/coordination | |
| vertigo/dizziness | |

*Padula WV et al. Brain Injury 1994; 8: 125-133.*

"POST-TRAUMA VISION SYNDROME": Is it a useful term?

# NO - WHY NOT?

- 1. not all of the symptoms claimed are **visual**

- 2. it is implausible that all the listed symptoms have a **visual/ocular motor cause**:

  - mTBI has diffuse effects: vestibular, cognitive, psychologic, musculoskeletal….

  - some problems are multimodal:
    *e.g. intolerance to light AND sound*
    *e.g. attentional problems with reading OR conversation*

- 3. weak **theoretical basis**
  - outmoded (1960s) concepts of **'competition'**
    between "**ambient" and "focal" visual processing** (archaic terms)

    *…how would eye movements fit into this concept anyway?*

## 2. ARE EYE MOVEMENTS ABNORMAL AFTER MILD HEAD TRAUMA?

- **nerve palsies** rare (0.3%)

- **convergence** insufficiency in 37%, **accommodation** insufficiency in 40%

- **pursuit** – mixed results:
    - impaired prediction
    - normal but **inconsistent** gain…*(Stubbs et al, 2019; Stuss et al, 2003)*

- **saccades** – basic properties (velocity, latency, amplitude) are intact in mTBI.
  …but patients struggle when the test is made more **complex**:
    - self-paced saccades
    - antisaccades
    - memory-guided saccades
    - saccades with added working memory task

**Conclusion: Pursuit and saccades can be a useful means to reveal cognitive dysfunction, but in themselves are NORMAL.**

*Stubbs et al. Scientific Reports 2019; 9: 921: 1-11.*
*Stuss et al.. Brain 2003; 126, 2363–2380*

How are “impaired saccades” ***inferred*** in neuro-optometric reports?

**KING-DEVICK TEST**

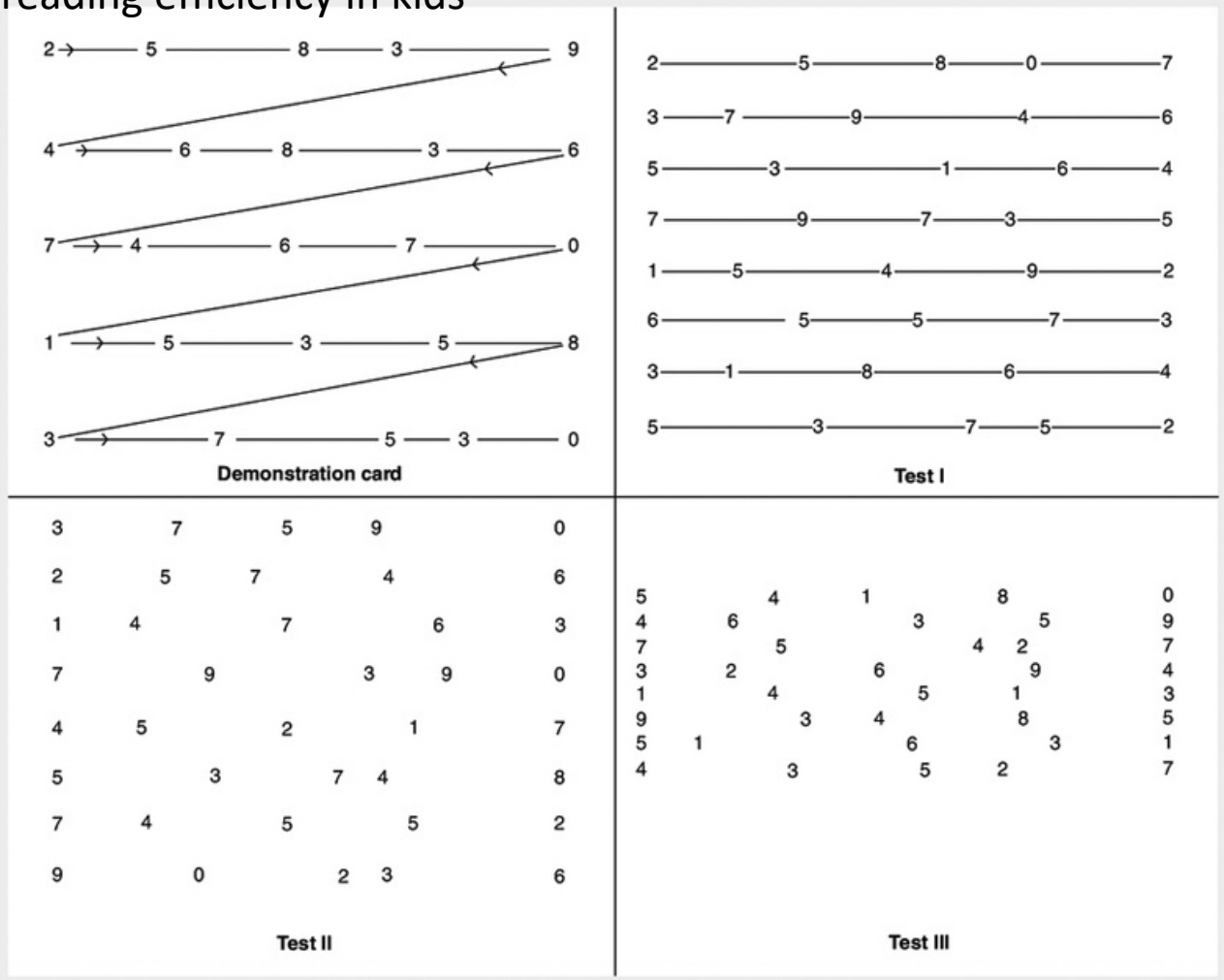
- initially developed as a test of reading efficiency in kids

- promoted as a rapid, cheap, easy sideline screen for concussion

- little data on ***chronic*** post-mTBI state

*“The KD test requires vision, eye movements (saccades, convergence and accommodation), attention and language function.”*

*Fuller et al, 2019*




*Fuller et al. Brit J Sports Med 2019; 53: 1526-1532.*

## 3. CAN EYE MOVEMENT PROBLEMS CAUSE VISUAL SYMPTOMS?

True at a generic level:

- nerve palsies cause binocular **blurred vision** or **diplopia**
- nystagmus and opsoclonus cause **oscillopsia**
- frequent and large square wave jerks can **slow reading** in PSP

How about the mTBI-related eye movement problems?

**CONVERGENCE INSUFFICIENCY:**

- **Specific symptoms**:
  - Blurred or horizontal double vision
  - at near BUT NOT FAR,
  - resolved by covering either eye.

- **Claimed less specific symptoms*:**
  - Near-induced headaches, eye strain
  - Reading problems: moving print
    losing place on a line
    poor concentration
    poor reading comprehension

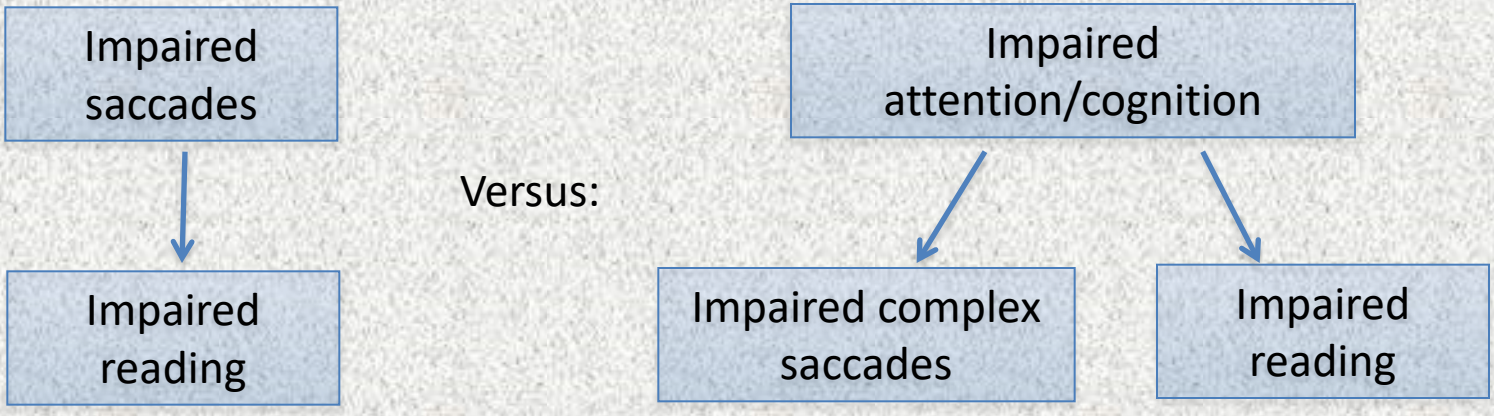
*How can you be sure that less-specific symptoms are due to poor convergence?
- at near BUT NOT FAR
- resolved by covering one eye
(or using prisms, but beware placebo effect!)

**PURSUIT AND SACCADIC ('OCULOMOTOR') DYSFUNCTION:**

• severe pursuit impairments and saccadic dysmetria from cerebellar dsyfunction are asymptomatic.

• mTBI patients with normal pursuit and saccades can complain of headache, nausea and dizziness during eye movement tests (e.g. VOMS screening tool).

• if saccadic impairments correlate/co-occur with visual problems as in reading, this may point, not to a causal relation, but to a common causal factor:



**THE READING COMPLAINTS IN mTBI:**

- Blurry vision or horizontal double vision at near only
  - consider accommodative or convergence insufficiency…maybe dry eyes for blur

or

- Vision is clear but they lose which line they are on, have to re-read material, have trouble remembering what they've read….
  This is "attentional dyslexia"

Anyone who has tried to read boring technical material late at night after a busy day has experienced attentional dyslexia.

This is associated with **regressive saccades, longer fixations, more saccades, inaccurate saccades**, just as reported in a study of mTBI eye movements with the King-Devick test *(Rizzo et al, 2016).*

**Eye movements can reflect attentional dysfunction. They don't cause it.**

## 4. CAN EYE MOVEMENT TRAINING REDUCE VISUAL SYMPTOMS IN mTBI?

### A.CONVERGENCE

- 1 **retrospective** (43 subjects, 80 declined) – "improved in all"

*Gallaway et al, 2017*

- 1 observational prospective, **no controls** (n = 19)

*Conrad et al, 2017*

- 1 prospective with placebo in a cross-over design (n = 12)
  improved measures,
  also reduction in subjective CISS* scores (not stated for placebo group)
  **6 months later, CISS scores relapsed to baseline.**

*Thiagarajan et al, 2013*

### B. ACCOMMODATION

- 1 **retrospective** (**no controls**) had accommodative training but did **not** report its effects.

*Ciuffreda et al, 2008*

- 1 prospective with placebo in a cross-over design (n = 12)
  improved accommodative amplitude, facility, velocity **but not gain.**
  symptoms? …CISS quoted again

*Thiagarajan et al, 2014*

*CISS = convergence insufficiency symptom survey

## C. VERSION (CONJUGATE) EYE MOVEMENTS:

- 1 prospective (treated 18, untreated 32) with **only outcome = VEP**

*Freed & Hellerstein, 1997*

- 1 prospective (9 trauma, 5 stroke) of 6 weeks training – **no controls**

*Ciuffreda et al, 2006*

- 1 retrospective (33 trauma, 7 stroke) – **no controls**

  "success in 90%" = improvement in **≥1 of 9 symptoms, ≥1 of 11 signs**

*Ciuffreda et al, 2008*

- 1 prospective with placebo in a cross-over design (n = 12)

*Thiagarajan et al, 2014a, 2014b; Yadav et al, 2014*

RESULTS…improved:

**stability of fixation** horizontally (but not vertically) ??

mild increase in **saccadic gain** (≈5%)

fewer saccades during 'simulated reading'

**visual attention** *(visual search and attention test)*

**reading speed** from 142 to 177 words per minute….

(BUT…correlated with Δ vergence, accommodation, **attention**,… not Δ saccades)

Sounds good? Let's look into this study further….

## THE 2013/14 CIUFFREDA GROUP STUDY - 5 papers from 1 experiment

*Thiagarajan et al, 2013, 2014a, 2014b, 2014c; Yadav et al, 2014*

- Subjects n = 12, age 23-33 years
- mTBI 1 - 10 years prior

- Cross-over design:
  - **6 WEEKS** with 12 sessions of 45 minutes
  - 6 weeks placebo training

- all subjects did 15 minutes of the same 3 training types in each session, no matter what their symptoms/signs were.
  - vergence
  - accommodation
  - versions: fixations, saccades with 'RSVP' rapid serial visual presentation

What is RSVP?
Count the chickens

## WHAT'S WRONG WITH THE 2013/14 CIUFFREDA GROUP'S STUDIES?

### A) SUBJECT ISSUES

- No **diagnostic criteria** for mTBI… "documented"
- No description of **symptoms/signs**
- Small **n = 12**
- **Randomized** assignment ? .."odd/even"
- **Blinding** of subjects…but not evaluators
- Narrow age range of **23-33 years** (do older subjects have same plasticity?)
- **Medications** not listed (1/5 papers: exclusion criteria "Medications that alter ocular motor function and/or attentional state")
- **Drop out rate of 3/12** in initial study (all from Rx first group), **7/15** in follow-up

### B) DESIGN ISSUES:

- **Cross-over** design - more appropriate if wash-out periods can re-set the baseline.
- **All subjects did all training** regardless of their findings – which aspect of training helped?

### C) STATISTICAL ANALYSIS ISSUES:

- Many t-tests without correcting for **multiple comparisons**.
- Sub-analysis of **separate ANOVAs** for 2 cross-over groups rather than 1 ANOVA.
  This yielded conflicting results sometimes!
- no **symptom/daily function** assessment, apart from CISS

"We considered this evidence to be very low-certainty. We downgraded by two levels because of the study limitations described above, in particular the limitations of a cross-over study design for this intervention, and the lack of data reported from the control (no intervention) group. We downgraded by one level for imprecision due to the small number of participants."

*Rowe FJ, et al. **Cochran**e Database Syst Rev 2018; 3: CD011290*

"No relevant evidence was identified for oculomotor vision treatment, so the panel provided a good clinical practice recommendation based on consensus."

*H Rytter et al, JAMA Network Open 2021; 4: e2132221*

"…a moderate level of evidence that patients have impaired near point of convergence up to several months postconcussion, and a low level of evidence that impairments can be successfully treated with oculomotor therapy. These findings should be cautiously evaluated; the studies are limited by weak/moderate quality, small sample sizes, varied methodology, and nonrandomized treatment groups."

*AL Santo et al, J Sport Rehab 2020; 29: 1179*

Since 2014….

*Småkjaer et al, Neurol Resl 2022: 44: 439*

Prospective trial with no controls, 10 weeks training
N = 27, no mTBI diagnostic criteria, Time since injury not stated
Wilcoxon rank sum tests, uncorrected for multiple comparisons (26!!)

Results:

all 26 subjective measures improved (COPM, MFI-20)!
Objective tests: Reading aloud speed increased
(…but before treatment, mean = 132 wpm, normal = 120-130)
King-Devick test

*Rollett & Morandi, Can J Optom 2019 81: 53*

Retrospective, 'selected', no controls, 6-24 weeks (who, why and how?)
N = 56, no mTBI diagnostic criteria, Time since injury = 2-60 months
simple statistics uncorrected for multiple comparisons

Results:

symptoms not stated, only 1 symptom assessment (CISS score) in results
except for King Devick, all 13 variables = vergence/accommodation-related
claim: 1) everything improved! Everyone improved on >1 measure
2) better results with more sessions

# THE RATIONALE FOR VISION THERAPY IN mTBI

- **Are visual symptoms common after mild head trauma?**

Non-specific visual symptoms are, as are non-visual symptoms like fatigue and headache.
It is NOT proven that these are due to visual dysfunction.

- **Are eye movements abnormal after mild head trauma**?

Convergence and accommodation can be affected.
Pursuit and saccades are normal, but can index cognitive dysfunction in demanding tests.

- **Can eye movement problems affect vision after mild head trauma?**

Convergence problems can cause binocular symptoms at near.
It is unlikely that pursuit or saccadic dysfunction cause symptoms.

- **Can eye-movement training reduce visual symptoms from mild head trauma?**

no evidence for sustained symptomatic benefit from any training
effects on accommodation/convergence are debatable, and short-lived
any effects from saccade/fixation training are likely due to improving attention

*****NO CONTROLLED EVIDENCE FOR >6 WEEKS TRAINING*****

**Going forward,**
**What do we need?**

- prospective randomized study

- adequate sample size,
  diagnostic criteria,
  standard time since injury

- symptom/functional characterization

- baseline: cognition
  co-morbid conditions (pain, depression)
  medications

- control arms - a) natural history;
  b) comparison with cognitive (attention) rehabilitation

- appropriate statistics

- objective AND functionally relevant outcomes

- reassessment 6 months later (do controls catch up? are benefits transient?)

REVIEW

# Vision Therapy: Ocular Motor Training in Mild Traumatic Brain Injury

Jason J. S. Barton, MD, PhD, FRCP(C),[1] and Paul J. Ranalli, MD, FRCP(C)[2]

Vision therapy in the form of ocular motor training is increasingly used to treat visual complaints, particularly in the setting of persistent symptoms after mild traumatic brain injury (mTBI). In this review, we discuss the rationale behind this intervention and the evidence for its utility. Although the efficacy of exercises for primary convergence insufficiency is plausible and supported by data, there is not yet strong evidence of benefit for the post-traumatic variant. It is not established that abnormalities in fixation, pursuit, and saccades in mTBI are the cause of post-concussive symptoms, or that these abnormalities arise from ocular motor damage rather than being secondary effects of cognitive problems with attention or executive control. The few studies to date have significant methodological weaknesses. More substantial evidence is required before vision therapy can be accepted as a useful tool in the rehabilitation of patients with brain trauma.

ANN NEUROL 2020;00:1–9

# WHY DO WE TREAT:

- (Good) evidence-based proof of efficacy? NO
- If insufficient evidence, at least a plausible rationale? NO

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Review

## Vision therapy: Occlusion, prisms, filters, and vestibular exercises for mild traumatic brain injury

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REVIEW

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ANN NEUROL 2020;00:1–9

COMMENTARY

## Consensus Statement on Visual Rehabilitation in Mild Traumatic Brain Injury

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