Clinical Use of Visual Evoked Potentials (VEP) in Patients with Neurological Conditions

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Has a no relevant financial relationships to disclose

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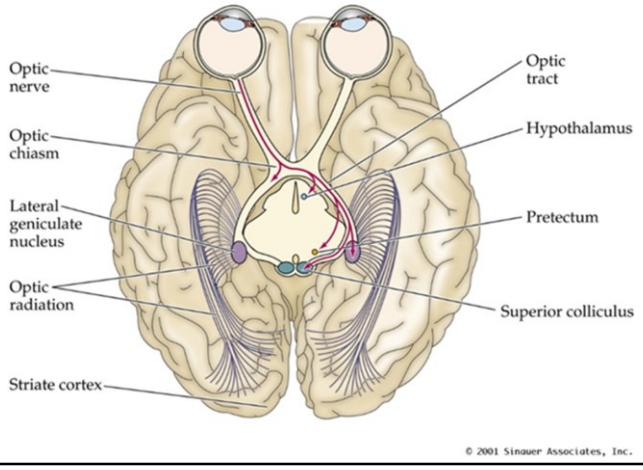
Outline

- **Overview:** Visual Evoked Potential (VEP)
- **Overview:** Traumatic Brain Injury (TBI)
- **Clinical research studies on VEP in mTBI**
  - Optimized VEP parameters
  - Effect of binasal occlusion (BNO) on VEP in mTBI
  - Effect of oculomotor visual rehabilitation on VEP parameters
- **Clinical implications**
- **A Case report: Patient with multiple sclerosis (MS)**
- **Summary**
- **Points to remember**
- **Future directions**

Visual Evoked Potentials (VEP)

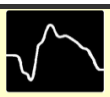
- *VEP refers to an electrical signal generated over the primary visual cortex (V1) in response to a time-locked visual stimulus.*
- *Objective, rapid, repeatable, and non-invasive method to assess functionality and integrity of the retinal and early-afferent, visuo-cortical pathways (Odom et al. 2010; Yadav et al. 2012).*
- *This technique has proven to be beneficial for special populations (e.g., infants and young children, non-verbal patients, cognitively-impaired patients) (Ludlam et al. 1970; Odom et al. 2010), as well as in acquired brain injury (Padula et. 1994; Yadav et al. 2013; Yadav et al. 2014).*

Visual Pathway



Types of VEP

- **Pattern VEP (pVEP)**
- **Flash VEP**
- **Steady state sweep VEP**



INTERNATIONAL SOCIETY FOR CLINICAL ELECTRO-PHYSIOLOGY OF VISION

Western University OF HEALTH SCIENCES

- Mission

The objectives of the society are:

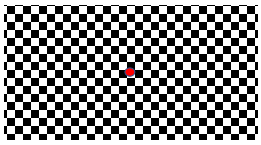
- to promote and extend the knowledge of clinical electrophysiology of vision
- to promote co-operation and communication among workers in the field of clinical and basic electrophysiology of vision.

https://iscev.wildapricot.org/

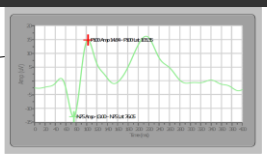
VEP Apparatus

The DIOPSYS™ NOVA-TR VEP system (Diopsys, Inc., Pine Brook, New Jersey, USA)

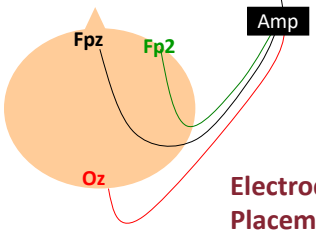
VEP Clinical Set-Up



Stimulus



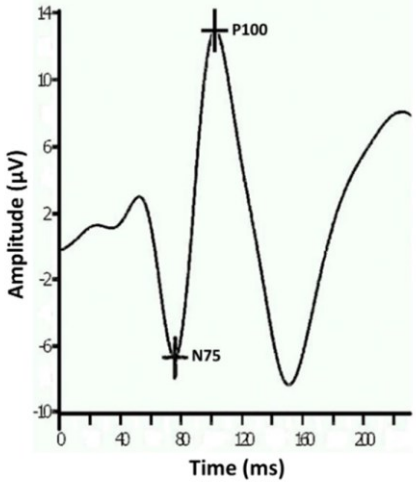
VEP Waveform



Electrode Placement

VEP Parameters

- The pattern VEP has two response components, one is the N75, and the other is the P100 .
- The N75 reflects the negative peak occurring approximately 75 msec after stimulus onset, whereas the P100 reflects the positive peak occurring approximately 100 msec after stimulus onset.
- ***The N75-P100 (peak-to-trough) difference represents the VEP amplitude.***
- ***The VEP latency is defined "as the time from the stimulus onset to the largest amplitude of a positive (P100) and/or negative peak (N75)" (Odom et al., 2010).***



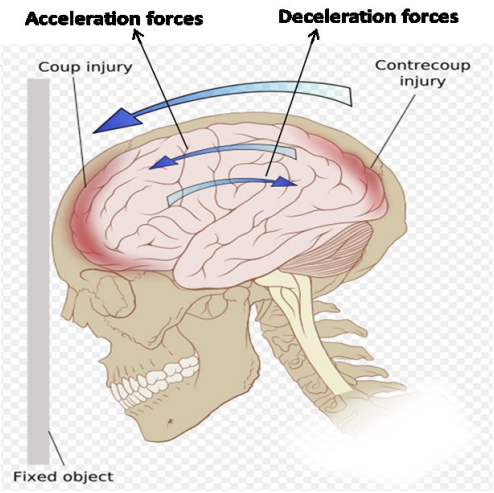
Traumatic Brain Injury (TBI)

- Major medical, economic, and public health problem in the USA
- 1.7 million people suffer from a TBI every year
- MVA, assaults, falls
- Iraq/Afghanistan wars (D. Warden, 2006)
- Sports-based concussion (Abrahams et al. 2013; Giza et al. 2013)
- Centers for Disease Control and Prevention (CDC) defined ***"TBI as an event involving an injury to the head (brain) due to blunt or penetrating trauma"*** (Marr and Coronado, 2002).
- Mild, moderate, and severe categories of TBI
- ***Mild TBI (mTBI) – 70-80%, most common and thus most research has focused on it*** (Kraus and Nourjah, 1998)

Traumatic Brain Injury: Two Phases

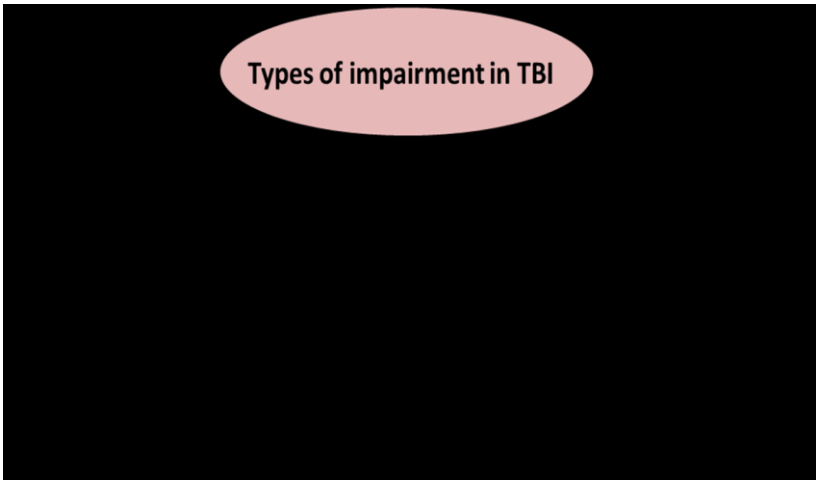
- ***Primary injury*** **-** mechanically-based, coup-contrecoup event within the cranium, which involves rapid and powerful acceleration, deceleration, and rotational forces – causes diffuse axonal injury (immediate effect)

- ***Secondary injury*** **-** biomolecular/biochemical changes (delayed effect; days to weeks later)



(Image taken from: https://en.wikipedia.org/wiki/Coup_contrecoup_injury)

Traumatic Brain Injury: General Deficits



Mild Traumatic Brain Injury (mTBI): Visual Deficits

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Some common visual deficits:

- *Oculomotor problems (40-90%)*
- *Visual-field defects (40%)*
- ***Increased and abnormal visual motion hypersensitivity (VMS) (estimated 30-40%)***
- *Visual/general attentional deficits (50-60%)*

Clinical Research Studies in mTBI

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Optimization of the pattern visual evoked potential (VEP) in the visually-normal and mild traumatic brain injury (mTBI) populations

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Purpose

- ***The purpose of this study was to assess the effect of 3 different check sizes (10, 20, and 40 min arc) at 2 contrast levels (20% and 85%) on the VEP amplitude and latency in visually-normals, as well as in individuals with mTBI.***
- ***The goal was to optimize these VEP test parameters in the visually-normal and mTBI populations.***
- The hypothesis is that specific stimulus parameters will *optimize* the VEP response in each population.
- In the mTBI population, an objective was to improve their diagnostic capability and use for assessment of therapeutic efficacy in future studies.
- ***To develop a VEP protocol which is rapid, high yield, and targeted for mTBI patients.***

Methods

Subjects

- 19 visually-normal adults (mean age 26 years, 12 females and 8 males)
- 16 mTBI (mean age 27 years, 9 females and 7 males, 6 months-10 years post insult), thus past natural recovery, period of 6-9 months
- Best corrected visual acuity of 20/20 at distance and near in each eye

Stimulus

- ***6 test conditions: (3 check sizes X 2 contrasts) - 10, 20, and 40 min arc X 20% and 85% contrast levels***
- 74 cd/m^2 luminance, 1 Hz temporal frequency, 1 m test distance, 17 H X15 V deg. test field
- Small central fixation target (0.5˚ diameter)
- 5 trials (each 20 seconds) per test condition: one outlier was removed, and the average of 4 trials was used for analysis
- Binocular viewing with refractive correction

Conclusions

- ***In both groups, the 20 min arc check size at both low and high contrast levels provided the largest VEP amplitude, along with normal latency values.***
- ***Therefore, the 20 min arc check size at both contrast levels represents an optimal VEP test parameter***
- ***This conveniently provides for a common targeted protocol, which thus makes clinical VEP testing simplified in these two populations.***
- ***These optimized parameters were used to assess VEP responsivity in the subsequent studies.***

Clinical Research Studies in mTBI

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Effect of binasal occlusion (BNO) and base-in prisms on the visual-evoked potential (VEP) in mild traumatic brain injury (mTBI)

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Visual Motion Sensitivity (VMS)

- One of the most common and debilitating, yet poorly understood, visual sequelae of mTBI is increased "visual motion sensitivity" (VMS).
- VMS patients may report:
  - nausea
  - vertigo
  - unsteadiness
  - balance difficulties
  - disorientation
  - sense of visual confusion/chaos
  - "supermarket syndrome"
  - provoked by OKN drum or by repetitive midline vergence testing

Visual Motion Sensitivity (VMS)

Three techniques have been used to reduce VMS symptoms in patients with TBI:

1. **Binasal occlusion (BNO) technique**

2. **Spectacle lens tints (neutral gray, reddish blue):** reduces luminous intensity of the bothering peripheral stimulus

3. **Desensitization maneuvers:** hand motion, Optokinetic (OKN) drum

Dr. Ciuffreda's youtube video link:

https://www.youtube.com/watch?v=j4-1_y2BWcA&feature=youtu.be

Binasal Occlusion (BNO) spectacles

- (BNO) has been used clinically to reduce the intensity of the symptomatic increased VMS, in particular for mild traumatic brain injury (mTBI) patients.
- BNO can be accomplished by using strips of translucent scotch tape, transparent nail polish, and/or opaque electrical tape, placed either on the front or the back surface of the spectacle lenses, placed nasal to the pupillary-limbal margin.
- The BNO can be oriented either vertically, or tilted 15˚ superiorly-temporalward to allow for convergence at near to be unobstructed.
- The occluders block a region of visual space in the near retinal periphery contralateral to the occluder eye placement.

Purpose

- The purpose of the present study was to assess quantitatively the effect, and relative contribution, of binasal occlusion (BNO) and base-in prisms (BI) on visually-evoked potential (VEP) responsivity in those having mild traumatic brain injury (mTBI) and the symptom of visual motion sensitivity (VMS), as well as in visually-normal (VN) individuals for comparison.

Methods

Subjects

- 20 visually-normal adults (mean age 25.5 years, 14 females and 6 males)
- 15 mTBI (mean age 35.2 years, 11 females and 4 males, 1-27 years post insult, past natural recovery period of 6-9 months)
- mTBI with increased VMS
- Best corrected visual acuity of 20/20 at distance and near in each eye

Stimulus

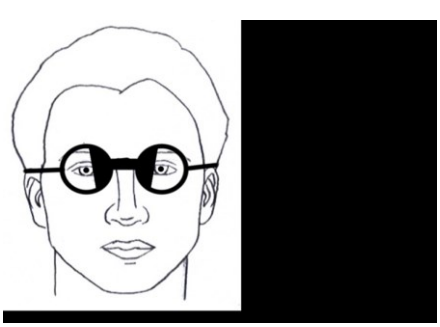
- Checkerboard test pattern (20 min arc), 17H X 15V degrees test field
- 85% contrast, 74 cd/m^2 luminance, and 1 Hz temporal frequency alternation
- 20 second stimulus duration
- Small central fixation target (0.5˚ diameter)

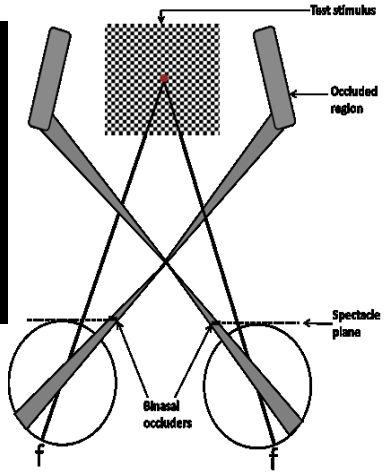
Methods

Test Conditions

- The central field VEP amplitude and latency were assessed binocularly with refractive correction under the following four experimental conditions in both groups:
  - **Condition 1:** Baseline VEP (comparative condition/normalcy)
  - **Condition 2:** VEP with binasal occlusion (BNO) alone
  - **Condition 3:** VEP with 2 pd base-in (BI) prisms each eye (total 4 pd BI prisms)
  - **Condition 4:** VEP with the combination of BNO and BI prisms
- Last three conditions were counterbalanced to prevent order effects.
- Five trials per test condition were conducted, one outlier was removed, and average of 4 trials was used for analysis.

Test conditions with BNO



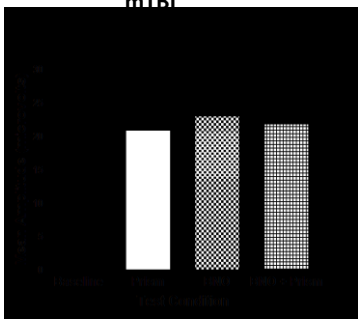


- A 5.7° H x 15 ° V region of space 5.5 ° lateral to the edge of the test stimulus on either side was blocked by the binasal occluders

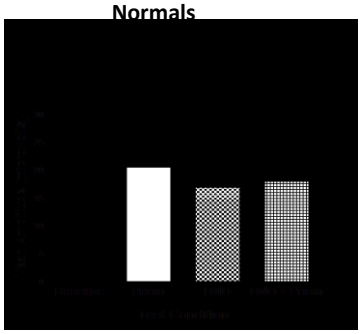
Results

Group mean VEP amplitude

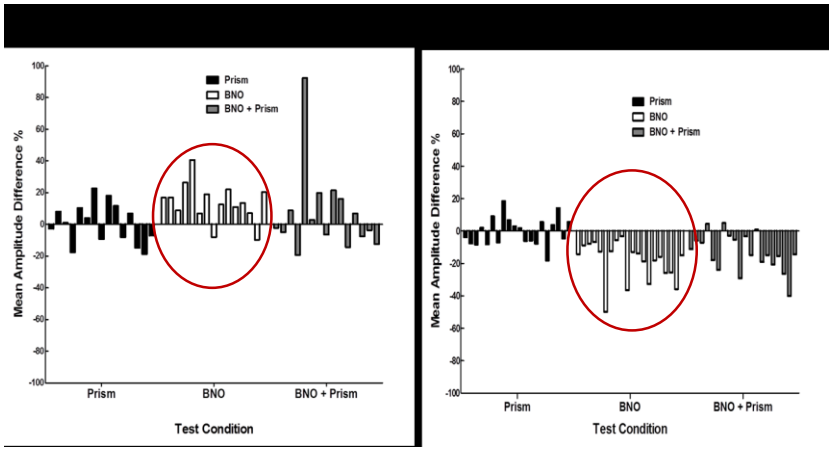
mTBI



Normals



- ***In both groups, only the BNO condition demonstrated significant, but opposite, directional effects with respect to the baseline and BI prism conditions.***
- ***In both groups, the mean latency increased by no greater than 2 ms, but it was within normal limits, for all 3 test conditions, as compared to their respective baseline.***


Prism
BNO
BNO + Prism
Mean Amplitude Difference %
100
80
60
40
20
0
-20
-40
-60
-80
-100
Prism
BNO
BNO + Prism
Test Condition
Prism
BNO
BNO + Prism
Mean Amplitude Difference %
100
80
60
40
20
0
-20
-40
-60
-80
-100
Prism
BNO
BNO + Prism
Test Condition

Subjective Responses

Table V. Perceptually-based, subjective responses for the walking task in the mTBI group.

Persons with mTBI ($n = 15$)	Subjective responses
11	Most comfortable and most stable walking with the BNO alone
2	Most comfortable and most stable, as well as confident, walking with the BNO alone
1	Most comfortable, most stable, brain feels 'relaxed', reduced attention to peripheral motion/noise, can 'control' surrounding visual information to prevent a sensory overload
2	Uncomfortable walking either with BNO or BNO + Prism, BNO blocked their field-of-view, provided a sense of visual discomfort and annoyance

Conclusions

- ***With BNO only, individuals with mTBI and VMS demonstrated significant, consistent, and repeatable increases in VEP amplitude, as compared to other test conditions.***
- ***With BNO only, the VEP objective findings were consistent with improvements in their subjective visual perception and performance in sensorimotor tasks.***
- ***The BNO-VEP test can now be used clinically in the objectively-based, differential diagnosis of suspected individuals with mTBI and VMS from visually-normal individuals, with a very high degree of probability (>90%).***

Clinical Research Studies in mTBI

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Effect of oculomotor vision rehabilitation on the visual-evoked potential and visual attention in mild traumatic brain injury

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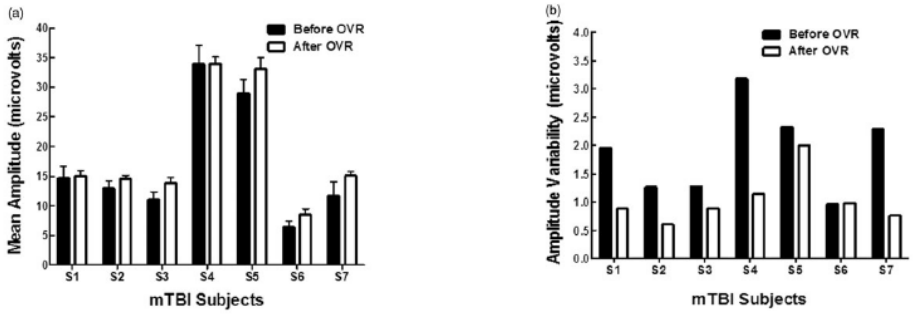
Department of Biological and Vision Sciences, SUNY State College of Optometry, New York City, NY, USA

Purpose and Methods

- ***The purpose of the present study was to investigate the effect of OVR on VEP responsivity in the mTBI population.***
- Seven individuals with mTBI (mean age = 29.5 years), time injury ranged from 1-6 years
- ***Training of 3 oculomotor systems: version, vergence, and accommodation (9 hours total)***
- OVR training was performed twice a week for 6 weeks for a total of 9 hours, 3 hours for each oculomotor system

Results



After successful vision rehabilitation, VEP amplitude significantly increased and its variability significantly decreased; latency was constant and normal

Conclusions

- ***The significant changes in VEP responsivity suggest that oculomotor vision rehabilitation positively affects the visual system at early visuo-cortical levels (e.g., V1).***

- ***Considerable visual system neuroplasticity even in the older, damaged brain***

Clinical Implications

- ***The optimized VEP protocol is rapid, high yield, and targeted for mTBI population, and this could be used to assess various types of visual dysfunctions in patients with mTBI such as abnormal VMS.***
- ***BNO-VEP test condition provided an objective, non-invasive, rapid and direct response from the primary visual cortex (V1) for the diagnosis of mTBI/concussion. Thus, this test has the potential to be used as an objective, visual system biomarker for the diagnosis of mTBI/concussion.***
- ***The VEP optimized protocols could also be used to assess the progression of visual-rehabilitation provided to these patients with mTBI.***

A Case report: Patient with Multiple Sclerosis (MS)

- ***"Multiple sclerosis (MS) is an unpredictable disease of the central nervous system that disrupts the flow of information within the brain, and between the brain and body".***
- National MS Society study estimate nearly 1 million people in the United States are living with MS.
- The society also estimates that 2.3 million people live with MS globally.
- ***MS causes vision loss, pain, fatigue, and impaired coordination.***
- It adversely affect their activities of daily living's (ADL's).
- ***Visual evoked potential (VEP) clinical technique could be used to diagnose and to assess the progression of this condition.***

Purpose

- ***This is a case presentation of multiple sclerosis (MS) in a 35-year-old white female with visual disturbances in absence of active optic neuritis or reduced visual acuity.***

- ***The enhancing effect of tinted lenses on symptomatology and visuo-cortical responses are presented as a novel approach to cases of symptomatic patients with multiple sclerosis during remission periods.***

Case Report

- A 35-year-old-white female with relapsing-remitting multiple sclerosis (RRMS) and previous bouts of optic neuritis presented with mild vision blur of both eyes and ***constant dizziness exacerbated with peripheral visual motion.***

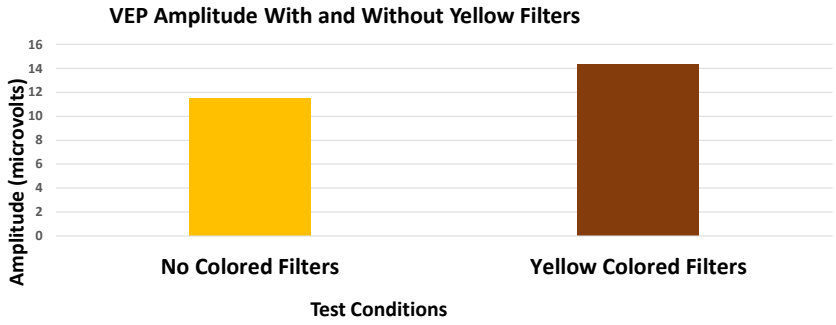
Clinical examination:

- Best Corrected Visual Acuity: **OD-20/20; OS-20/20; OU-20/20**
- Randot Circles Local stereopsis: **100 sec arc**
- Randot Circles Global Stereopsis: **250 sec arc**
- There were no signs of optic neuritis.
- Color vision were unremarkable.

VEP Parameters

- The DIOPSYS NOVA-TR VEP system was used (15V x 17H deg., black-and-white checkerboard stimulus, 1Hz alternation).
- The following standard clinical pattern VEP parameters were used: ***check size 20 min arc, contrast 85% , test duration 20 seconds, and 74 cd/m^2***.
- ***Standard clinical pattern VEP testing was performed with and without yellow colored filters (transmittance = 80%) binocularly.***
- Two trials per condition were performed and averaged.

Results



- ***With yellow colored filters, an enhanced objective visuo-cortical response (~3 µV) was correlated with the patient's subjective visual impression.***
- ***Yellow colored filters seem to be helpful in patients with MS.***

Clinical Implications

- ***Eye care providers could consider using this novel approach of using colored filters in patients with MS presenting with visual disturbances such as, constant dizziness exacerbated with peripheral visual motion during remission. during remission.***
- ***In addition, clinical VEP testing could be used as an objective technique to assess the effect of colored filters at the visuo-cortical level.***
- ***This approach will be helpful for the clinicians in prescribing colored filters with confidence in patients with MS.***

Important Points to Remember

- ***No VEP in patient's with a history of seizure***
- ***Proper electrode placements***
- ***Quite and dark room***
- ***Analysis of VEP report, correlate with symptoms and other clinical findings***
- ***Baseline VEP in clinical patients, mainly in cooperative young children***

Future Directions

- **Repeat similar studies in younger children with mTBI**
- **Repeat BNO studies in patients with vestibular issues**
- **Perform color filters studies in different neurological disease condition population, such as mTBI, MS etc.**

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- Dr. Ciuffreda's Brain Injury Research Laboratory members


Thank you.


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