Optometric Insights and Therapeutic Interventions for CVI
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Disclosure Statement:
• Nothing to disclose

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Causes of Blindness in Children
- Cortical Visual Impairment (18%)
- Retinopathy of Prematurity (15%)
- Optic Nerve Hypoplasia (14%)
- Congenital Anomalies (microphthalmos, coloboma, 6%)
- Leukocoria-cataract, persistent hyperplastic primary vitreous, or retinoblastoma
- Others

Definitions
- Cortical Visual Impairment
  - Original term, primarily looked at acuity issues
- Cerebral Visual Impairment
  - Europeans typically use this vs. Cortical
- Neurological Visual Impairment
  - My preference, some east coast children’s hospitals

Important Considerations of CVI
- Timing of brain insult – inutero/postnatal
- Stage of brain development
- Location of insult
- Severity – diffuse vs. localized
- Duration of insult
- Previous treatment

Common Causes of CVI
- Asphyxia
- Hypoxia
- Ischemia
- Developmental Brain Defects
- Hydrocephalus
- Head Injury
- Stroke
- Infections – meningitis, encephalitis

Visual Considerations – Performance
- Visual Motor Disturbances
  - Moving the eyes to direct visual attention to the target
  - Dorsal pathway
- Visual Spatial Disturbances
  - Localization of objects, judgment of direction and distance of objects, orienting body to world
  - Dorsal pathway
- Visual Perceptual Disturbances (info processing)
  - Discrimination, recognition and integration of images
  - Ventral pathway, Visual cognitive issues with good VA?
“Eyes don’t tell people what to see, people tell eyes what to look for.”
Lawrence MacDonald, OD

Three Visual Networks – beyond VA

- **Dorsal Pathway**
  - Primary visual cortex, posterior parietal lobe-beyond
  - Visual spatial abilities, input from a crowded visual scene with visually guided movement

- **Mirror Pathway (dorsal?)**
  - F5 area of premotor cortex-in observer and actor
  - Allows infants to understand and anticipate actions long before they can move their limbs sufficiently well

- **Ventral Pathway**
  - Lower temporal and inferior temporal
  - Visual Recognition – Often chief concern in CVI

Other Important Neural Networks

- **Peri-personal and Extra-personal Space**

- **Ambient-Peripheral Pathway (magno)**
  - Brainstem mediated, localization, quick acting

- **Focal-Central Pathway (parvo)**
  - Cortically mediated, higher cognitive, slower acting

- **Interhemispheric Processing**
  - R/L processing, gaze palsy
  - Example of reading, numerosity

- **Others**

On the Visual Development Side

- The visual world of an infant is generally considered as inward and developing outward over time. (Distance to mom’s face and breast)
- Prescribe from findings at one distance or multiple distances? Full prescription or partial?
- Example – At 20 inches (autorefractors) you may see 4 diopters hyperopia, move into 12-14 inches and see +.75 lag. This is the experiential world of an infant. We should be careful of overprescribing plus at near as it may lock the patient inward.
Right and Left Hemisphere Processing

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<tr>
<th>RIGHT</th>
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<tr>
<td>□ Spatial</td>
<td>□ Language</td>
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<td>□ Big Picture / Whole</td>
<td>□ Details / Part</td>
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<td>□ Simultaneous</td>
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Specialization and Cooperation is KEY !!!

Simultaneous and/or Sequential?

*Difficulty in Dual Tasking

Testing and Evaluation

- Observations and Case History
- Visual Acuity, Refraction
- Visual Fields, Pupils
- Visual Acquisition Skills
  - Eye Movements, Accommodation, Binocularity
- Visual Information Processing Skills
  - Visual memory, figure/ground, closure, etc.
- Anterior/Posterior Segment Health
- Visually Evoked Potential

Eye Movement Considerations

- Fixation
- Optokinetic Nystagmus/Motion Processing
- Pursuits – smooth tracking
- Saccades – jumps to targets
- Vergence
- EOM Conditions- nystagmus, range of movement, gaze palsy, etc.

Visual Considerations – Basic VF

- Hemianopia/Quadrantopia
- Visual Neglect/USI – 20% minification in affected field, does this also occur in CVI ?
- Field evaluation should thus include size, motion and spatial aspects (including peri and extrapersonal space)

USI – Allocation of Attention
Overlapping Diagnostic Entities

- Delayed Visual Maturation
- Autism Spectrum
- Severe bilateral central scotoma
- Dyskinetic Eye Movement Disorders
- Profound Mental Retardation
- Amblyopia ? Aniso vs. Isometric

Delayed Visual Maturation – F/G ?

Visual Characteristics of CVI

- Variable level of vision loss, fluctuations based on environment, fatigue, arousal, etc.
- Poor sustained attention to visual stimuli, especially complex stimuli
- Delay in response to visual stimuli
- Improved visual function in familiar settings and with familiar objects

Visual Characteristics of CVI

- Preference for looking at lights versus objects
- Preference for viewing objects at close range and odd angles
- Better vision with moving vs. static objects
- WHAT DO THESE SUGGEST ?
- Purely visual acuity issues and/or considerations of visual performance ?

Common Interventions - Compensatory

- Large, high contrast, lighted, reflective, moving targets
- Touch or sound added to object
- Simple vs. complex presentations, but avoid overstimulation
- Bring in from different angles, views
- Target and environmental lighting
- Extra time and patience by observer

Optometric Interventions

- Visual Guidance – based on needs
- Lenses – multiple possible benefits
- Prism – yoked, Peli for hemianopsia
- Selective Occlusion – improves VEP ?
- Vision Therapy/Rehabilitation

“Spatial perceptions are by no means purely visual but are rather visual-muscular-labyrinthine.”

- Sherrington
Visual Guidance – beyond typical

- Compensatory strategies noted earlier, but what else might one try?
- Move objects from peri- to extrapersonal space (z-axis), include multi-sensory inputs
- Modify figure/ground relationships to improve contrast and attentional components
- Brimmed hat to reduce stimuli, side shields
- Infant/Toddler massage, Vestibular input
- Others

Vestibular Input – A Missing Piece?

- Linear Stimulation
  - Calming, 15 minutes = 8 hours of serotonin release
- Rotational Stimulation
  - Increased Arousal, Extensor tone increased-posture
  - Better foundational basis to begin localization?
- Clinical Applications
  - Testing-the upset child
  - Treatment-facilitates interaction and arousal, and can also be helpful in eye movement dysfunctions

Massage and Visual Function

- Demonstrates the importance of massage to accelerate the maturation of electroencephalographic (EEG) activity and of visual function, in particular visual acuity. OT’s often use deep touch!

Value of Lens Application

- Refractive – typically the main use…but
- Accommodative – low in amblyopes, others
- Spatial – size and distance perception
  - Move spatial aspects inward/outward?
- Increases Peripheral Awareness/Motion
- Modifies VOR gain – effects upon a clear image with head movement and also increased arousal

Yoked Prisms

- Effects of shifting of space, and of rotation which results in emphasizing or deemphasizing visual space. This results in changes in relationships of figure ground in the environment
- Treatment of Visual Neglect/Unilateral Spatial Inattention (USI)
- Dynamic changes in VOR gain. Arousal? Extensor tone? (Watch for toe walkers, head upright)
- Modify the Nullpoint for Nystagmus
- Effects upon Postural Control, Mobility - Padula

What is Abnormal Egocentric Localization?

From Suchoff, Chaffredo, et al.-2001
Karnath – Phil Trans Royal Soc 1997

20% Horiz. Minification in Neglected Field

Neglected Field
Non-Neglected Field

Prism Base – Optical Field Distortion

Prism in Left USI – 2 Applications

- Directional and Expansion/Compression
- Compensatory – Direct Effect – Base R
  - Visually shift egocenter to midline – Karnath
- Therapeutic – Indirect – Base L
  - Creates mismatch, patient resets egocentric localization with visual, motor, vestibular - Rosetti

Rossetti 1989 study on yoked prism

Modifying postural adaptation following CVA through prismatic shift of visuo-spatial egocenter

**PELI Prism, Field Expansion Prism**

- With loss of visual field in hemianopsia, a prism can provide access to the non-seen visual field without scanning.
- Can show improved visual field over time, if you discontinue prism, the loss may return.
- Can show changes in postural control and mobility.

**L Hemianopsia, 6 weeks with PELI**

**VEP Without and With Binasal**

**Binusal Effects with mTBI**

- TBI demonstrate reduced amplitude VEP's.
- The use of binasal is believed to decrease the aberrant motion sensitivity, thus reduce noise in processing. This allows the VEP to become normalized.

**Selective Occlusion - Binasal**

**Optometric Interventions - Summary**

- Visual Guidance – based on needs
- Lenses – multiple possible benefits
- Prism – yoked, Peli, impact on mobility
- Selective Occlusion – modifies processing
- Vision Therapy/Rehabilitation
- KEY – each patient has specific visual needs, treat with any combination above
### Vision Therapy/Rehabilitation Cases
- Septo-Optic Dysplasia
- Anoxic brain injury at birth
- Methamphetamine Exposure Inutero
- Cerebral palsy

### Septo-Optic Dysplasia Concerns
- Sensory Concerns-Sensory Integration OT
- Decreased Visual Acuity-Optic nerve hypoplasia
  - Holds objects up close
- Minimal Sustained Fixation
- Tipping head down to see in primary gaze
- Left Gaze Preference
- Left exotropia, increases in Right gaze

### Septo Optic Dysplasia Goals
- More upright posture, eyes primary gaze
- Increase working distance
- Increased Sustained Fixation
- Increase Down gaze-to decrease head down
- Increase Right gaze-to decrease head turn
- Increase bilaterality, decrease left exotropia

### Septo-Optic Dysplasia Treatment
- Horizontal Vestibular Input-L gaze preference
  - Slow Rotations to Left 10X-eyes go Right
  - Fast Rotations to Right 5X-eyes go Left, add reaching for cortically directed movement
- Vertical Vestibular Input-Up gaze preference
  - Slow Rotations toward head 10X-eyes go Up (sidelying)
  - Fast Rotations toward feet 5X-eyes go Down after you stop, add reaching for cortically directed movement

### Overview of CVI
- More involved than simply visual acuity
- Importance of Multiple Visual Pathways
- Young CVI vs. Older developed with mTBI
- Consider:
  - Visual Motor Disturbances
  - Visual Spatial Disturbances
  - Visual Perceptual Disturbances (VIPS)
- KEY — Look at basic development and subcortical/cortical pathways to help achieve maximum independence and performance

### References
- Hyvarinen L and Jacob N. What and how does this child see? 2011.