The Strabismus That You May Not Know
They didn’t teach us that in Optometry School

A look beyond the traditional view

“He who sees things grow from the beginning, will have the finest view of them.”
Aristotle 384-322 B.C.

Introduction

• Introduction
  Jason’s story
  • Wife is sensory based peds OT
  • As we say in the south “Lookin’ fer aimsers”
  • Neurology of Eye Movements, Leigh and Zee
  • Vestibular Rehabilitation, Herdmann
  • OT/PT courses
  • New ways of thinking about vision and visual functions
  • Dr. Curtis Baxstrom
Introduction

- Introduction
  - How did we get here?
    - OT interactions
    - Therapy outcomes
    - Considerations for basis of understanding
  - Cases
    - Beyond traditional views of sensory-motor fusion, accommodation, convergence, and EOMs
    - Are we missing anything?
    - I got questions

What is a Strabismus?

- Muscle position?
- Muscle tone or phasic problem?
- Visual motion processing problem?
  - Vergence overaction?
- Nerve Paresis or palsy?
  - Visual field - deficit, constriction, loss, asymmetry, functional, organic, etc?
  - Breakdown in fusion without reserves?
  - Co-morbid Attentional loss?
  - Loss or lack of bilaterality in system?
  - Stress?

What is a Strabismus?

- Long hair?
- Accommodation/refractive?
  - Convergence?
  - Motor control?
  - Spatial awareness development?
  - Sympathetic imbalance?
- Fixation imbalance or loss?
  - Diplopia avoidance?
  - Infections?
- Adaptation to any of the above?
Prevalence of strabismus

• Ocular alignment of neonates study (n=3324)
  – Orthotropia 22.7%
  – Exotropia 61.1%
  – Intermittent exotropia 13.0%
  – Esotropia 0.2%
  – Intermittent esotropia 0.5%
  – Esodeviation to exodeviation 2.5%

Current State of Treatment

Surgical

Current treatment with surgery is for symptoms with unknown causes.
Cutting a muscle and repositioning when it is not a muscle problem is not optimal.
Latest surgical studies want earlier intervention... due possibly to better motion processing.
Current State of Treatment

Surgical

Surgical outcomes are less than optimal, yet considered standard of care.
There are no multi-center, randomized, double blind, placebo controlled studies for surgery, yet it is still considered standard of care.
What do you do with abduction deficits in surgery?

BCBS and Cigna policies on strabismus surgery “...despite the paucity of randomized controlled studies”!

Current State of Treatment

Surgical side effects –

• Marked overcorrection/undercorrection
• Infection
• Scleral perforation
• Foreign body granuloma at surgical site
• Allergic rxn to suture material
• Conjunctival inclusion cyst
• Conjunctival scarring
• Anesthesia (more than 2 in childhood shows delayed learning)

Current State of Treatment

Surgical side effects –

• Anterior segment ischemia
• Change in eyelid position
• Lost muscle
• Slipped muscle
• Poorly positioned muscle (vertical or horizontal)
• Nystagmus (latent)
• Oculocardiac reflex
• Others
• Why has earlier surgery been pushed in US?
  – Better surgical outcomes?
  – Anesthesiology on infants has improved
What are outcomes of early surgery?

<table>
<thead>
<tr>
<th>Condition</th>
<th>No Tx</th>
<th>Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amblyopia</td>
<td>0-14%</td>
<td>41-72%</td>
</tr>
<tr>
<td>Stereopsis</td>
<td>Gross</td>
<td>Better quality</td>
</tr>
<tr>
<td>Fusion</td>
<td>Monofix</td>
<td>6-24mo no better</td>
</tr>
<tr>
<td>IOOA</td>
<td>15%</td>
<td>72-78%</td>
</tr>
<tr>
<td>DVD</td>
<td>2%</td>
<td>62-76%</td>
</tr>
<tr>
<td>Side effects</td>
<td>Development?</td>
<td>See previous slides</td>
</tr>
</tbody>
</table>

Current State of Treatment

Optometric treatment
- Therapy is slow.
- Why is therapy not always successful?
- What else should we consider during treatment?
- Are deficient muscle positions/strength the CAUSE of strabismus?
- ie-diplopia patient from hospital, int XT patients, "stubborn" ET, vertical deviations, etc...

Others
- OT's, PT's, Bodywork, DC's, Cranial Osteopathy/Cranial-Sacral, Acupuncture
Current State of Treatment

Optometric side effects

Time

Monofixation syndrome
Loss of surgical opportunity

Big Picture - Neurological vs. Muscular vs. Other Causes

- Treatment of causes vs. treatment of symptomology
- The simpler thing is to treat it surgically vs. developmentally
- Faster outcomes in surgery, but it may not be stable due to current adaptations and/or they have reached maximum ability (i.e., monofixation syndrome)
  - Consecutive XT following Infantile ET surgery
  - Vertical diplopia after -5.00 ATR cylinder Lasik surgery. Ophthalmologist wants to do surgery for 4th nerve palsy?
    - Really, a nerve palsy from lasik?
    - Prolonged deprivation leading to vertical deviation study
  - Nystagmus after strabismus surgery

Current State of Treatment

Surgery as first approach is based on symptoms, not the cause.

Most often OD’s and OMD’s think and treat as simply ET or XT
If we can we define the type, cause, and underlying adaptations that sets the stage for the emergence of the strabismus we will have better treatment strategies.
Why do we allow OMDs to make rules regarding therapy that they are ignorant of?
Types of ICD strabismus

- **ICD listing of types**
- **H50** Paralytic strabismus
- **H52** Other strabismus
- **H51** Other disorders of binocular movement
- **H52** Disorders of refraction and accommodation
H51 Other disorders of binocular movement
H51.0 Palsy (spasm) of conjugate gaze
  H51.1 Convergence insufficiency and excess
    H51.11 Convergence insufficiency
    H51.12 Convergence excess
H51.2 Internuclear ophthalmoplegia
  H51.20 ... unspecified eye
  H51.21 ... right eye
  H51.22 ... left eye
  H51.23 ... bilateral
H51.8 Other specified disorders of binocular movement
H51.9 Unspecified disorder of binocular movement

What percentage of your patients are infantile ET?

Types of strabismus

Esotropia
  Infantile Esotropia
    Hx of OD and OMD approaches
    Abduction deficit leading to cross fixation
    Inflammatory or structural cause of CN6 deficit?
      Petrophenoidal Ligament (Ligament of Gruber)
      Vaccination, reports of recurrent CN6 involvement
    Others
      Birthing process, craniosynostosis, etc
    Most studies are showing motion processing limited in development
    Vestibular origins??? VOR/OKN asymmetry, adaptations...DVD/IOOA

Infantile Esotropia

Nixon, et al. study
Sondi, Archer, VonNoorden study
PEDIG 2002 - 175 infantile eT (40% reported at birth)
  Parents observations?
Scheiman and Wick reviewed infantile esotropia -found 28-54% of esotropia is infantile in origin
What percentage did you say earlier?
Types of Infantile Esotropia

- Infant, constant eT, Abduction deficit, VOR no help
- Infant, constant eT, Abduction deficit, VOR helps
- Infant, No abduction deficit
  - Intermittent eT, clears spontaneously
  - Intermittent eT, straightens with gaze change, blink, nose tap
  - Intermittent eT, occasional alignment, int. cross fixator
  - Constant eT, cross fixator
- Toddler/Adult, no surgery, visual sequellae less prevalent (IOOA, DVD, motion asymmetry, LN)
- Toddler/Adult, had surgery, visual sequellae prevalent
- Any above combined with accommodative esotropia

What Causes Abduction Deficit?

- How long does it take to establish eT with an abduction deficit?
- When does it disappear?
- RARE - bilateral sixth nerve palsy, uni-maybe
  - Diagnoses is usually limited to those that are seen at birth through 1 year or older
- Birth trauma
- Viral infection
- Vaccination – recurrent cases reported
- Other

Birch and Stager prism study

Compensatory prism with infantile esotropia
- Up to 4 mo. strabismics showed some stereo = normals
- After 4 mo. the stereo still dropped off with compensatory prism in place vs. normals
- Why?
  - Ocular motor may not be symmetrical
  - Development of atrophy / contracture?
  - Development of tonus to support ARC?
  - Lack of proprioceptive support?
  - No change in abduction deficit or motion asymmetry?
    - As convergence becomes more active, more input from asymmetry
    - What mechanism supports higher level of stereo?
    - Brain Periodization – pruning?
Neurologic Concerns of Early Infantile Esotropia Surgery

• Treats symptoms vs. causes
• Short vs. Long term results
  — Increases Amblyopia!
• Monofixation syndrome is considered optimal success
• Removes possibility of spontaneous recovery (Shon-2001, et.al.)...how can we reason spontaneous recovery?

Neurologic Concerns of Early Infantile Esotropia Surgery

• Effects upon proprioceptive feedback
  — Feldenstruktur fibers, 20% of EOM fibers, 1:1 and 2:1 nerve-motor ratio
• Effects upon pulley/double insertion of EOM (Brunech, Ruskell)
• Appropriate age for surgery has yet to be determined
• Complications / Side effects of surgery

Types of eso strabismus

• Accommodative Esotropia
  — Pure Refractive
  — Non-Refractive
  — Mixed
• Monofixation Esotropia Syndrome
• Basic Non-Accommodative Esotropia
• Esotropia And Visual or Neurologic Abnormality (e.g., sensory esotropia)
• Intermittent Esotropia
• Divergence Insufficiency Esotropia (paresis, paralysis). Is this a partial form of abduction deficit?
• Mixed (Partially Accommodative) Esotropia.
# Infantile vs. Accommodative ET

<table>
<thead>
<tr>
<th>Feature</th>
<th>Infantile</th>
<th>Accommodative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset</td>
<td>B-6 mo</td>
<td>&gt;6 mo to 7yrs</td>
</tr>
<tr>
<td>Angle</td>
<td>25-60PD</td>
<td>10-40PD</td>
</tr>
<tr>
<td>Refraction</td>
<td>&lt;+3.00D</td>
<td>&gt;+3.00D</td>
</tr>
<tr>
<td>Amblyopia</td>
<td>uncommon</td>
<td>common</td>
</tr>
<tr>
<td>LN, MLN</td>
<td>common</td>
<td>uncommon</td>
</tr>
<tr>
<td>DVD, IOOA</td>
<td>common</td>
<td>uncommon</td>
</tr>
<tr>
<td>Motion Asym</td>
<td>common</td>
<td>uncommon</td>
</tr>
<tr>
<td>VOR</td>
<td>common</td>
<td>uncommon</td>
</tr>
</tbody>
</table>

**Eye Scan 2-3 months**

(VOR gain)

**Eye Scan 4-6 months**
DVD and/or IOOA

Dissociated Vertical Deviation (DVD) - is a vertical deviation with decreased visual input

Inferior Oblique Over Action - is a vertical deviation when the inferior oblique is being used (i.e., Left eye in right gaze or right eye in left gaze) or over elevation and abduction of the eye

What leads to DVD and/or IOOA?

Dissociated Vertical Deviation

- 50-75% of infantile eT have DVD, post surgical
- Usually not before 2 y.o.
- Can be monocular in amblyopic eye
- No dual DVD (bilateral suppression?)
- Head tilt common to same side for fusion or opposite side for suppression of hyper-deviation
- Torticollis may be a postural manifestation of DVD
- DLR is best model I’ve found to describe DVD
Inferior Oblique Overaction

• Rarely before 1 year old
• Up to 75% in infantile esotropia after surgery
• Look L, R - suppression and decreases VF
• Possibly 2ndary to abduction deficit and via Inferior Oblique secondary muscle action or DLR

Overview of Abnormal EOM

• Abduction Deficit – common in infantile eT
  – If you see them early enough!
• Motion processing – Tychsen
• DVD, IOOA, LN – Brodsky
• PEDIG studies –DVD, IOOA, LN
• *Effects of monocular patch vs. binasal?
• Binasals may attempt to equalize sensory input (or balance it?), increase alternation and promote abduction eye as lead eye

There have been attempts by some OMDs to change the approach which mainstream OMDs (AAPOS) consider as standard of care. These OMDs are renegades.
VonNoorden Am J Ophthalmol
Review of Surgical Outcomes

• Before 2 yr the optimal outcomes were best
• Before 2 yr ALSO has the highest % of unacceptable outcomes
• Best overall outcome including optimal, desirable, acceptable occurs in older than 4 year old
• More recent studies on earlier surgery show no more cases with stereo, but better level of stereo
• ? type of stereopsis testing
• Why not evaluate abduction deficit/cross fixation?

Rethy, MD-Mistake of Strabology

• Miss the possibility of prevention
• Believe in unknown causes
• If a problem cannot be solved as a whole, take it apart
• Apply symptomatic tx, not causal therapy
• The turn...”will be soon overwhelmed by the sensory adaptation (ARC) more or less rapidly developing the stabilization of the tonus of convergence”.
• “The adaptive stabilization of the convergence tonus has to be treated before the harmless causes can be eliminated.”

Limitations of Rethy’s Work

• Based on Donder’s work only in accommodation
• Typically +1-2 D Hyperopia end up +6-8 D
• Wide span of binasal occlusion may have limited the size of fusional fields during therapy, but emphasis is lateral abduction
  – Often patients are head turners during therapy...but effects upon vestibular input to EOM?
• Plus increases VOR gain, thus affect N-T motion?
“Treatment should be directed toward what is best for the patient, not for the surgeon.”
Stefan Rethy, MD

The main body of literature on interventions for IE are either retrospective studies or prospective cohort studies. It has not been possible through this review to resolve the controversies regarding the type of surgery, non-surgical intervention and age of intervention. There is clearly a need for good quality trials to improve the evidence base for the management of IE.

So can WE treat esotropia successfully?
Optometric Approach Summaries

• Problems in Optometry – Scheinman and Wick – 20 pages
• Eye Care for Infants and Young Children – Moore – 4 pages
• Visual Development, Diagnosis and Treatment of the Pediatric Patient – Duckman – 3 pages
• Clinical Management of Strabismus – Caloroso and Rouse – 2 pages
*Recall that 28-54% of all esotropias are infantile, is there only one kind of infantile eI?

Optometric Approach Summaries

• London, Griffin, Mazer-13 mo surgery, 11yo VT
• Christenson-post surgery, after one year old
• Forrest- 8.5 mo phoric by 2yo, essentially motor therapy
• Maples- seen 6 mo, started tx at 18 mo
• Topical Journal on Infants, OVD 37(3) 2006
• Data not found regarding motion processing, abduction deficit, IOOA, DVD, in any cases

Testing

• Neuromuscular evaluation
  – Near/far, Worth, Parks, Hess-Lancaster, OKN, VOR
• Vestibular/vision motion evaluations
  – ROM, VOR (DVA), OKN, PRN, posture, tone, binocular status
• Adaptation evaluation
  – Sitting vs. Standing
  – Prism adaptation – differences in Developmental vs. Acquired Strabismus
  – Effects upon mobility
Neurology of Eye Movements

- **VOR** – Vestibulo-ocular reflex (16 msec)
  - Maintains fixation and stability by registering very short period of time
  - Sub-cortical response at birth
  - Gain is ratio of head to eye movement
  - Two types rotational (semi-circular canals) and translational (otoliths)
    - 1.0 at birth down to 0.6-0.8 when affected by development and other
      cortical responses
  - Used in therapy for strabismus and other therapies
  - Gain is changed by lenses and therapy
    - Low plus/minus
    - Prism affects in one plane
      - BU, BD, BI, BO - implications

Neurology of Eye Movements

- **VOR**
  - Maintenance of posture
  - Kinetic/transitory contractions of muscles for maintenance of equilibrium
    and EOM during movement - phasic
  - Maintains muscular tone of EOMs - tonic posture
    - Specifically a saccule function (vertical stimulation)
Neurology of Eye Movements

- VOR
  - Testing
    - DVA 2 hertz
      - Head thrust on infants
    - ENG
  - Patient complaints – dizziness, lack of coordination, vertigo, reading delays, hx of ear infection, and blur with motion
  - Almost always affected with ABI
  - Sometimes causative in oculomotor deficiencies
  - Primarily reflexive early on, cortical develops control later on a continuum

DOLL'S EYE TESTING: When the head is rotated to the left, the endolymph moves toward the left ampulla and away from the right ampulla. When the head is rotated to the right, the endolymph moves toward the right ampulla and away from the left ampulla.
Neurology of Eye Movements

- Vestibular system is fully myelinated at birth
- Sensory system for acceleration/deceleration
- 60% of compensatory eye movements
- Supplemented with OKN and smooth pursuits to provide stable eye movements
- Smooth pursuits overrides (integrates) VOR
- If SP is overriding mechanism, patients with poor SP ability can only marginally suppress VOR

Summary
- Short or transient eye stabilization and movement that is suppressed or integrated by SP system

Neurology of Eye Movements

- "The semicircular canals respond to angular acceleration and the otoliths respond to linear acceleration. Together they provide inputs for the VOR."

r-VOR and t-VOR respectively

The Neurology of Eye Movements - Leigh and Zee
Neurology of Eye Movements

- OKN - Latency of 140 msec
  - Registers sustained stimulus through sub-cortical with cortical integration (along with the continuum of development)
  - Indirect in infants (sub-cortical) and direct SP pathway in adult type movement (cortical)
  - Stimulated by visual motion input on retina
  - Involves optokinetic system, smooth pursuit, and saccades (see latency breakdown)
  - Testing - OKN drum 60 degrees per second UP TO 180 degrees per second

Neurology of Eye Movements

- OKN
  - "hard wired" lateral to nasal
  - Development of nasal to lateral begins at 2-3 months
    - Can have asymmetry up to 6 months, but should be symmetric at 9 months
  - Deficiencies found in strabismus or deprivation amblyopia (commonly early onset)
Why is OKN important?

- Birth T to N present, N to T begins 2-3 mo.
- Symmetry about 9 mo.
- Visual experience needed for maturation
- *Stereo parallels development of OKN 4-6 mo.
- *Can be used as differential test for time of onset / type of esotropia
- Likely on a continuum
- Right and left not necessarily symmetrical
• Pursuits – 90-150 msec latency –
  – Cortical
  – Driven by retinal slip (motion)
  – ≥60 degrees per second
  – Thought to override VOR response
  – Motion processing area to flocculus and ventral paraflocculus in cerebellum via VM nuclei in the pontine nuclei.
  – Motor output to EOMs via the VESTIBULAR nucleus.
  • Many other pathways
Neurology of Eye Movements

• Saccade – 150-250 msec latency –
  - Sub-cortical and cortical
  - Smooth pursuit tracking interrupted from at approximately 51 inches per second at 250 milliseconds up to 86 inches per second at 150 milliseconds performed at 1/3 meter (33 cm)
  - Mediated by the vestibular system through SP/VOR/OKN
  - Large visual-motor movement planned and implemented without peripheral feedback during movement (Brooks, 1986, p. 127)
    • Implies peripheral "map" with schema holding muscle tension, velocity, size information to get to point B.
    • Predictive saccades possible in 12-14 week olds

Neurology of Eye Movements

• Neural Integrator (cortical control)
  - Prolongs/decreases signal from peripheral vestibular apparatus
    • Signals from SCC/otoliths
  - Velocity signal aligns eye to speed of rotation (VOR)
    • Horizontal oculomotor – Nucleus Prepositus Hypoglossi
    • Vertical and torsional oculomotor – Intestinal Nucleus of Cajal
  - Integrates information signals from VOR/OKN/SP to allow for normal eye movements
Neurology of Eye Movements

- “Velocity signals from SCC or acceleration signals from otoliths, need a signal encoding eye position” – Herdman, Vestibular Rehabilitation
- Feldenstruktur fibers role?

Neurology of Eye Movements

- Feldenstruktur fibers
  - New findings with electron microscopy (Dr. Richard Brunech)
  - 1:1 or 1:2 neuron to motor unit
  - So far only found in the ear muscles and EOMs
  - 20% of all motor neurons in EOMs
  - Not fully developed till 6-8 years of age
- Proprioceptive feedback loop for EOM position
  - should we cut? grow back? Near work implications?

Neurology of Eye Movements

Horopter
Measurement surface of points having images of two eyes which yield the impression of identical visual directions
Central Visual Locus
Approximately 10.5cm behind eyes
Motion detection at retinal level
Theoretical basis for stereopsis
Core concepts for applications in VT

- **VOR** - 16 msec latency
  - Registers brief stimulus through sub-cortical and is overridden or integrated by smooth pursuit system

- **OKN** - 140 msec latency
  - Registers sustained stimulus through sub-cortical with cortical integration (along with the continuum of development)

Core concepts for applications in VT

- **Pursuits** – 90-150 msec latency –
  - Cortical (with attention)
  - Cortically Suppresses VOR

- **Saccade** – 150-250 msec latency –
  - Sub-cortical and cortical

- **Multiple inputs with vision**
  - Stationary central visual input with moving periphery, vice versa (watching a moving target)
  - Linear/rotary vestibular input with stationary eyes (driving a car)
  - 3D vision syndrome questions?

Duality of the Systems

Spatial Worlds are all found in all sensory systems and are reciprocally interwoven

Proprioception/Tactile, Motor, Vestibular, Auditory, Visual

- Developed vs. acquired
  - Differences for early onset vs. late onset strabismus vs. acquired (ABI)?
  - When is the initial onset of amblyopia? What’s the trigger?
  - Asymmetry-small amount is needed for ideal performance, but overly asymmetric can be a concern as well

- Motor/Proprioception theories
  - Flexion / Extension
  - Tonic (tone) / Phasic (motion)
Duality of the Systems

- **Tonic vs. Phasic Receptors**
  - **Tonic Receptors ("Slow Adapting")**
    - The neuron continues to fire until the stimulus is removed
    - Example: You poke yourself with a needle. It will hurt until it is removed.
    - Tonic receptors are constantly on
  - **Phasic Receptors ("Fast Acting")**
    - Fire only when stimulus first is perceived or removed
    - Example: Putting your clothes on; you are only aware of them for a short period of time.
    - Phasic receptors are usually "off" until a stimulus turns them "on".
      - Example: You are not aware of the temperature until it becomes hot or cold.

---

Duality of the Systems

- Vestibular - Keiner, et al., Herdman
  - SCCanals are "phasic", Otoliths (saccule and utricle) are "tonic"

- Visual – Sensory-Motor theories
  - Motor fusion
  - Sensory fusion
  - All appear to have both phasic and tonic components!
Duality of the Systems

• Visual - Binocular Rivalry
  – The development of OKN and stereo

• Visual - Accommodation/Convergence – Slow/Fast Vergence
  – Tx - traditionally we just vergence think about ranges and adaptation?

• Visual - Spatial
  – Ambient/Focal processes
  – Size of target attended to can be variable
  – Spatial Awareness - x, y and z-axis
  – Tx Considerations

Duality of the Systems

• Visual-EOM-
  – Input from EOM proprioception and vestibular input to EOM
  – Horizontal Tx
  – Linear vs. Rotational
    – Why does it sometimes appear to worsens?
  – Other EOM and SCC relationships – each one to one
  – Considerations
    • Surgical intervention upon proprioception
    • Ear infections upon strabismus
Adaptations

- Short and Long Term Adaptations
  - Older patients - diplopia
  - Younger patients - may learn to suppress
  - Recovery of initial cause (decreased swelling, circulation, rewiring, etc.)
  - Fast Vergence - phasic
  - Slow Vergence - tonic
  - Muscle Length changes with contracture
  - Spreading of committance
  - Surgical Concerns
  - Other

Types of Amblyopia

- Strabismic Amblyopia
  - Exotropia
    - Most likely in surgical intervention
    - Less likely with accommodative ET
  - Exotropia
  - Vertical
  - Cyclo
Types of Amblyopia

- **Refractive Amblyopia**
  - Hyperopia – bilateral >6D?, 9?, 12+?
  - Myopia – bilateral >-6D?, -9, -12?
  - Astigmatism – 3D?, 4, 5?
  - Anisometropia >2D
    - Spectacle compensation (match BC and CT)
    - Contact lens compensation due to anisokonia (retinal image size)
  - Pathologies are not true amblyopias
    - Microphthalmia (>6.00 or so)
    - Colobomas

- **Spectacle compensation (match BC and CT)**
- **Contact lens compensation due to anisokonia (retinal image size)**
- **Pathologies are not true amblyopias**
  - Microphthalmia (>6.00 or so)
  - Colobomas

Types of Amblyopia

- **Deprivation amblyopia**
  - Infantile (congenital) Cataracts
  - Ptosis
    - Myogenic – malinsertions (How often does this really happen?)
    - Mechanical
    - Cicatricial
    - Traumatic
- **Amblyopia, unspecified – really?**

Overall Treatment

- **General Overview**
  - Origin - Developmental vs. Acquired vs. Mixed
  - Relate to Duality of Systems – Reciprocally Interwoven
    - Example- prop/tactile, auditory, vestibular, visual and space worlds
  - Traditional treatment strategies – are they enough?
    - Look for underlying visual deficits impeding therapy
      - Example-Cross fixation and motion processing asymmetry
      - Abduction deficits
  - Use other systems in attempt to reset underlying neurology
    - Example-vestibular to drive EOM, modifying cortical control
    - Secondarily, yoked vestibular input to yoked EOM control
Overall Treatment

• General Overview
  – Further Treatment Considerations
    • Jump prism work – relate to motion processing deficit?
    • Ear infections/Effusion – related to strabismus?
• Considerations for Pre-Treatment
  – Arousal/Attention before and during each session – Vestibular, Syntonics
  – Prep with motion and serotonin/dopamine – duality of systems
  – Neurotransmitters
  – Nutritional Counseling

Standard Treatment

• OVERVIEW
  – Lenses and Prisms
  – Occlusion
    • Break Cross Fixation Pattern – modify distribution of light (confusion)
      – Esotropia-Mono and Binasals – Where do they alternate fixation? possibility of reducing vertical
      – Exotropia-Bitemporals to work alternating fixation across midline
  – Vision Therapy
    • Traditional vs. Duality of Systems

Modify Relationship Between Peripheral Lock to Central Confusion
Traditional Treatment

- Traditional Visual
  - Monocular
    - Acuity / Amblyopia
    - Eye Movements
  - Biocular
    - Squincher-spatial aspects
    - MFBF
  - Binocular
    - Levels and Ranges of Fusion

Sequential considerations, but each patient is individual depending upon needs, previous skills – phasic and tonic perspectives

- Monocular
  - Work paresis/palsy
  - Equalize skills
    - Extend Ranges - Pursuits, Saccades, VOR, Motion-OKN
    - Check cross fixation

- Biocular
  - Watch over and undershooting
  - Cross fixation patterns

- Binocular
  - Paresis/Palsy cases extend binocular ranges, especially in angles of overshooting and/or undershooting, emphasize jump ductions
  - Stereopsis
    - Static vs. Dynamic (does it break down with movement?)
Summary of Traditional Optometric Approaches

• Refractive “Error” Correction
• Prism
• Orthoptic training
• Monocular occlusion
• Surgical referral
• What is the difference between this and OMD?

Developmental Optometry

• Developmental Visual Guidance
• Possible referral for abduction deficit
• Lenses
• Selective Occlusion / Binasal
• Vision Therapy
  – Direct
  – Passive
  – Delayed
• Alternative considerations-Syntonics

Outside the box treatment

Therapy

Use sub-cortical responses with cortical integration for all eye movement functions

Tactile/propiocception inputs
  Motor space world
  Posture
  Stability for accurate eye movements
  Breakdown of suppression via tact/prop phasic input
  Cervical ocular reflex
  Infinity walk
Outside the box treatment

Considerations in therapy

Auditory
- Auditory processing of motion – inferior colliculus to superior colliculus
- Biaural hearing as precursor to binocular vision?

Vestibular – from SCC and otolith organs
- Direct connection from SCC and otoliths to EOMs
- SCC are phasic inputs to EOMs. Otoliths are tonic inputs to EOMs
- Drives VOR, OKN, SP, Saccades, & PRN (core basis of eye movements)
- Treat phasic in direction of deviated eye: R-turn = SCC stimulation to right
- Treat tonic via linear/vertical stimulation
- Treat phasic via SCC

Outside the box treatment

- Vestibular use to drive EOM fxn - linear vs. rotational
  - Linear (tonic)-Exotropia, affects all EOM
  - Rotational (phasic)-Esotropia, each affects separate EOM
  - Mixed Input - Belgau, can modify binocular ranges
  - Postural Tone in ABI
  - Asymmetric PRN-related to strabismus, ear infections, developmental in origin?
Outside the box treatment
Considerations in Eye Movements

Vision
- Infantile ET
  - Asymmetric bilateral phasic input (2nd to Abduction deficit)
  - Asymmetric OKN in N-T direction
- Accommodative ET
  - Initially phasic, but can convert to tonic with mal-adaptation
- Partial or Non-Accommodative Strabismic ET
  - Is this phasic vestibular processing?
  - Proprioception

Exotropia
- Low bilateral tonic input
- Linear/vertical stimulation to increase overall tone
- CI – intermittent or positional XT
  - Core of CI is overall muscle tonus
  - Otolith stimulation with prop/tactile feedback
Prevention and Guidance
• Equal Access / Alternation – bottle, feeding, crib placement (West-study that the abducting eye leads binocularity)
• Stress Reduction – talk and sing
• Developmental Intruders vs. Motor Guidance
• Vestibular input – possible effect for H and V deviations?
• Observe and break the pattern
• Biochemistry

Vestibular Applications
• Parents including it daily, with fixation (mirror)
  – Consider prism with it therapeutically?
• Increase arousal – involved in therapy, postural control improved, suppression? (BO/BI ranges)
• Repeated VOR during the day
• Post rotary nystagmus to break abduction deficits
• Alternating R and L eyes between rotations, binasal sets the stage

Vestibular Applications
• Pursuits
• Saccades (eye throwing?)
  – Monocular prism jumps
• OKN Cloth (motion)
• VOR – doll’s eye
• Monocular prism jumps
• Vergence if fusing (keystone binocular cards)
• Ron, et. al. study on oculomotor subsystem transfer
*Binasals help sets stage for monocular work
What vestibular stimulation direction should one emphasize for:
1 – abduction deficit
2 – motion asymmetry

GOAL OF OPTOMETRIC INTERVENTION
1-Break Cross Fixation
2-Improve N-T Motion Processing with sub-cortical responses
3-Promote Alternation and Fusion

Treatment Considerations
- Partial or Non-Accommodative Esotropia
  - Fast and Slow Accommodative-Vergence System (Ciuffreda and Hung)
  - “Vergence Adaptation” allows decrease in angle over time
- Current view ignores the following:
  - Vestibular component
  - Proprioceptive component
  - Auditory component
OVERVIEW — more than just vergence

Sensory Inputs to central processing
- Olfactory, tactile/proprioception, auditory, vestibular, vision

Central processing to motor outputs
- Vestibular nucleus – primary
- Cerebellum – adaptive process

Motor outputs
- Guided mobility
- Eye movements
- Posture
- Balance
- Tone

Cerebellum – a key link to duality?
Other Considerations

• OT / PT / Movement Therapy/ etc.
• Cranial Osteopathy and/or Cranial-Sacral
• Chiropractic
• Interactive Metronome
• Syntonics
• Others

Treatment

• Lifespan Management of Case
  – Preventive Care – Use of lenses, visual hygiene
  – Resilience - eT late in day, flu or ear infection, etc.
  – Education on what to expect, what to do if strabismus returns
• Others

Thank You

• Comments, criticisms, complaints, confusion...
  – Jason Clopton (Jason)

drclopton@drclopton.com

• 931-372-2020