Motor and Visual-Spatial Applications in Vision Therapy

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I have no financial relationship or commercial interest in any of the content provided

Goals

• Outline relevant neurological pathways/areas involved in processing visuospatial and motor information
• Outline various theories involved
• Discuss integration with multiple sensory systems
• Discuss implications in the vision therapy room to tap into motor and visual spatial processing

Visuospatial & Motor

Why are these concepts important to Optometry?
What real world influences could they have?
  Movement
  Balance/Postural control
  Spatial & Temporal awareness
  Body awareness
  — Efficient action

Visuospatial & Motor

“...vision is an act which is mediated by eye and brain, but which emanates from a growing action system.”
“...visual-motor functions form the foundation for discernment and perception of visual sensory information”

— Gesell

Visuospatial & Motor

more efficient action in motor/movement/visuospatial exploration

ability to efficiently process visual information

deriving "better" meaning
Visuospatial & Motor

“Self produced movement with its concurrent visual feedback is necessary for the development of visually guided behavior.”
— Richard Held

“Movement-produced stimulation in the development of visually guided behavior”

Kitten Carousel — Held & Hein (1963)

Concept of Ranges

— Discussing Larry MacDonald pertaining to “ranges of performance”
— Emmetropia and orthophoria representing evidence of a visual problem

Range — the latitude through which any function may perform without upsetting its balance or relationship with any other function
— can act as a buffer or cushion to functioning, allowing freedom and smoothness of action/performance

Concept of Ranges

— visuospatial and motor ranges of performance
— other sensory modalities integrate and allow levels of performance
— interplay between systems

Concept of Ranges

— reciprocal interweaving in neuromotor development
— asymmetry to symmetry
— balance of muscle groups

Neurology of Motor

Brain Areas Involved in Motor Function

Primary Motor Cortex (M1) - generates impulses to control execution of movement
Supplementary Motor Area (SMA) - planning of sequential movements & bilaterality
Premotor Cortex - sensory guidance of movement and control of proximal & trunk muscles

- SMA & premotor cortex send information to the primary motor cortex as well as to brainstem motor regions

Posterior Parietal Cortex - putting visual information into motor commands

ACTION ← PERCEPTION
Neurology of Motor

- Neurons in M1, SMA and premotor cortex form fibers leading to corticospinal tract — main pathway for voluntary motor control
- Basal Ganglia - determines what movements are to be made, and suppresses involuntary motor movements
- Cerebellum - coordinates/refines movement and integrates timing/rhythm aspect
- Neurology of Motor — development or sequence of skills that expand or build on one another
- require a solid foundation before moving to more specific higher-level/cortical motor actions
- begin under reflex control and progress to voluntary, planned, coordinated movements

Neurology of Motor

Primitive Reflexes
- automatic, involuntary movement patterns directed by brainstem
- survival component
- no cortical control
- integration necessary for efficient movement/action to develop
- if not integrated, will likely limit or halt appropriate motor development, and subsequently lead to deficits in voluntary ocular control
- and other visual/spatial/postural/perceptual actions

Vision

Primary Visual Pathways
Through LGN to V1 & beyond:
- Parvocellular (What Is It?) — major synapse in inferior temporal cortex
- Magnocellular (Where is it?) — major synapse in posterior parietal cortex
Vision...as a detailed Spatial and Motor coordinator

Dynamic Visual Processing

Higher-level cortical vs. subcortical (midbrain) visual processing
Object & Spatial vision
— need balance and interweaving

Dynamic Visual Processing

— visual system serves as guide/director for efficient and safe movement through our space world
— deficits can be seen in higher-level skeletal, visceral, and cortical eye movements

Dynamic Visual Processing

— General, Special & Eye movement patterns for action
— Posture & Body Mechanics
— Integration
— Ambient Visual Processing

--- ANTIGRAVITY SYSTEM ---

Movement Patterns for Action

Getman described:
— General movement patterns
— Special movement patterns
— Eye movement patterns

"Thoughts that never fully possess the muscles never fully possess the mind"
— Unknown
General Movement Patterns

“If there is to be achievement of the ultimate potentials every child brings, there must be a greater recognition of why movement skills are so important”
— Getman

— general movement patterns build foundation for later, more specialized motor actions

Special Movement Patterns

— eye-hand motor patterns
  — visual-tactile system
— when general movement patterns have been firmly established, specialized movement can occur to derive further meaning from environment

Eye Movement Patterns

— again, building on the foundation of other movements in order to have efficient eye movements
— identification (what) and centering/localizing (where) of target

“Vision develops under the tutelage of the active touch”
— Renshaw

— required manipulation of objects
— place & grid cells
  — spatial mapping and body schemata

Special Movement Patterns

— emphasis placed on bilaterality and reciprocal interweaving of both hemispheres
  
“...although the visual system and all of its movements...is the supreme receiver of information, and the dominant input system for cognition, the hands must be recognized as the supreme action system for the output that follows visual discrimination and decisions.”

Special Movement Patterns

— begins with basic and primitive reflex type movements
— works at the level of integrating multiple sensory-motor patterns to increase fluency and smoothness in (bilateral) movement
  — vestibular : head movements
  — proprioceptive : active awareness and coordination of moving
Eye Movement Patterns

— requires dynamic between both centering and identification systems for optimal performance
— ie. reading, sports, etc
— consists of fixational, pursuit, and saccadic ocular movements

Posture & Body Mechanics

Posture & Body Mechanics in VT

— Harmon describes that prior to a meaningful “visual image,” a number of steps must occur:
  1) body balanced for a stable base to aim accurately
  2) head, neck, body must establish a frame of reference —visual space— to direct movements
  3) map of limits in environment and area of activity
  4) understanding details of activity, relationship with each other, and relationship with other objects of significance
  5) stepwise pattern in performance of activity

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

Posture & Body Mechanics in VT

1) lenses to alter placement of activity to less stressful position
2) develop visual skills to allow efficient input
3) maintain proper posture during activities to minimize stress
4) develop/train head & body support, bilateral integration to build appropriate motor and visuospatial constructs

Posture & Body Mechanics in VT

— labyrinth, EOMs, neck muscles, and trunk muscles integrated to provide gravitational balance and visuospatial support
— “trunk-neck-ocular”
— system serves as a steering or driving mechanism and frame of reference for visuospatial tasks
Integration

**Integration**

- the coordination of two or more processes...to enhance performance
  - improve the brain’s ability to learn new tasks and develop the capacity to apply this to all tasks
  - cortical-subcortical integration

Reticular Formation

- area in the brainstem which filters/controls information from multiple sensory pathways
  - inhibits or facilitates
  - receives motor neurons for tone, balance, posture during movement
  - gaze centers (PPRF) for control of eye movements and to cerebellum to refine

Cerebellum

- mainly considered an integrator or regulator for motor action
  - close involvement with visual and vestibular systems
  - phylogenetic divisions

Vestibular System

- consists of SCC and otolith organs to:
  1) detect linear and rotational movement
  2) stabilize gaze
  3) maintain balance and posture
  4) structure accurate spatial world

Visual-Vestibular-Somatosensory Integration

- accurate head & body information for efficient motor and visuospatial exploration not possible with any one system
Visual-Vestibular-Somatosensory Integration

visual — orientation of body in space
vestibular — head position/movement
somatosensory — joint information relative to support surface

— some compensation if one system affected, but involvement of two often results in marked discomfort

Visual-Vestibular

Vestibulo-ocular reflex (VOR) — stabilizes gaze/eye movements during movements
— allows for smooth visual scene
— oscillopsia = inadequate integration

Cortical Visual Processing

Integration

— for smooth, efficient movement through our spatial world, a symbiotic relationship must exist between the three systems

Ambient Visual Processing
Ambient Visual Processing

Midbrain/Superior-collicular
— vision = bimodal process involved in both detail and spatial/motor
— concepts initially explored by Trevarthen (monkey), Schneider (hamster) and furthered by Ungerleider & Mishkin

“Vision is a dynamic interactive process of motor and sensory function, mediated by the eyes for the purpose of simultaneous organization of posture, movement and spatial orientation, for manipulation of the environment and, to its highest degree, of perception and thought”

— Padula

— 20% of peripheral retinal fibers to midbrain for spatial matching with kinesthetic, proprioceptive, and vestibular processes
— accurate spatial orientation for posture, movement, balance

— helps provide framework for building a spatial world and motor processes
— more efficient matching of visuomotor information, more incentive and comfort in exploring world
— need comfort visually for comfort motorically

Vision Therapy

✴ Reflexive motor control
Vision Therapy

- Angels in the Snow
- Rebounder/Trampoline
- Walking Rail
- Balance Board
- Directionality & Laterality

Angels in the Snow

Rebounder/Trampoline

Walking Rail

Balance Board

Directionality & Laterality
Vision Therapy
- Bimanual Circles/Lines
- Digital Movements
- Multi-Matrix

Bimanual Circles/Lines

Multi-Matrix

Vision Therapy
- Space Fixator
- Loaded Chart Saccades
- Dynamic MB

Space Fixator

Loaded Chart Saccades
Dynamic Marsden Ball

Vision Therapy

- Infinity Walk
- VOR Saccades

Infinity Walk

VOR Saccades

Integration of Visuospatial and Motor in VT

- utilization of dynamic, integrated motor/visuospatial activities
- underlying neurology evident

- more efficient system leads to more efficient total spatial/motor action system allowing greater degrees of freedom

Thank You!