LEARNING OBJECTIVES

• Describe two evidence-based applications for power mobility in the treatment of visual/perceptual deficits.
• State three current perceptions related to prescribing power mobility to children with Cerebral Palsy (CP) or adults with Cerebral Vascular Accidents (CVA).
• Identify how to determine if powered mobility is an appropriate mobility device for clients with CP or CVA.
• List two possible outcome measures to determine the success of using power mobility as an intervention for visual/perceptual deficits.

VISUAL DEFICITS AND PERCEPTIONS

• How often do you screen for visual deficits?
  – What do you do to screen?
• Is there certain deficits you automatically rule out for independent mobility?
  – In children?
  – In adults with newly acquired injuries?

OUTLINE OF LECTURE

Why are we looking at vision?
• How we use vision
• How vision develops

HOW WE USE vision

• The overall function of the brain is to filter, organize, and integrate sensory information.
  – Neural structures of the brain are devoted to taking in sensory input, analyzing it, and responding to it.
• Vision is the primary sensory system used to acquire information about the environment.
  – 80-90% of all learning occurs through the visual channel

HOW WE USE VISION

• Speeds up information processing
  – Instant identification of objects
  – Can identify with other senses but takes longer
  – Moving in both static and dynamic environments

Faster information processing
= Better adaption to dynamic environments

WHICH ONE?? (GENERALLY SPEAKING)

Ophthalmologist
• MD specialized in diseases of eye and eye surgery.
• Focus on disease
  – Treatment options of medicine or surgery

Optometrist
• Primary health care provider who specializes in examination, diagnosis, and treatment of diseases/disorder of the visual system.
• Have a focus on how vision relates to the individual’s environment
• Can specialize and receive credentials in the field of vision rehabilitation.
  – (ex: COVD)

VISUAL DEFICITS OCCUR FROM...

• Disease
• Trauma
• Aging
• A combination of any or all of the above

VISUAL DEFICITS

• Visual deficits...
  – Under-diagnosed (either overlooked or attributed to other causes)
  – Interfere with therapy
  – Can be a main deterrent to the prescription of independent mobility
  – Considered irreversible or untreatable

“REHABILITATIVE OPTOMETRIC SERVICES FOR SURVIVORS OF ACQUIRED BRAIN INJURY”

Generally, after brain injury, the visual system is not comprehensively evaluated, sometimes because there is a lack of articulated complaints due to impaired subjective experience or reduced cognition. Visual system evaluations are frequently neglected. Often referrals, if they are made at all, are made to ophthalmologists, reflecting the medical orientation of the delivery system. Ophthalmologists however, are primarily concerned with the physiologic health of the eye. Important as this is to the survivor of brain trauma, further issues of concern for visual information processing pertain to the function of the full visual system.

(Gianutsos, R. RamseyG, & Perlin, R.R., 1988)

VISUAL SYSTEM BASICS
**SYSTEM BASICS**

**Input**

Throughput

**Output**

**VISUAL PROCESSING**

Throughput: Cognitive Processes
- Filter
- Organize
- Integrate

Input: Visual System

Output: Perception
Transform information and use it to interact with the environment

Executive Functions:
- Plan, manipulate, initiate, and terminate activities

**VISUAL INFORMATION PROCESSING**

- Different areas of the brain are responsible for different parts of visual processing.
- Generally, the left side of the brain is responsible for processing visual information like letters and words.
- The right hemisphere is more global and takes in a general view of the environment. This hemisphere is responsible for depth, color, and shape discrimination.
- Cerebellar dysfunction can cause problems with laterality

**VISUAL ANATOMY REVIEW - INPUT**

- Light hits the rods and cones in the retina – starting a chemical reaction
- Optic Nerve
  - Carries visual stimuli to the occipital lobe
- Optic Chiasm
  - Half of the fibers from each optic nerve cross to pass to the opposite lobe in the opposite hemisphere

**VISUAL PATHWAY**

**VISUAL ANATOMY REVIEW – INPUT/ PROCESSING**

THEORETICAL VISUAL MODELS

THREE COMPONENT MODEL OF VISION

1. Visual Integrity
   - Visual acuity
   - Optics of the eye
   - Eye Health
2. Visual Efficiency
   - Accommodation
   - Binocular vision
   - Eye Movements
3. Visual Information Processing
   - Visual spatial skills
   - Visual analysis
   - Visual motor integration

VISUAL ACUITY

- 20/20 vision is considered normal
  - (Ex: 20/100 explains that someone with normal visual acuity could identify the letter presented at a distance of 100 feet, the individual tested needed to be at 20 feet prior to seeing the letter).
- Visual acuity below the level of 20/30 can be cause for referral
- There are ways to test acuity in very young children and people with cognitive deficits
  - (Broken wheel test, Teller Acuity Cards, etc.)
- Reduced visual acuity does not occur as an isolated problem

VISUAL ACUITY DEVELOPMENT

Viewing Distance: 24 inches

Newborn  4 weeks  8 weeks  3 months  6 months
Birth – 6 months (Critical Period)
- Rapid acuity improvement (almost to normal)
- Rapid period of development of accommodation and binocular vision
- Can visually explore his/her own environment
- Can transfer objects from hand to hand
- May become more interested in geometric patterns

First 5 years
- Sensitive period of visual development
- Visual system is plastic and capable of developing normally

CONTRAST SENSITIVITY

- Evaluates larger low contrast objects
- Strongly associated with mobility and driving as well as face recognition
  - Curbs, shadows, stairs, etc.
REFRACTIVE ERROR

• Myopia (Near sighted)
• Hyperopia (Far Sighted)
• Astigmatism

• Large fluctuations in young children, most variability occurring in the first two years, and minor changes thereafter
  - Huge prevalence of refractive disorders in children with disabilities

FOUNDATIONAL FUNCTIONS

Visual Acuity
Visual Fields
Oculomotor Control

VISUAL FIELDS
Portion of space where objects can be perceived while the individual is visually fixating on a single object in the straight ahead position.

VISUAL SPATIAL INATTENTION VS. UNILATERAL NEGLECT

• Often confused with each other
• Visual spatial inattention is typically the cause of a field cut (input disorder)
• Unilateral neglect is a perceptual deficit (output)

FIELD DEFICITS

VISUAL SCANNING TRAINING
• The purpose of scanning is to teach a person how to be aware of his or her full field of vision.
• This is most important with the patient with a visual field loss.
• Also very important for safe mobility.
**VISUAL FIELD DEFICITS**

- **Functional Implications to Mobility**
  - (Inferior) Difficulty with walking, seeing steps, curbs, etc.
  - (Superior) Trouble seeing signs – amplified when in a wheelchair

**OCULOMOTOR CONTROL\nVISUAL EFFICIENCY SKILLS**

- **Binocular Vision Disorders**
  - Alignment
  - Range of Motion
- **Ocular Motility Disorders**
  - Fixation
  - Saccades
  - Accuracy (over vs. undershoot)
  - Smooth Pursuit

**BINOCULAR VISION**

The ability for the visual system to fuse information from both left and right eyes into one image.

- Disorders lead to diplopia
  - One cause could be loss of ocular alignment (strabismus)
    - Obvious cosmetically
    - After the age of 6 – an individual loses the neuralplasticity to perform anomalous correspondence.
    - Strabismus is considered abnormal after 1 month of age
  - Most common cause in individuals with ABI is convergence insufficiency.

**OCULAR MOTILITY DISORDERS**

Deficits in Ocular Motility can indicate serious CNS diseases and developmental problems.

- **Fixation:** Almost all patients (except the very young, hyperactive, or inattentive) should be able to sustain fixation w/o movement of the eyes for 10 seconds
  - Nystagmus is a fixation disorder

**VESTIBULAR SYSTEM**

- **Contributes to balance and spatial orientation**
- **Damage to the vestibular spinal tract may result in abnormal eye movements (abnormal nystagmus)**
OCULAR MOTILITY DISORDERS: SACCADEIC DYSFUNCTION

Ideal saccades is a single eye movement that rapidly reaches and abruptly stops at the target of interest.

• Saccades may be inaccurate in 2 ways:
  • Slight undershoot (slightly short of the target and "glides" to alignment) – most common
  • Overshoot of the target – less common

http://i.vimeocdn.com/video/469637292_640.jpg

POWERED MOBILITY TO IMPROVE VISUAL/PERCEPTUAL DEFICITS

OCULAR MOTILITY DISORDERS: PURSUIT DYSFUNCTION

Condition in which the individual is unable to accurately follow/focus on a moving object

• Pursuit eye movements enable clear vision to moving objects
• Important for mobility!

OCULAR MOTILITY DEVELOPMENT

• Unlike acuity, ocular motility develops slower
• Improvements are seen throughout the early elementary school years
• Dependent upon challenging the visual system

EVALUATING PURSUITS

• Have the patient follow a single object in all directions.
  • Up, Down, R, L, Diagonal UR, Diagonal UL, Diagonal DR, Diagonal DL
• Must be fixated on object
• Differs from alignment/and ocular muscle range of motion

MODELS OF VISION

1. Visual Integrity
   • Visual acuity
   • Optics of the eye
   • Eye Health

2. Visual Efficiency
   • Accommodation
   • Binocular vision
   • Eye Movements

3. Visual Information Processing
   • Visual spatial skills
   • Visual analysis
   • Visual motor integration

(Scheiman, 2010)
DISTINCTIONS WITHIN THE FRAMEWORKS

• Visual Spatial Skills
  – Bilateral Integration
  – Laterality
  – Directionality
• Visual Spatial Dysfunction can lead to...
  – Poor athletic performance
  – Difficulty with rhythmic activities
  – Lack of coordination/balance
  – Tendency to work with one side of the body
  – Clumsy, prone to tripping and falling

DISTINCTIONS WITHIN THE FRAMEWORK

• Visual Analysis Skills
  – Visual discrimination
  – Visual figure/ground
  – Visual closure
  – Visual memory
• Visual analysis dysfunction can lead to difficulty reading, classifying objects, and picking out distinguishing features of environments/people.
• Visual memory needed for navigation

DISTINCTIONS WITHIN THE FRAMEWORK

• Visual Motor Skills: Skills related to a person’s ability to integrate visual processing skills with fine motor movement (eye-hand coordination)
• Visual Motor Dysfunction
  – Difficulty with handwriting
  – Difficulty with responding to visual stimuli while driving PWC

VISUAL PROCESSING

• Even if someone has good visual acuity and ocular motility...they may still have a vision problem! There is more to vision than just seeing.
• Visual cognitive skills require extracting and organizing visual information, as well as integration with higher level cognitive processes.
• Must filter out irrelevant information to attend to the task
  – Dependent on prior experience and development

VISUAL ATTENTION

• Varies from global to focal
• Critical for higher level components of visual processing
• Involves all of the CNS to perform

Attention = Alert & Attending

VISUAL COGNITION

• Use visual cognition to develop cognitive concepts that we apply in decision making and problem solving
• Forms the basis of all academics
• Forms the basis of many vocations
ALL LEVELS MUST WORK TOGETHER

Like parts of a car, loss or impairment of one level affects the functioning of all levels.

Eye movement disorders are rarely present in isolation. Rather, they are generally found associated with accommodative, binocular, and visual information processing dysfunctions.

PIECING TOGETHER VISUAL SYSTEM DEVELOPMENT

VISUAL DEVELOPMENT

• Vision begins to develop in the 3rd trimester with the start of differentiation of brain matter.
• The occipital lobe contains neural columns for visual development.

2 months - relies on visual input for head control
• Birth to 1 year - visual preference for postural orientation in sitting and standing
• 13-16 months - visual preference for independent standing and walking
• Birth-death - vision used as primary information when first learning a task or in novel environment

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PRE-TERM INFANTS:
• Preterm infants with very low birth weight are at a high risk of developmental deficits and visual deficits.
  • Retinopathy of prematurity (ROP)
  • Intraventricular hemorrhage (IVH)
  • Periventricular leukomalacia
• One area of the brain that is particularly vulnerable at this time is the primary visual pathway, from the retina to the cortex. During this prenatal and neonatal time period the visual system undergoes significant growth (Mirabella, et al., 2006)

NEONATES AND INFANTS
• Learn first by oral interaction
• Later, learning occurs through hand function
• Learning also occurs through vision
• Learning: the process of acquiring information about features of the environment (texture, object weight, size)
• NOT ONLY ACQUIRED BY VISION

(Plummer, Yampolsky, Meyer)
http://www.sfn.org/index.cfm?pagename=brainBriefings_visualDevelopment

(Plummer, Yampolsky, Meyer)
http://www.health.howstuffworks.com
DEFINITIONS

• **Visual Perception**
  • Synthesize stimuli which leads to construction of visual representation
  • Used to navigate, and identify objects in space

• **Depth Perception**
  • “Although infants can perceive depth by six weeks of age, only after they have been locomoting independently for 2-6 weeks does the perception of depth become linked with emotion of wariness” (Bertenthal, Campos & Kermoian, 1992 as cited in Kermoian, 1997)

• **Haptic Perception**
  • “Recognition of objects and object properties by the hand without the use of vision” (Henderson & Pehoski, 2006)

VISUAL DEVELOPMENT AND MOBILITY

• “The amount of information that an infant can acquire from moving objects depends, in part, with his ability to follow objects” (Ruff, 1980, page 983)

• Self-produced mobility has an important impact on a child’s psychosocial and cognitive development. (Deck, Swinth & White, 2002; Nilsson & Nyberg, 1998; Teft, Guerette, & Furumaeu, 1999)

• Without mobility, children may exhibit depressed motivation, apathy and a lack of initiation. (Becdewith as cited in Staincliffe, 2003)

• Restricting mobility may affect the child’s interest and ability to communicate, participate in social and leisure activities, and create diminished self-efficacy.

VISION AND MOVEMENT

• Visual information leads to direction specific movements.

• Postural stability leads to distal mobility and is motivated by reaching.

• The relationship between vision, hand function and posture is apparent.

SELF-PRODUCED MOVEMENT IS SUPERIOR

“Self-produced transformations have an advantage in that motion can be initiated and controlled expressly for the purpose of gathering information; watching an object over whose motions the observer has no control leads to less efficient learning” (Ruff, 1980, page 985).
Visual system will develop with INDEPENDENT MOBILITY 
Does not develop as well with DEPENDENT MOBILITY

WHAT DOES ALL THIS HAVE TO DO WITH POWER WHEELCHAIRS?
• How are power wheelchairs traditionally used?
• Can powered mobility be beneficial as an adjunct treatment tool for visual/perceptual deficits?
• In return, can powered mobility result in “learning to drive” to improve independence for MRADLs?

TREATMENT MODALITIES
• Lenses
• Prisms
• Occlusion
• Organized Scanning training
• Orthoptics (Vision therapy)
  – Best prognosis for binocular vision problems not due to an alignment disorder.
  – Accommodation issues
  – Eye movement dysfunction
• Provide access to functional tasks and mobility
• Modify the task at hand

SPATIAL AWARENESS

• Coping skills develop through exploration
  • Where the child ends and the environment begins
  • 3-Dimensional
  • Decreased exploration = Constraining child
• Children become empowered through Power
• Become interested in ALL MOBILITY SKILLS

(Campos, 1988; Heidelise et al, 2004)
PERCEPTIONS RELATED TO POWER MOBILITY

- CVA (Stroke) – Will power limit independent walking?
  - Hemiplegic Manual Wheelchair/One Arm Drive – typical prescription
  - Is this functional? Safe? Therapeutic? Independence?
  - Safety Awareness – esp. with Neglect
- Pediatrics – Will power limit independent walking?
  - Manual (Tilt-n-Space) Wheelchair – typical prescription
  - Is this safe/efficient form of mobility? Independence?
  - Safety Awareness
  - Cognitive Skills

CASE STUDY: CVA - RESULTS

- Improvements noted with cause and effect, avoiding hazardous situations, attention, scanning to neglected side, and visual spatial awareness per video results.
- Speech therapists reported improvements with table top attention, vision, and cognitive tasks.

CASE STUDY: CVA - CONCLUSIONS

- Powered mobility, as an adjunct tool for visual/perceptual deficits, can be an effective intervention tool
- Participant became a more viable candidate for powered mobility upon discharge to improve his independence.

DISCUSSIONS/FURTHER TRIALS

- The effectiveness may be contributed to a constraint induced principle.
- Further case studies are being conducted at Banner Good Samaritan Rehabilitation Institute, St Josephs Hospital, and Mountain Valley Rehabilitation Hospital in Arizona.
- There has been additional case studies done with similar results

VISUAL SYSTEM RELATED TO POWER MOBILITY

- Visual system develops through movement as it relies on the vestibular and somatosensory systems
- Early intervention in pediatrics or following ABI is crucial for relearning
- Movement is the catalyst for developing visual/perceptual skills
- Don't ignore seating/positioning!!! Proximal stability leads to distal mobility.
POWERED MOBILITY TO IMPROVE VISUAL/PERCEPTUAL DEFICITS

• Don’t expect perfection!
  • Trials and Training are necessary, but are not the same as the person’s
daily environment.
  • ‘Driving tests’ can be too restrictive and unreasonable.
  • Look for improvements that indicate success is likely.
  • Ensure there is good support (family/school) to continue
training after delivery to refine driving skills.
  • It’s as simple as 1, 2, 3:
    1. Do they understand Cause/Effect?
    2. Are they aware of basic Directionality?
    3. Can they Stop?!

PEDIATRIC POWER MOBILITY

• Not just line following
  • Need to teach in variety of environments
  • Start with small, familiar space
  • Avoid directions and chatter
  • Indoors and outdoors
  • Avoid distractions and standing too close
    • Client needs to know that they are responsible for the action
    • Don’t interrupt unless necessary
    • Allow them to “interact” with the environment
      Be aware of your environment, contrast, glare, the floor/carpet that you are driving
      on!!

OTHER VISUAL DEFICITS AND POSSIBLE INTERVENTIONS?

• Functional scanning tasks
• Navigation tasks
• Grading the lighting in the environment
  – Play flashlight tag

POWER WHEELCHAIR PROGRAMMING OPTIONS

• Acceleration/Deceleration
  – Increase to make more “jerky”
  – Decrease to smooth out
• Auditory options?
  – Music
  – Warning beeps?
• Inhibition of specific direction during training periods

OUTCOME MEASURES

• Pediatric Powered Wheelchair Screening Test (PPWST) (Furumus, Guerette, Tefft, 2004)
  • CP and Ortho
  • Joystick only
  • Peer reviewed
• Driving to Learn™ (Nilsson)
• Video before/after treatment
• Specific tasks
  • - Scanning?
  • - Obstacle avoidance?
  • - Cognitive/attention measures?
POWERED MOBILITY TO IMPROVE VISUAL/PERCEPTUAL DEFICITS

• It is apparent that the ability to follow an object (smooth pursuit) and visual scanning are required for the development of spatial relations.
• Self-produced mobility is superior to passive mobility and leads to greater perceptual, visual and cognitive learning.
• Power mobility is an ideal intervention for improving visual/perceptual deficits in both children and adults.

QUESTIONS TO ASK THE EYE DOCTOR BEFORE REFERRING YOUR PATIENT

• Do you have experience working with learning disabled children?
• Do you have experience working with developmentally delayed, multiply handicapped, autistic, and physically impaired children?
• Do you have experience working with individuals with acquired brain injury?
• Do you test accommodative amplitude and facility?
• Do you evaluate fusional vergence amplitude and facility?
• Do you evaluate visual information processing skills?
• Do you offer vision therapy as a service in your practice?

(Plummer, Yampolsky, Meyer, 2009)

REFERENCES