Visual Aspects of TBI

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#UUPMR14
Disclosures

- ... etc.
Twitter Account
Here’s my Jersey!

#UUPMR14
What everyone thinks of Eye Doctors...

I'm going to puff some air at your eyeball on the count of 3, okay?
Primary care Optometrists

- Get you to see great
  - Contacts
  - glasses
- Check health of eyes
- Diagnose and treat ocular pathology
- Screen and treat binocular issues when patient seems symptomatic or has specific complaint.
Cortical visual processing system has two divisions

- **Anterior components**
  - Focus the image
  - Capture the image
  - Send the image for processing

- **Posterior components**
  - Refine and enhance the image
  - Process the image for adaptation: Localization, and identification
Dysfunction in the AVS disrupts acuity

- Primary role of acuity is to provide object detection and identification
- Requires a dynamic, flexible, well-coordinated anterior visual system
  - Deal with a vast array of ever changing objects
  - Objects constantly change in relationship as we or they move in space
To detect and identify, anterior system must...

- Keep images in focus
- Maintain focus over a range of focal distances
- Keep retina appropriately illuminated with light
- Be able to identify and discriminate between colors
- Discriminate contrast
- Use the eyes together to track and establish stereopsis
Ocular Alignment is the Key to Sensory Fusion

- Eyes must work in unison to achieve fusion
- Although each EOM muscle is capable of independent action, the cardinal rule governing these muscles is that no muscle works alone
  - All eye muscles work synergistically in the same eye and between the eyes
    - Nerve impulses to perform an eye movement are sent to both eyes simultaneously
    - Muscles in each eye receive equal innervation to contract or relax—cannot move one eye independently of the other
Law of Sensory Correspondence

- If eyes are properly aligned, image is focused on corresponding retinal points in the two foveas.
- Corresponding retinal points are receptor cells that capture the same information.
  - AKA- they will take the same picture.
Brock String
Physiological Diplopia

- Framing exercise
Phoria vs. Tropia
Cover Test

How does TBI affect this process???
Maddox Rod
## Dominic Maino O.D.
### Signs and Symptoms of TBI

<table>
<thead>
<tr>
<th>Visual attention</th>
<th>Medical</th>
<th>Pathological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall asleep reading</td>
<td>Headache</td>
<td>Poor Concentration</td>
</tr>
<tr>
<td>Fatigue after reading</td>
<td>Glare Sensitivity</td>
<td>Distractability</td>
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<tr>
<td>Avoids reading</td>
<td>Photophobia/Light Sensitivity</td>
<td>Depression</td>
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<tr>
<td>Poor depth perception</td>
<td></td>
<td>Poor Retention</td>
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<tr>
<td>Near blur</td>
<td></td>
<td>Poor Short term memory</td>
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<tr>
<td>Loose place reading</td>
<td></td>
<td></td>
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<tr>
<td>Fusional vergence</td>
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<tr>
<td>Re-reads often</td>
<td></td>
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<tr>
<td>Misplaces objects</td>
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<tr>
<td>Unaware of cars/pedestrians</td>
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<td>#UUPMR14</td>
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</tbody>
</table>
Goodrich, G et al.- 2007

- 50 patients admitted to Polytrauma Rehab Center (PRC) from December 2004 to November 2006
- Mean age of subjects 28.1 years
- All subjects had experienced a TBI
- Blast injuries accounted for half of all injuries

## Results

<table>
<thead>
<tr>
<th>Problem</th>
<th>All Subjects (n=46)</th>
<th>Blast (n=21)</th>
<th>NonBlast (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convergence Insufficiency</td>
<td>30%</td>
<td>24%</td>
<td>36%</td>
</tr>
<tr>
<td>Accommodative Dysfunction</td>
<td>22%</td>
<td>24%</td>
<td>20%</td>
</tr>
<tr>
<td>Pursuit/Saccade Dysfunction</td>
<td>20%</td>
<td>5%</td>
<td>32%</td>
</tr>
<tr>
<td>Visual Field Defects</td>
<td>21% (100 Eyes)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Brahm, et al. - 2009

- Frequency of visual impairment in combat-injured service members with TBI
  - Polytrauma Rehab Center (PRC) inpatient (n=68)
  - Polytrauma Network Site (PNS) outpatient (n=124)
- Mean age: 28 years old
  - 84% of PRC patients: TBI associated with blast event
  - 90% of PNS patients: TBI associated with blast event

Brahm et al.

- Convergence insufficiency (CI): 42%
- Accommodative Insufficiency: 42%
- Pursuit/Saccadic Dysfunction: 33%
- Visual Field Defects: 32%
- Bilateral poor visual acuity: 4%
Mitchell Scheiman O.D.

- 21point TBI Questionnaire
  - Jen Thomas
TBI Prevalence of Vision Problems

- 160 records of patient with TBI reviewed
  - 90% had either one of three problems
    - Binocular Vision Disorder
    - Accommodation insufficiency
    - Ocular Eye Muscle dysfunction

Ciuffreda Kapoor Rutner et al. Optometry 2007;78:155-61
TBI

- Accommodative Insufficiency: 41.1%
- Convergence insufficiency: 56.3%
- Strabismus: 25.6%
- Cranial Nerve Palsy: 10%
Hemianopsia

1. Total blindness of right eye due to complete lesion of right optic nerve
2. Bipolar hemianopsia due to midline chiasmal lesion
3. Right nasal hemianopsia due to lesion involving right perichiasmal area
4. Left homonymous hemianopsia due to lesion or pressure on right optic tract
5. Left homonymous inferior quadrantanopia due to involvement of lower right optic radiations
6. Left homonymous superior quadrantanopia due to involvement of upper right optic radiations
7. Left homonymous hemianopsia due to lesion of right occipital lobe
Midline shift syndrome

- Prism Adaptation demonstration.
Vision Therapy

- Vectogram
Photophobia

- Associated with acute uveitis
- Common in retinal dystrophies
- Can occur following meningitis
- A major symptom in some brain tumors
- More common in patients with migraine
- Common after TBI (59% report it)
- Psychogenic component?
A neural mechanism for exacerbation of headache by light

Rodrigo Noseda¹, Vanessa Kainz¹, Moshe Jakubowski¹, Joshua J Gooley², Clifford B Saper²,³, Kathleen Digre⁴ & Rami Burstein¹,³

The perception of migraine headache, which is mediated by nociceptive signals transmitted from the cranial dura mater to the brain, is uniquely exacerbated by exposure to light. We found that exacerbation of migraine headache by light is prevalent among blind individuals who maintain non–image-forming photoregulation in the face of massive rod/cone degeneration. Using single-unit recording and neural tract tracing in the rat, we identified dura-sensitive neurons in the posterior thalamus whose activity was distinctly modulated by light and whose axons projected extensively across layers I–V of somatosensory, visual and associative cortices. The cell bodies and dendrites of such dura/light-sensitive neurons were apposed by axons originating from retinal ganglion cells (RGCs), predominantly from intrinsically photosensitive RGCs, the principle conduit of non–image-forming photoregulation. We propose that photoregulation of migraine headache is exerted by a non–image-forming retinal pathway that modulates the activity of dura-sensitive thalamocortical neurons.

CGRP, Migraine and Photosensitivity

- Calcitonin Gene-Related Peptide (CGRP) modulates trigeminal activity in the eye and brain
- CGRP levels reported elevated in migraine
- Injection of CGRP induces headache and photophobia
  - CGRP receptor antagonist
Light induced Trigeminal Sensitization Without Central Visual Pathways

- Light can modify trigeminal activity without involving the central visual system
MRI

- Activation of the Trigeminal Nociceptive pathway
- Pre and post Sensitivity episode
Randy Kardon MD PhD

- Red light pain vs. Blue light pain
- **Photosensitivity Hypothesis**
- Abnormal sensitivity of the trigeminal nerve and its recipient sensory brainstem nucleus
- A trigeminal brainstem reflex mediated by light would be exaggerated in photosensitivity
Methods

15 normal subjects and 12 patients with photosensitivity were tested using red (640nm) and blue (485nm) Ganzfeld light, one second in duration over a 6 log unit range of intensity (0.5 log unit steps).

Time-stamped, computerized recording of the pupil, orbicularis and procerus muscle EMG, skin conductance and heart rate were measured simultaneously.
Brightness and Discomfort Perceived
(percent normalized to 1 second brightest blue light)

Log Stimulus Light Intensity

Control Subjects (Average of All)

TBI Patients (n=4)

Brightness and Discomfort Perceived
(percent normalized to 1 second brightest blue light)

Log Stimulus Light Intensity
Contact Lens: Artificial pupil

During a week before the APCL fitting

During a week after wearing the APCLs for 2-5 weeks

Symptom rating

#UUPMR14
Photophobia and Light-Induced Headache: Novel Long-Term Effects of Pilocarpine
Tints

- Blue Blockers
- FL41
- Really Dark
Conclusions

Physiological evidence is provided in humans that photic-EMG responses are exaggerated in photosensitive patients.

The photic-blink reflex may be mediated by melanopsin containing retinal ganglion cells (MCGs).

MGCs likely provide input to the trigeminal sensory nucleus, which stimulates the facial nucleus, as evidenced by EMG responses of orbicularis and procerus muscles.

CGRP may mediate excessive trigeminal sensory activation.

Treatment Options: CGRP antagonists, blue blocking lenses, occlusive contact lenses, pilocarpine.